

# A Practical Guide to Trade Policy Analysis



**What is *A Practical Guide to Trade Policy Analysis*?**

*A Practical Guide to Trade Policy Analysis* aims to help researchers and policymakers update their knowledge of quantitative economic methods and data sources for trade policy analysis.

**Using this guide**

The guide explains analytical techniques, reviews the data necessary for analysis and includes illustrative applications and exercises. An accompanying DVD contains datasets and programme command files required for the exercises.

**Find out more**

Website: <http://vi.unctad.org/tpa>

# Contents

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Contributing authors and acknowledgements	3
Disclaimer	4
Foreword	5
Introduction	7
<b>CHAPTER 1: Analyzing trade flows</b>	<b>11</b>
A. Overview and learning objectives	13
B. Analytical tools	14
C. Data	34
D. Applications	39
E. Exercises	54
<b>CHAPTER 2: Quantifying trade policy</b>	<b>61</b>
A. Overview and learning objectives	63
B. Analytical tools	63
C. Data	79
D. Applications	84
E. Exercises	93
<b>CHAPTER 3: Analyzing bilateral trade using the gravity equation</b>	<b>101</b>
A. Overview and learning objectives	103
B. Analytical tools	103
C. Applications	120
D. Exercises	131

<b>CHAPTER 4: Partial-equilibrium trade-policy simulation</b>	<b>137</b>
A. Overview and learning objectives	139
B. Analytical tools	141
C. Applications	162
D. Exercises	172
<b>CHAPTER 5: General equilibrium</b>	<b>179</b>
A. Overview and learning objectives	181
B. Analytical tools	181
C. Application	200
<b>CHAPTER 6: Analyzing the distributional effects of trade policies</b>	<b>209</b>
A. Overview and learning objectives	211
B. Analytical tools	212
C. Data	218
D. Applications	221
E. Exercise	229

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## Disclaimer

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## Foreword

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This book is the outcome of joint work by the Secretariats of UNCTAD and the WTO. Its six chapters were written collaboratively by academics and staff of the two organizations. The volume aims to help researchers and policy-makers expand their knowledge of quantitative economic methods and data sources for trade policy analysis. The need for the book is based on the belief that good policy needs to be backed by good analysis. By bringing together the most widely used approaches for trade policy analysis in a single volume, the book allows the reader to compare methodologies and to select the best-suited to address the issues of today.

The most innovative feature of the book is that it combines detailed explanations of analytical techniques with a guide to the data necessary to undertake analysis and accompanying tutorials in the form of exercises. This approach allows readers of the publication to follow the analytical process step by step. Although the presentations in this volume are mostly aimed at first-time practitioners, some of the most recent advances in quantitative methods are also covered.

This book has been developed in response to requests from a number of research institutions and universities in developing countries for training on trade policy analysis. Despite the growing use of quantitative economics in policy making, no existing publications directly address the full range of practical questions covered here. These include matters as simple as where to find the best trade and tariff data and how to develop a country's basic statistics on trade. Guidance is also provided on more complicated issues, such as the choice of the best analytical tools for answering questions ranging from the economic impact of membership of the WTO and preferential trade agreements to how trade will affect income distribution within a country.

Although quantitative analysis cannot provide all the answers, it can help to give direction to the process of policy formulation and to ensure that choices are based on detailed knowledge of underlying realities. We commend this guide to those engaged in creating trade policy and we hope that by contributing to the understanding of state-of-the-art tools for policy analysis, this guide will improve the quality of trade policy-making and contribute to a more level playing field in trade relations.



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# INTRODUCTION

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## I Supporting trade policy-making with applied analysis

Quantitative and detailed trade policy information and analysis are more necessary now than they have ever been. In recent years, globalization and, more specifically, trade opening have become increasingly contentious. Questions have been asked about whether the gains from trade exceed the costs of trade. Concerns regarding the distributional consequences of trade reforms have also been expressed.

It is, therefore, important for policy-makers and other trade policy stakeholders to have access to detailed, reliable information and analysis on the effects of trade policies, as this information is needed at different stages of the policy-making process. During the early stages of the process, it is used to assess and compare the effects of various strategies and to develop a proposal. When the proposal goes through the political approval process, this information is required in order to be able to conduct a policy dialogue with all stakeholders. Finally, information and analysis are necessary for the implementation of the measures.

General principles are not enough. Multilateral market access negotiations focus on tariff commitments, but commitments to reduce so-called bound rates may or may not affect the tariff rates that a country actually applies to imports, depending on the gap between the bound and the applied rate. A careful examination of the proposals is thus necessary to assess the effect of tariff commitments on market access. Similarly, the effect of preferential trade agreements on trade and welfare depends on the relative size of trade creation and trade deviation effects. Policy-makers preparing to sign a preferential trade agreement should have access to an assessment of the likely effect of the agreement, or at least to analyses of previous relevant experiences. While the effects of tariff changes are relatively straightforward, the effects of non-tariff measures depend on the specific measure and can vary substantially depending on the circumstances.

It is a long way from the tariffs and quotas contained in international economics textbooks to the jungle of real world tariffs and non-tariff measures, and analyzing the effects of changing a tariff in an undistorted textbook market is very different from responding to the request of a minister who envisages opening domestic markets and who wants to know how this will affect income distribution. Thus, the objective of this book is to guide economists with an interest in the applied analysis of trade and trade policies towards the main sources of data and the most useful tools available to analyse real world trade and trade policies.

The book starts with a discussion of the quantification of trade flows and trade policies. Quantifying trade flows and trade policies is useful as it allows us to describe, compare or follow the evolution of policies between sectors or countries or over time. It is also useful as it provides indispensable input into the modelling exercises presented in the other chapters. This discussion is followed by a

presentation of gravity models. These are useful for understanding the determinants and patterns of trade and for assessing the trade effects of certain trade policies, such as WTO accessions or the signing of preferential trade agreements. Finally, a number of simulation methodologies, which can be used to “predict” the effects of trade and trade-related policies on trade flows, on welfare, and on the distribution of income, are presented.

## II Choosing a methodology

The key question that a researcher is faced with when asked to assess the effects of a given policy measure is deciding which methodological approach is best suited to answer the question given existing constraints. At this stage, dialogue between researchers and policy stakeholders is crucial as, depending on the circumstances, researchers may help policy-makers to determine relevant questions and to guide the choice of appropriate methodologies.

The choice of a methodology is not necessarily straightforward. It involves choosing between descriptive statistics and modelling approaches, between econometric estimation and simulation, between ex ante and ex post approaches, between partial and general equilibrium. Ex ante simulation involves projecting the effects of a policy change onto a set of economic variables of interest, while ex post approaches use historical data to conduct an analysis of the effects of past trade policy. The ex ante approach is typically used to answer “what if” questions. Ex-post approaches, however, can also answer “what if” questions under the assumption that past relations continue to be relevant. Indeed, this assumption underlies approaches that use estimated parameters for simulation. Partial equilibrium analysis focuses on one or multiple specific markets or products, ignoring the link between factor incomes and expenditures, while general equilibrium explicitly accounts for all the links between sectors of an economy – households, firms, governments and the rest of the world. In econometric models, parameter values are estimated using statistical techniques and they come with confidence intervals. In simulation models, behavioural parameters are typically drawn from a variety of sources, while other parameters are chosen so that the model is able to reproduce exactly the data of a reference year (calibration).

In principle, the question should dictate the choice of a methodology. For example, computable general equilibrium (CGE) seems to be the most appropriate methodology for an ex ante assessment of the effect of proposals tabled as part of multilateral market access negotiations. In reality, however, the choice is subject to various constraints. First, methodologies differ significantly with regard to the time and resources they require. Typically, building a CGE model takes a long time and requires a considerable amount of data. Running regressions require sufficient time series or cross sections of data, while the calibration of a partial equilibrium model only requires data for one year. There are, however, relatively important sunk costs and thus large economies of scale and/or scope. Once a CGE has been constructed, it can be used to answer various questions without much additional cost. More generally, familiarity with certain methodologies or institutional constraints could dictate the use of certain approaches.

Methodologies can also be combined to answer a given question. In most cases, it is sound advice to start with descriptive statistics, which, besides paving the way for more sophisticated analysis, often go a long way towards answering questions that one might have on the effects of trade

policies. Similarly, when assessing the distributional effects of trade policy, it can be useful to combine approaches. The effect of changes in tariffs on prices is estimated econometrically, while the effect of the price changes on household incomes is simulated.

Different methodologies or simply different assumptions may lead to conflicting results. This is not a problem as long as differences can be traced back to their causes. The difficulty, however, is that policy-makers do not like conflicting results. This leads us to another important point, which is the importance of the packaging of results. Presenting and explaining results in a clear and articulate way, avoiding jargon as much as possible, is at least as important as obtaining those results. It is also crucial to spell out clearly the assumptions underlying the approach used and to explain how they affect the results.

### III Using this guide

This practical guide is targeted at economists with basic training and some experience in applied research and analysis. More specifically, on the economics side, a basic knowledge of international trade theory and policy is required, while on the empirical side, the prerequisite is familiarity with work on databases and with the use of STATA software.<sup>1</sup>

The guide comprises six chapters and an accompanying DVD containing empirical material, including data and useful command files. All chapters start with a brief introduction, which provides an overview of the contents and sets out the learning objectives. Apart from the chapter on CGE (Chapter 5), each chapter is divided into two main parts. The first part introduces a number of analytical tools and explains their economic logic. In Chapters 1, 2 and 6, the first part also includes a discussion of data sources. The second part describes how the analytical tools can be applied in practice, showing how the raw data can be retrieved and processed to quantify trade or trade policies or to analyse the effects of the latter. Data sources are presented and difficulties that may arise when using the data are discussed. The software used for trade and trade policy quantification, gravity model estimation and analysis of the distributional effects of trade policies (Chapters 1, 2, 3 and 6) is STATA. In the chapter on partial equilibrium simulation, several ready-made models are introduced. While the presentation of these applications in the chapters can stand alone, the files with the corresponding STATA commands and the relevant data are provided on the DVD. The CGE chapter (Chapter 5) differs from the others in that it does not aim to teach readers how to build a CGE but simply explains what a CGE is and when it should be used.

Datasets and program files for applications and exercises proposed in this guide can be found on the accompanying DVD and on the *Practical Guide to Trade Policy Analysis*' website: <http://vi.unctad.org/tpa>. A general folder entitled "Practical guide to TPA" is divided into sub-folders which correspond to each chapter (e.g. "Practical guide to TPA\Chapter1"). Within each of these sub-folders, you will find datasets, applications and exercises. Detailed explanations can be found in the file "readme.pdf" available on the website and in the DVD.

### Endnote

1 A considerable amount of resources for learning and using STATA can be found online. See: <http://vi.unctad.org/tpa>.



## TABLE OF CONTENTS

A. Overview and learning objectives	13
B. Analytical tools	14
1. Overall openness	15
2. Trade composition	19
3. Comparative advantage	26
4. Analyzing regional trade	28
5. Other important concepts	32
C. Data	34
1. Databases	34
2. Measurement issues	37
D. Applications	39
1. Comparing openness across countries	39
2. Trade composition	41
3. Comparative advantage	48
4. Terms of trade	53
E. Exercises	54
1. RCA, growth orientation and geographical composition	54
2. Offshoring and vertical specialization	55
Endnotes	56
References	59

## LIST OF FIGURES

Figure 1.1.	Trade openness and GDP per capita, 2000	16
Figure 1.2.	Overlap trade and country-similarity index <i>vis-à-vis</i> Germany, 2004	20
Figure 1.3.	Decomposition of the export growth of 99 developing countries, 1995–2004	22
Figure 1.4.	Export concentration and stages of development	23
Figure 1.5.	Import matrix, selected Latin American countries	29
Figure 1.6.	EU regional intensity of trade indices with the CEECs	30
Figure 1.7.	HS sections as a proportion of trade and subheadings	35
Figure 1.8.	Zambia's import statistics against mirrored statistics	38
Figure 1.9.	Distribution of import–export discrepancies	38
Figure 1.10.	Main export sectors, Colombia, 1990 and 2000	41
Figure 1.11.	Main trade partners, Colombia (export side), 1990 and 2000	42
Figure 1.12.	Geographical orientation of exports, Colombia vs. Pakistan, 2000	43
Figure 1.13.	Geographical/product orientation of exports, Colombia vs. Pakistan, 2000	44
Figure 1.14.	Grubel-Lloyd indexes at different level of aggregation of trade data	45
Figure 1.15.	Normalized Herfindahl indexes, selected Latin American countries	47
Figure 1.16.	Chile trade complementarity index, import side	48
Figure 1.17.	Evolution of Costa Rica's export portfolio and endowment	49
Figure 1.18.	Relationship between per-capita GDP (in logs) and EXPY (in logs), 2002	51
Figure 1.19.	EXPY over time for selected countries	51
Figure 1.20.	Barter terms of trade of developing countries, 2001–2009	53

## LIST OF TABLES

Table 1.1.	Evolution of aggregated GL indices over time: central and eastern Europe, 1994–2003	21
Table 1.2.	Regional imports, selected Latin American countries, 2000	28
Table 1.3.	Complementarity indices: illustrative calculations	31
Table 1.4.	Real exchange rate: illustrative calculations	32
Table 1.5.	Grubel-Lloyd index: illustrative calculations	45
Table 1.6.	Decomposition of export growth 1995–2004, selected OECD countries	46
Table 1.7.	Largest and smallest PRODY values (2000 US\$)	50
Table 1.8.	Correlates of EXPY	52

## LIST OF BOXES

Box 1.1.	Intensive and extensive margins of diversification	24
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## A. Overview and learning objectives

This chapter introduces the main techniques used for trade data analysis. It presents an overview of the simple trade and trade policy indicators that are at hand and of the databases needed to construct them. The chapter also points out the challenges in collecting and analyzing the data, such as measurement errors or aggregation bias.

In introducing you to the main indices used to assess trade performance, the discussion is organized around how much, what and with whom a country trades. We start with a discussion of the main indices used to assess trade performance. These indices are easy to calculate and require neither programming nor statistical knowledge. They include openness, both at the aggregate level and at the industry level (the “import content of exports” and various measures of trade in parts and components). We will also show you how to analyze and display data on the sectoral composition and structural characteristics of trade, including intra-industry trade, export diversification and margins of export growth. Next, we will discuss various measures that capture the concept of comparative advantage, including revealed comparative advantage indexes and revealed technology and factor-intensity indexes.

Then we will illustrate how regional trade data can be analyzed and displayed, a subject of particular importance in view of the spread of regionalism and the high policy interest in it. In particular, we will discuss the use of trade complementarity and regional intensity of trade indices, applying them to intra-regional trade in Latin America. Before turning to data, we will further introduce two other concepts related to trade performance, namely the real effective exchange rate and terms of trade.

There exists a large variety of data sources for trade data. Original data are affected by two major problems, however. On the one hand, import value data are known to be more reliable than export values or import volumes, which calls for prudence in interpretation when dealing with bilateral flows or unit values. On the other hand, trade and production classifications differ, which means that it is often necessary to aggregate data when both types of information are needed. Both problems being well known, a number of secondary data sources provide partial answers to these problems. We discuss these problems and their possible solutions in the second part of the chapter.

In the last part of this chapter you will find a number of applications that will guide you in constructing the structural indicators introduced in the first part. The applications will help you understand how they should and how they should not be interpreted in order to reduce the scope for misunderstanding. A typical case is the traditional trade openness indicator (exports plus imports over GDP). We will mention all the controls that should be taken into account and will illustrate why the concept of trade “performance” can be misleading.

In this chapter, you will learn:

- how goods are classified in commonly used trade nomenclatures
- where useful trade databases can be found and what their qualities and pitfalls are

- what the key measurement issues are that any analyst should know before jumping into data processing
- what main indices are used to assess the nature of foreign trade in terms of structural, sectoral and geographical composition
- how to display trade data graphically in a clear and appealing way.

After reading this chapter, you will be able to perform a trade analysis that will draw on the relevant types of information, will be presented in an informative but synthetic way and will be easy to digest for both specialists and non-specialists alike.

## B. Analytical tools

Descriptive statistics in trade are typically needed to picture the trade performance of a country. What do we mean by “trade performance”? The answer we will provide in this chapter is based on three main questions around which we can organize a description of a country’s foreign trade: (i) How much does a country trade?; (ii) What does it trade?; and (iii) With whom does it trade? Each of these three questions is implicated in the effects trade can be expected to have on the domestic economy. The answer to each of them has a distinct “performance” flavour, depending on the policy objectives that motivate the study of a country’s foreign trade.

Let us start with “how much”. This question is intimately related to the concept of “trade openness”, which typically measures the economy’s ability to integrate itself into world trade circuits. Trade openness can also be understood as an indicator of policy performance inasmuch as it results from policy choices (e.g. trade barriers and the foreign-exchange regime). Geographical and other natural factors that are by and large given (sea access, remoteness etc.) also play a role in determining a country’s openness. Another measure of the integration of a country into the world economy is the extent to which it is involved in global value chains. We will therefore show how to construct country- and sector-level indicators that capture the sourcing of intermediate inputs beyond national borders (offshoring and vertical specialization measures).

As to the “what” question, a country’s import and export patterns are determined in the standard trade model by its endowment of productive factors and the technology it has available. Some factors, such as land and natural resources, are given by nature, while others, such as physical and human capital, are the result of past and present policies. The question of “what” is also directly linked to the question of diversification of a country’s exports, a subject of concern for many governments. We will show how to assess properly the degree of diversification of a country’s exports.

Influencing trade patterns may be a legitimate policy objective. Governments typically try to achieve this with supply-side policies aimed at “endowment building” and technology enhancement (and to a lesser extent with demand-side policies such as reducing trade barriers). Moreover, any meaningful discussion of what a country trades should take into account what it *can* trade, ideally through direct measurement of factor and technology endowments. As endowment data are rarely available, in their absence revealed comparative advantage (RCA) indices are used; because they are based on trade data, however, they cannot be used to compare actual with potential sectoral trade patterns. We will also discuss

other measures that build upon the index of revealed comparative advantage to measure the technology and endowment content of exports.

In contrast to the framework of comparative advantage, in the “intra-industry trade” (IIT) paradigm, e.g. Krugman’s monopolistic-competition model (Krugman, 1979) or Brander and Krugman’s reciprocal-dumping one (Brander and Krugman, 1983), a country’s specialization pattern cannot be determined *ex ante* and diversification increases with country size. The IIT and standard paradigms do not necessarily compete for a unique explanation of trade patterns. They describe different dimensions of trade. Because their implications differ both for the effectiveness of trade policy and for the sources of the gains from trade (specialization in the standard model, scale economies, competition and product diversity in IIT), it is useful to separate empirically the two types of trade. We will show how this can be done using IIT indices.

Finally, consider the “with whom” question. The characteristics of a country’s trading partners affect how much it will gain from trade. For instance, trade links with growing and technologically sophisticated markets can boost domestic productivity growth. So it matters to know who the home country’s “natural trading partners” are, which typically depends on geography (distance, terrain), infrastructure and other links, such as historical ties. A full discussion of the determinants of bilateral trade, including the gravity equation, is postponed until Chapter 3. In this chapter we will limit ourselves to descriptive measures concerning the geographical composition of a country’s foreign trade and its complementarity with its trading partners.

We will show how to assess and illustrate whether an economy is linked with the “right” partners, for instance those whose demand growth is likely to help lift the home country’s exports. We will also show how the observation of regional trade patterns can help government authorities assess whether potential preferential partners are “natural” or not, in other words whether they appear to have something to trade with the home country.

An excellent introduction to some commonly used indices, together with some examples, can be found on the World Bank’s website.<sup>1</sup> We will present some of these indices in this section, illustrate their uses and limitations, and propose some additional ones.

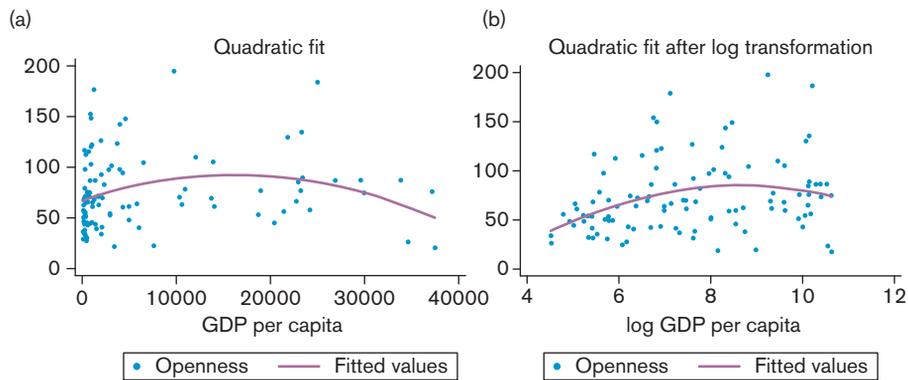
## 1. Overall openness

### a. Trade over GDP measure

The most natural measure of a country’s integration in world trade is its degree of openness. One might suppose that measuring a country’s openness is a relatively straightforward endeavour. Let  $X^i$ ,  $M^i$  and  $Y^i$  be respectively country  $i$ ’s total exports, total imports and GDP.<sup>2</sup> Country  $i$ ’s openness ratio is defined as:

$$O^i = \frac{X^i + M^i}{Y^i} \quad (1.1)$$

The higher  $O^i$ , the more open is the country. For small open economies like Singapore, it may even be substantially above one. The index can be traced over time. For example, the Penn World Tables (PWTs) include this measure of openness covering a large number of years.<sup>3</sup>

**Figure 1.1 Trade openness and GDP per capita, 2000**

Source: Author calculations from World Bank WDI

**Notes:** Openness is measured as the sum of imports and exports over GDP. Per capita GDP is in US dollars at Purchasing Power Parity. In panel (a), the curve is an OLS regression line in which the dependent variable is openness and the repressor GDP per capita. In panel (b), GDP per capita is in logs. Observe how the appearance of the scatter plot changes: the influence of outliers is reduced, and even though panel (b) still gives a concave relationship, the turning point is not at the same level of per-capita GDP as in panel (a). In the latter it is slightly below PPP\$20,000. In the former it is around  $\exp(9.5) = \text{PPP}\$13,400$  (roughly). This is to attract your attention to the fact that qualitative conclusions (the concave shape of the relationship) may be robust while quantitative conclusions (the location of the turning point) can vary substantially with even seemingly innocuous changes in the estimation method. All in all, it looks as if openness rises faster with GDP per capita at low levels than when it is at high levels.

However, it is far from clear whether we can use  $O^i$  as such for cross-country comparisons because it is typically correlated with several country characteristics. For instance, it varies systematically with levels of income, as shown in the scatter plots of Figure 1.1, where each point represents a country. The curve is fitted by ordinary least squares. Countries below the curve can be considered as trading less than their level of income would “normally” imply.

**Stata do file for Figure 1.1 can be found at “Chapter1\Applications\1\_comparing openness across countries\openness.do”**

```
use openness.dta, replace
replace gdppc = gdppc/1000
replace ln_gdppc = ln(gdppc)
twoway      (scatter openc gdppc) (qfit openc gdppc) if (year==2000 & openc<=200),      /*
*/      title("Quadratic fit") legend(lab(1 "Openness"))      /*
*/      xtitle ("GDP per capita")
twoway      (scatter openc ln_gdppc) (qfit openc ln_gdppc) if (year==2000 & openc<=200),      /*
*/      title("Quadratic fit after log transformation")      /*
*/      legend(lab(1 "Openness")) xtitle ("log GDP per capita")
```

Does it matter that openness correlates with country characteristics such as the level of income (as just shown), location (e.g. landlocked-ness) or size? It does, for two reasons. One has to do with measurement and the other has to do with logic.

Concerning measurement, because “raw” openness embodies information about other country characteristics it cannot be used for cross-country comparisons without adjustment. For instance, Belgium has a higher ratio of trade to GDP than the United States, but this is mainly because the United States is a larger economy and therefore trades more with itself. If we want to generate meaningful comparisons we will have to control for influences such as economic size that we think are not interesting in terms of the openness ratio. This controlling can be done with regression analysis and we will provide an example in Application 1 below.

As for logic, suppose that one wants to assess the influence of openness on growth econometrically. The measure of openness used as an explanatory variable in the regression analysis will have to be cleansed of influences that may embody either *reverse causality* (from growth to openness) or *omitted variables* (such as the quality of the government or institutions, which can affect both openness and growth). If we failed to do this, any relationship we would uncover would suffer from what is called “endogeneity bias”.

In order to get rid of endogeneity bias in growth/openness regression, one must adopt an identification strategy consisting of using “instrumental variables” that correlate with openness but do not influence income except through openness. For instance, Frankel and Romer (1999) used distance from trading partners and other so-called “gravity” variables (more on this will be discussed in later chapters) as instrumental variables. Using this strategy, they found that openness indeed has a positive influence on income levels. Another approach consists of using measures of openness based on policies rather than outcomes. We will look at measures of openness based on policy in Chapter 2.

Observe in passing that even for something seemingly straightforward like interpreting the share of trade in GDP raw numbers can be meaningless. The same degree of openness has a very different meaning for a country with a large coastline and close to large markets than for one that is landlocked, remote and with a lower level of income.

## b. Import content of exports and external orientation

The import content of exports is a measure of the outward orientation of an exporting industry. In order to calculate it, we need to introduce its building blocks. First, we define the import-penetration ratio for good  $j$  as  $\mu_{jt} = m_{jt}/c_{jt}$ , where  $m_{jt}$  is imports of good  $j$  in year  $t$  and  $c_{jt}$  is domestic consumption (final demand) of the same good in the same year.<sup>4</sup> Let also  $y_{kt}$  and  $z_{jk}$  be respectively industry  $k$ 's output and consumption of good  $j$  as an intermediate. Note that  $z_{jk}$  has no time subscript because, in practice, it will be taken from an input-output table and will therefore be largely time-invariant (input-output tables available to the public are updated rather infrequently).<sup>5</sup> Then the imported input share of industry  $k$  can then be calculated as:

$$\alpha_{kt} = \frac{\sum_{j=1}^n \mu_{jt} z_{jk}}{y_{kt}} \quad (1.2)$$

Next, let  $x_{kt}$  be good  $k$ 's exports at time  $t$ . The *net external orientation* of industry  $k$  can thus be estimated as the difference between the traditional export ratio (or “openness to trade” index,  $x_{kt}/y_{kt}$ ) and the imported input share given by expression (1.2); that is,

$$\tilde{\alpha}_{kt} = \frac{x_{kt}}{y_{kt}} - \alpha_{kt} = \frac{x_{kt} - \sum_{j=1}^n \mu_{kt} z_{jk}}{y_{kt}} \quad (1.3)$$

In practice, this measure is rather difficult to calculate because of its heavy data requirements and its dependence on input–output tables; one may think of its primary virtue as serving as a reminder of what the analyst would want to consider. With sufficiently detailed input–output tables, however, it is a particularly good measure of the real outward orientation of an industry.<sup>6</sup>

### c. Trade in intermediate goods

The integration of an industry in the world economy can also be measured by the amount of trade in parts and components along with the related international fragmentation of production.<sup>7</sup>

Various measures of foreign sourcing of intermediate inputs (henceforth, offshoring) have been proposed. First, there exist classifications of all product codes containing the words “part” or “component”.<sup>8</sup> The problem with using trade data on parts and components is that they do not allow us to distinguish between goods/services used as intermediate inputs from those used for final consumption. In order to take this distinction into account, input–output tables can be used instead.

### d. Offshoring

The measure of offshoring based on input–output tables, originally suggested by Feenstra and Hanson (1996), is the ratio of imported intermediate inputs used by an industry to total (imported and domestic) inputs. For industry  $k$ , we define offshoring as:

$$OS_k = \sum_j \left[ \frac{\text{purchase of imported inputs } j \text{ by industry } k}{\text{total inputs used by industry } k} \right] \left[ \frac{M_j}{D_j} \right] \quad (1.4)$$

where  $M_j$  represents imports of goods or services  $j$  and  $D_j$  represents domestic demand for goods or services  $j$ . When input–output tables include information on imported inputs,<sup>9</sup> this formula simplifies to:

$$OS_k = \sum_j \left[ \frac{\text{purchase of imported inputs } j \text{ by industry } k}{\text{total inputs used by industry } k} \right] \quad (1.5)$$

A similar measure can be calculated at country level, as:

$$OS^i = \frac{\sum_k \sum_j [\text{purchase of imported inputs } j \text{ by industry } k]}{\sum_k [\text{total inputs used by industry } k]} \quad (1.6)$$

where  $i$  indexes countries.

### e. Vertical specialization

The index of vertical specialization proposed by Hummels et al. (2001) indicates the value of imported intermediate inputs embodied in exported goods. It can be calculated from input–output tables as:

$$VS_k^i = \left( \frac{\text{imported inputs}_k^i}{\text{gross output}_k^i} \right) \times \text{export}_k^i \quad (1.7)$$

where  $i$  indexes countries and  $k$  indexes sectors. The first term expresses the contribution of imported inputs into gross production. Multiplying this ratio by the amount that is exported provides a dollar value for the imported input content of exports. If no imported inputs are used, vertical specialization is equal to zero. A similar measure can also be calculated at country level as the simple sum of sector level vertical specialization:

$$VS^i = \sum_k VS_k^i \quad (1.8)$$

## 2. Trade composition

### a. Sectoral and geographical orientation of trade

The sectoral composition of a country's trade matters for a variety of reasons. For instance, it may matter for growth if some sectors are drivers of technological improvement and subsequent economic growth, although whether this is true or not is controversial.<sup>10</sup> Moreover, constraints to growth may be more easily identified at the sectoral level.<sup>11</sup>

Geographical composition highlights linkages to dynamic regions of the world (or the absence thereof) and helps to think about export-promotion strategies. It is also a useful input in the analysis of regional integration, an item of rising importance in national trade policies.

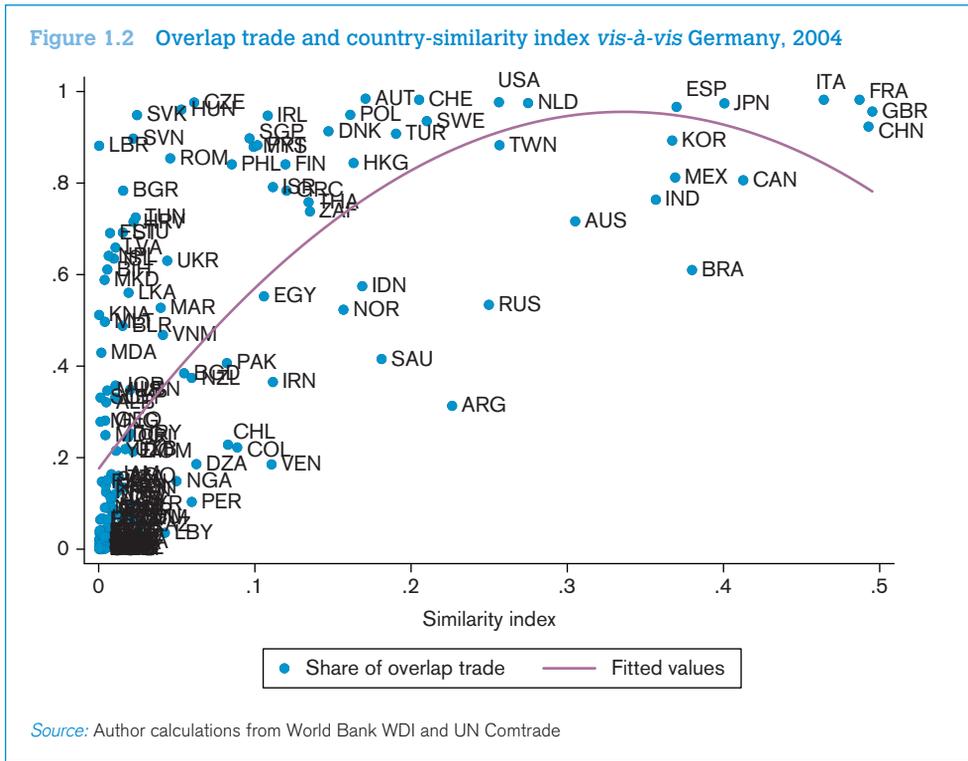
Simple indexes for the share of each sector in a country's total imports or exports can be constructed using a dataset with sector-level trade data. Likewise, one can construct indexes of the share of each partner in a country's total imports or exports using bilateral trade data. One can go a step further and assess to what extent a country's export orientation is favourable, i.e. to what extent the country exports in sectors and toward partners that have experienced faster import growth.<sup>12</sup>

### b. Intra-industry trade

For many countries, a large part of international trade takes place within the same industry, even at high levels of statistical disaggregation. A widely used measure of the importance of intra-industry trade is the Grubel-Lloyd (GL) index:

$$GL_k^j = 1 - \frac{|X_k^j - M_k^j|}{X_k^j + M_k^j} \quad (1.9)$$

where, as usual,  $X_k^j$  is  $i$ 's exports to  $j$  of good (or in sector)  $k$  and the bars denote absolute values. By construction, the GL index ranges between zero and one. If, in a sector, a country is either only



an exporter or only an importer, the second term will be equal to unity and hence the index will be zero, indicating the absence of intra-industry trade. Conversely, if a country in this sector both exports and imports, the index will be closer to the number one as similarity in the value of imports and exports increases. High values of the GL index are consistent with the type of trade analyzed in, say, Krugman’s monopolistic-competition model.<sup>13</sup> For this reason, for a developing country’s trade with an industrial country, rising values are typically associated with convergence in income levels and industrial structures.<sup>14</sup>

Typically, similar countries (in terms of economic size, i.e. GDP) share more intra-industry trade. This is shown in Figure 1.2, which scatters the similarity index and the share of overlap trade between Germany and its trading partners for 2004. The similarity index on the horizontal axis is constructed as in Helpman (1987) as:

$$S_i^j = 1 - \left[ \frac{GDP^i}{GDP^i + GDP^j} \right]^2 - \left[ \frac{GDP^j}{GDP^i + GDP^j} \right]^2 \tag{1.10}$$

where GDP is in real terms. The trade overlap index is defined as the sum of exports plus imports in products (HS, six digit) characterized by two-way trade (GL index > 0), divided by the sum of total exports and imports. Countries that have per capita income levels similar to Germany’s have a higher share of overlap trade (see Figure 1.2).

Stata do file for Figure 1.2 can be found at “Chapter1\Applications\Other applications\overlap\_trade.do”

```
use "overlap.dta", replace
twoway (scatter overlap simil_index, mlabel(partner)) /*
*/ (lfit overlap simil_index), /*
*/ title("Overlap trade and country-similarity index vis a vis Germany,2004") /*
*/ legend(lab(1 "Share of overlap trade")) xtitle ("Similarity index")
```

GL indices should however be interpreted cautiously. First, they rise with aggregation (i.e. they are lower when calculated at more detailed levels), so comparisons require calculations at similar levels of aggregation.<sup>15</sup> More problematically, unless calculated at extremely fine degrees of disaggregation GL indices can pick up “vertical trade”, a phenomenon that has little to do with convergence and monopolistic competition. If, say, Germany exports car parts (powertrains, gearboxes, braking modules) to the Czech Republic which then exports assembled cars to Germany, a GL index calculated at an aggregate level will report lots of intra-industry trade in the automobile sector between the two countries; but this is really “Heckscher-Ohlin trade” driven by lower labour costs in the Czech Republic (assembly is more labour-intensive than component manufacturing, so according to comparative advantage it should be located in the Czech Republic rather than Germany).<sup>16</sup>

Note that GL indices typically rise as income levels converge, as shown in Table 1.1 for the central and eastern European countries (CEECs) and the EU.

The rise of IIT indices reflects two forces. First, as economic integration progresses so does “vertical trade” of the type described above. Second, as low-income countries catch up with high-income ones they produce more of the same goods (technological sophistication increases). This produces “horizontal trade” in similar but differentiated goods, consistent with the monopolistic-competition model.

### c. Margins of export growth

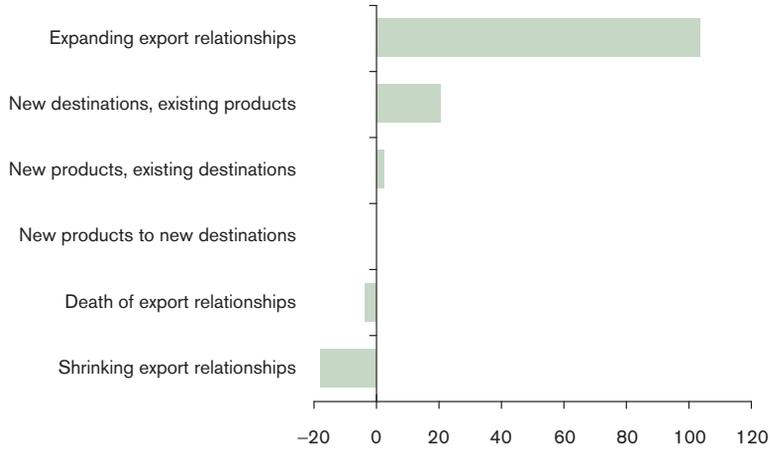
Trade patterns are not given once and for all but rather constantly evolve. A particularly important policy concern, which motivates much of reciprocal trade liberalization, is to get access to new

**Table 1.1 Evolution of aggregated GL indices over time: central and eastern Europe, 1994–2003**

Year	GL index
1994	69%
1995	72%
1996	74%
1997	77%
1998	81%
1999	82%
2000	84%
2001	85%
2002	84%
2003	83%

Source: Tumurchudur (2007)

**Figure 1.3** Decomposition of the export growth of 99 developing countries, 1995–2004



Source: Brenton and Newfarmer (2007)

markets and expand export opportunities. Export expansion, in terms of either products or destinations, can be at the intensive margin (growth in the value of existing exports to the same destination(s)), at the extensive margin (new export items, new destinations) or at the “sustainability margin” (longer survival of export spells). A useful decomposition goes as follows. Let  $K_0$  be the set of products exported by the home country in a year taken as the base year, and  $K_1$  the same set for the year taken as the terminal one. The monetary value of base-year exports is given by:

$$X_0 = \sum_{K_0} X_{k0} \tag{1.11}$$

and that of terminal exports by:

$$X_1 = \sum_{K_1} X_{k1} \tag{1.12}$$

The variation in total export value between those two years can be decomposed into:

$$\Delta X = \sum_{K_0 \cap K_1} \Delta X + \sum_{K_1 / K_0} X_k - \sum_{K_0 / K_1} X_k \tag{1.13}$$

where the first term is export variation at the intensive margin, the second is the new-product margin and the third is the “product death margin”. In other words, export growth can be boosted by exporting more of existing products, by exporting more new products or by fewer failures. More complicated decompositions can be constructed, along the same lines, combining products and destinations. A useful fact to know is that the contribution of the new-product margin to export growth is generally small (see Figure 1.3).<sup>17</sup>

There are two reasons for that, one technical and one substantive. The technical one is that a product appears in the extensive margin only the first year it is exported; thereafter, it is in the

intensive margin. Therefore, unless a firm starts exporting on a huge scale the first year (which is unlikely), the extensive margin's contribution to overall export growth can only be small. The substantive reason is that most new exports fail shortly after they have been launched: median export spell length is about two years for developing countries. There is a lot of export entrepreneurship out there but there is also a lot of churning in and out. Raising the sustainability of exports (which requires an understanding of the reasons for their low survival) is one under-explored margin of trade support.<sup>18</sup>

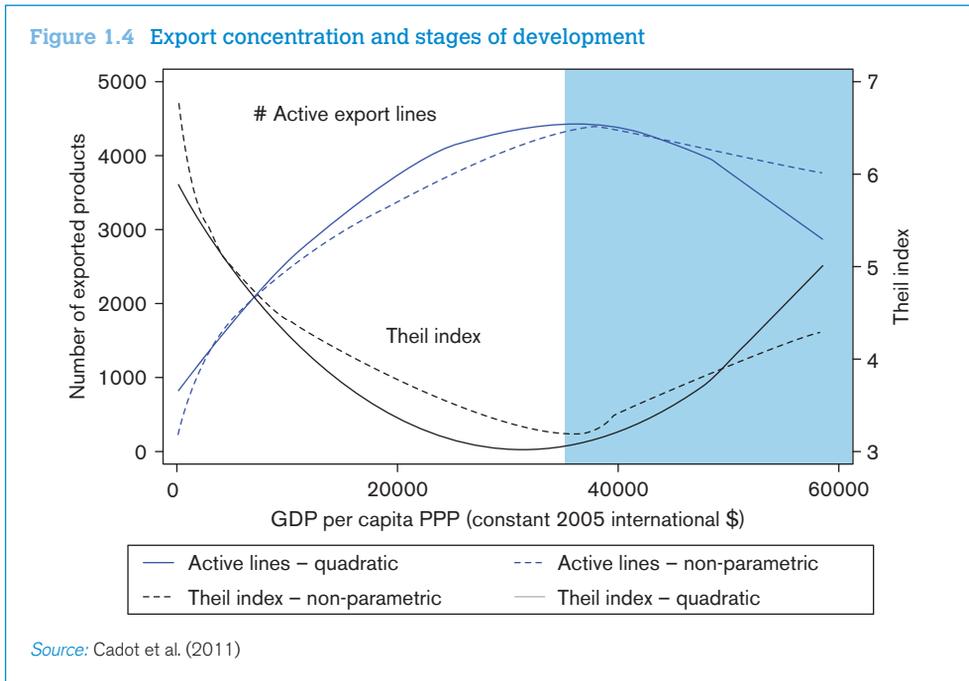
d. Export diversification

The simplest measure of export diversification is the inverse of the Herfindahl concentration index, which is constructed using the sum of the squares of sectoral shares in total export. That is, indexing countries by  $i$  and sectors by  $k$ , the Herfindahl index is equal to  $h^i = \sum_k (s_k^i)^2$ , where  $s_k^i$  is the share of sector  $k$  in country  $i$ 's exports or imports.<sup>19</sup>

By construction,  $h^i$  ranges from  $1/K$  to one, where  $K$  is the number of products exported or imported. The index can be normalized to range from zero to one, in which case it is referred to as the normalized Herfindahl index:

$$nh^i = \frac{h^i - 1/K}{1 - 1/K} \tag{1.14}$$

If concentration indices such the Herfindahl index are calculated over active export lines only, they measure concentration/diversification at the intensive margin. Diversification at the extensive margin can be measured simply by counting the number of active export lines. The first thing to observe is that, in general, diversification at both the intensive and extensive margins goes with economic development, although rich countries re-concentrate (see Figure 1.4).



Whether diversification is a policy objective in itself is another matter. Sometimes big export breakthroughs can *raise* concentration. On the other hand, in principle diversification reduces risk (although the concept of “export riskiness” remains relatively unexplored).<sup>20</sup> In addition, diversification at the extensive margin reflects “export entrepreneurship” and in that sense is useful evidence concerning the business climate. However, one should be careful in taking diversification as a policy objective *per se*. For example, diversification has often been justified as a means to avoid the so-called “natural resource curse” (a negative correlation between growth and the importance of natural resources in exports), but whether that “curse” is real or is rather a statistical illusion has recently become a matter of controversy.<sup>21</sup>

### Box 1.1 Intensive and extensive margins of diversification<sup>22</sup>

One drawback of measuring diversification by simply counting active export lines (as in Figure 1.4) is that whether a country diversifies by starting to export crude petroleum or asses and hinnies is considered the same: one export line is added (at a given level of product disaggregation). Hummels and Klenow (2005) have proposed a variant where new export lines are weighted by their share in world trade. According to that approach, starting to export a million dollars worth of crude oil counts more than starting to export a million dollars worth of asses because the former is more important in world trade (and therefore represents stronger expansion potential).

Let  $K^i$  be the set of products exported by country  $i$ ,  $X_k^i$  the dollar value of  $i$ 's exports of product  $k$  to the world and  $X_k^W$  the dollar value of world exports of product  $k$ . The (static) intensive margin is defined by Hummels and Klenow as:

$$IM^i = \frac{\sum_{K^i} X_k^i}{\sum_{K^i} X_k^W} \quad (1.15)$$

In other words, the numerator is  $i$ 's exports and the denominator is world exports of products that are in  $i$ 's export portfolio. That is,  $IM^i$  is  $i$ 's market share in what it exports. The extensive margin (also static) is:

$$XM^i = \frac{\sum_{K^i} X_k^W}{\sum_{K^W} X_k^W} \quad (1.16)$$

where  $K^W$  is the set of all traded goods.  $XM^i$  measures the share of the products belonging to  $i$ 's portfolio in world trade.

Stata implementation of Hummels and Klenow's product decomposition can be found at "Chapter1\Applications \Other applications\IM\_EM\_hummels\_klenow.do"

```

g x_i_k = trade_value
bysort reporter year: egen sum_i_x_i_k = total(x_i_k) /*Sum of i's export of all products exported by i*/
bysort year: g temp1 = x_i_k if reporter=="All"
bysort year product: egen temp2 = max(temp1) /*World exports of product k in year t*/
bysort reporter year: egen sum_i_x_w_k = total(temp2) /*Total world exports of all products exported by i*/
bysort year: egen sum_w_x_w_k = total(x_i_k) /*Total world exports of all products in the world*/

g im_i = sum_i_x_i_k / sum_i_x_w_k
g em_i = sum_i_x_w_k / sum_w_x_w_k
sum im_i em_i
keep reporter year im_i em_i
duplicates drop
replace im_i = im_i*100
replace em_i = em_i*100
sum im_i em_i

```

Hummels and Klenow's decomposition can be adapted to geographical markets instead of products. Let  $D^i$  be the set of destination markets where  $i$  exports (anything from one to 5,000 products – it does not matter),  $X_d^i$  the dollar value of  $i$ 's total exports to destination  $d$  and  $X_d^W$  the dollar value of world exports to destination  $d$  (i.e.  $d$ 's total imports). All these dollar values are aggregated over all goods.

The intensive margin is then:

$$IM^i = \frac{\sum_{D^i} X_d^i}{\sum_{D^i} X_d^W} \quad (1.17)$$

where  $D^W$  is the set of all destination countries. In other words, it is  $i$ 's market share in the destination countries where it exports ( $i$ 's share in their overall imports). The extensive margin is:

$$XM^i = \frac{\sum_{D^i} X_d^W}{\sum_{D^W} X_d^W} \quad (1.18)$$

It is the share of  $i$ 's destination markets in world trade (their imports as a share of world trade). Clearly, the decomposition can be further refined to destination/product pairs and to the import side.

Stata implementation of Hummels and Klenow's geographical decomposition can be found at "Chapter1\Applications \Other applications\IM\_EM\_hummels\_klenow.do"

```

use BilateralTrade.dta, replace
egen tt=sum(exp_tv)
sum tt
collapse (sum) exp_tv imp_tv, by ( ccode pcode year)
egen tt=sum(exp_tv)

```

(Continued)

**Box 1.1 (Continued)**

```

drop tt
g x_i_d = exp_tv
bysort ccode year: egen sum_i_x_i_d = total(exp_tv) /*Sum of ccode's export to all its destinations*/
bysort pcode year: egen x_w_d = total(exp_tv) /*Total world exports to each destination*/
bysort ccode year: egen sum_i_x_w_d = total(x_w_d) /*Total world exports to all destinations served by
ccode*/

bysort year: egen sum_w_x_w_d = total(exp_tv) /*Total world exports to all destinations in the world*/
g em_i = sum_i_x_w_d / sum_w_x_w_d
g im_i = sum_i_x_i_d / sum_w_x_w_d
sum im_i em_i
keep ccode year im_i* em_i*
duplicates drop
replace im_i = im_i*100
replace em_i = em_i*100
sum im_i em_i

```

### 3. Comparative advantage

#### a. Revealed comparative advantage

The current resurgence of interest in industrial policy sometimes confronts trade economists with demands to identify sectors of comparative advantage. However, this is not a straightforward task. The traditional measure is the revealed comparative advantage (RCA) index (Balassa, 1965). It is a ratio of product  $k$ 's share in country  $i$ 's exports to its share in world trade. Formally,

$$RCA_k^i = \frac{X_k^i / X^i}{X_k / X} \quad (1.19)$$

where  $X_k^i$  is country  $i$ 's exports of good  $k$ ,  $X^i = \sum_k X_k^i$  its total exports,  $X_k = \sum_i X_k^i$  world exports of good  $k$  and  $X = \sum_i \sum_k X_k^i$  total world exports. A value of the RCA above one in good (or sector)  $k$  for country  $i$  means that  $i$  has a revealed comparative advantage in that sector. RCA indices are very simple to calculate from trade data and can be calculated at any degree of disaggregation.

A disadvantage of the RCA index is that it is asymmetric, i.e. unbounded for those sectors with a revealed comparative advantage, but it has a zero lower bound for those sectors with a comparative disadvantage. One alternative is to refer to imports rather than exports applying the same formula as above, but where  $X$  is replaced by  $M$ . Another solution is to rely on a simple normalization proposed by Laursen (2000). The normalized RCA index, NRCA, becomes:

$$NRCA_k^i = \frac{RCA_k^i - 1}{RCA_k^i + 1} \quad (1.20)$$

The interpretation of the NRCA index is similar to the standard RCA measure except that the critical value is 0 instead of 1 and the lower (-1) and upper (+1) bounds are now symmetric.

Balassa's index simply records country  $i$ 's current trade pattern. Other indicators, presented below, are better suited for suggesting whether or not it would make sense to support a particular sector.

### b. Revealed technology content: PRODY index

An alternative approach draws on the PRODY index developed by Hausmann et al. (2007). The PRODY approximates the "revealed" technology content of a product by a weighted average of the GDP per capita of the countries that export it, where the weights are the exporters' RCA indices for that product:

$$PRODY_k = \sum_i RCA_k^i Y^i \quad (1.21)$$

where  $Y^i$  denotes country  $i$ 's GDP per capita. Intuitively, PRODY describes the income level associated with a product, constructed giving relatively more weight to countries with a revealed comparative advantage in that product, independent of export volumes.<sup>23</sup>

Hausmann et al. (2007) further define the productivity level associated with country  $i$ 's export basket as:

$$EXPY^i = \sum_k \frac{X_k^i}{X^i} PRODY_k \quad (1.22)$$

which is a weighted average of the PRODY for country  $i$ , using product  $k$ 's share in country  $i$ 's exports as weights. In calculating EXPY, products are ranked according to the income levels of the countries that export them. Products that are exported by rich countries get ranked more highly than commodities that are exported by poorer countries.

### c. Revealed factor intensities

A recent database constructed by UNCTAD (Shirotori et al., 2010) estimates "revealed" factor intensities of traded products, using a methodology similar to Hausmann et al. (2007). Let  $k^i = K^i/L^i$  be country  $i$ 's stock of capital per worker. Let  $H^i$  be a proxy for its stock of human capital, say the average level of education of its workforce, in years. These are *national factor endowments*. Good  $k$ 's revealed intensity in capital is:

$$k_k = \sum_{i \in I^k} \omega_k^i k^i \quad (1.23)$$

where  $I^k$  is the set of countries exporting good  $k$ . This is a weighted average of the capital abundance of the countries exporting  $k$ , where the weights  $\omega$  are RCA indices adjusted to sum up to one.<sup>24</sup> "Revealed" simply means that a product exported by a country that is richly endowed in physical capital is supposed to be capital intensive. For instance, if good  $k$  is exported essentially by Germany and Japan, it is revealed to be capital intensive. If it is exported essentially by Viet Nam and Lesotho, it is revealed to be labor-intensive. Similarly, product  $k$ 's revealed intensity in human capital is:

$$h_k = \sum_{i \in I^k} \omega_k^i h^i \quad (1.24)$$

where  $h^i = H^i/L^i$  is country  $i$ 's stock of human capital per worker. The database covers 5,000 products at HS6 and over 1,000 at SITC4–5 between 1962 and 2007.<sup>25</sup>

## 4. Analyzing regional trade

Preferential trade agreements (PTAs) are very much in fashion. The surge in PTAs has continued unabated since the early 1990s. Some 474 PTAs have been notified to the GATT/WTO as of July 2010. By that same date, 283 agreements were in force.<sup>26</sup> It has been frequently argued since Lipsey (1960) that forming a free trade agreement (FTA) is more likely to be welfare-enhancing if its potential members already trade a lot between themselves, a conjecture called the “natural-trading partners hypothesis”. However, the theory so far suggests that these agreements do not necessarily improve the welfare of member countries.<sup>27</sup> We will discuss ways to measure trade diversion and trade creation *ex post* in Chapter 3 when we consider the gravity equation and in Chapter 5 when we treat partial equilibrium models. Here we will focus on another aspect, namely whether the countries that form or plan to form a preferential area are “natural trading partners” or not.

A first step is to visualize intra-regional trade flows, showing raw figures and illustrating them in a visually telling way. Raw data on regional trade flows for four Latin American countries (Argentina, Brazil, Chile and Uruguay) are shown in Table 1.2.

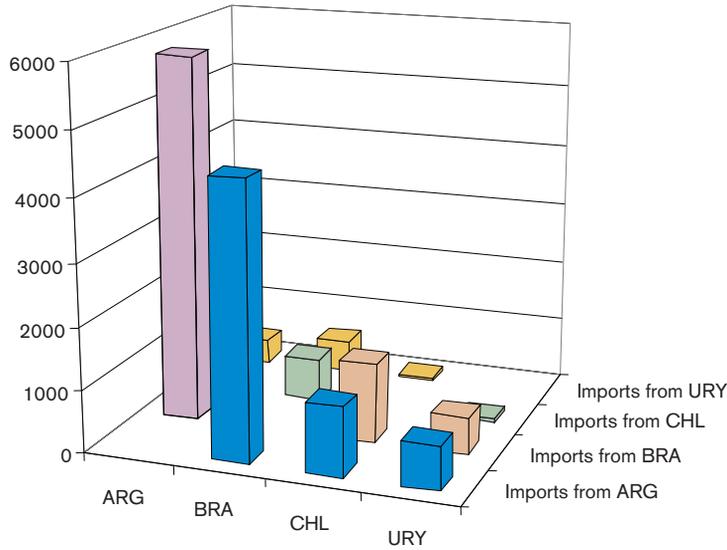
Table 1.2's data can be illustrated in a three-dimensional bar chart as shown in Figure 1.5. The figure highlights the overwhelming weight of Brazil and Argentina in regional trade.

**Table 1.2 Regional imports, selected Latin American countries, 2000**

<i>Exporter</i>	<i>Importer</i>			
	<i>Argentina</i>	<i>Brazil</i>	<i>Chile</i>	<i>Uruguay</i>
ARG	–	4397	1100	694
BRA	5832	–	1270	603
CHL	494	695	–	50
URY	379	535	56	–
Total Cono Sur + BRA	6705	5627	2426	1347
As % of total imports	30.5%	11.3%	18.5%	47.9%
COL	43	169	176	5
ECU	34	18	47	2
PER	23	140	195	3
VEN	23	811	103	1
Total other Latin America	123	1139	521	12
As % of total imports	0.6%	2.3%	4.0%	0.4%
CAN	278	1024	420	19
MEX	540	777	607	38
USA	4268	13000	3129	332
Total NAFTA	5087	14800	4156	388
As % of total imports	23.1%	29.7%	31.6%	13.8%
Total imports	22000	49800	13100	2813

*Source:* Author calculations from Trade, Production and Protection Database (Nicita and Olarreaga, 2006)

Figure 1.5 Import matrix, selected Latin American countries



Source: Author calculations from Trade, Production and Protection Database (Nicita and Olarreaga, 2006)<sup>28</sup>

a. Regional intensity of trade

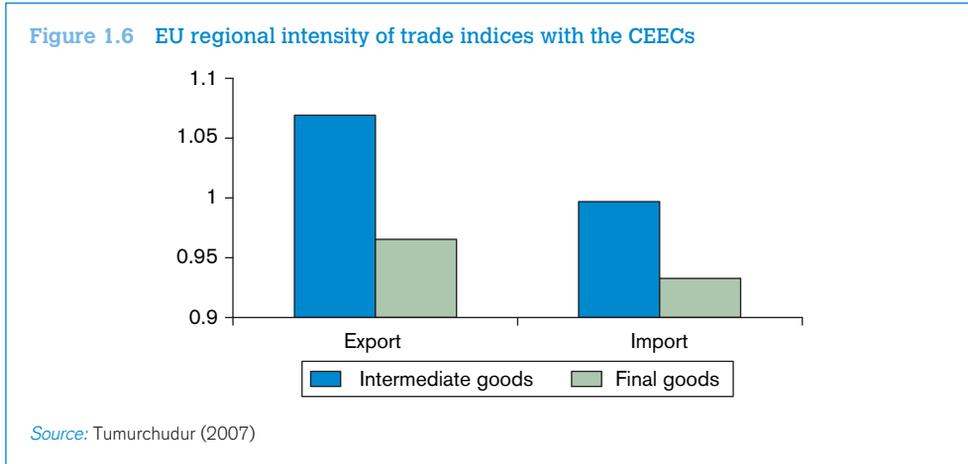
Regional intensity of trade (RIT) indices measure, on the basis of existing trade flows, to what extent countries trade with each other more intensely than with other countries, thus providing information on the potential welfare effects of a regional integration agreement.<sup>29</sup> These indices are purely descriptive and do not control – or only imperfectly so – for factors that affect bilateral trade, factors that are truly controlled for only in a gravity equation. Chapter 3 will illustrate how econometric analysis can shed additional light on the welfare effects of PTAs using the gravity equation. It should be kept in mind, of course, that econometric analysis requires observable effects and can thus be performed only “ex-post”, once the agreement is in place (and preferably has been for several years).

Yeats' RIT indices (Yeats, 1997) are perhaps the most cumbersome to calculate among our simple indices, although no particular difficulty is involved. Let  $X_k^j$  be country  $i$ 's exports of good  $k$  to country  $j$ ,  $X^j = \sum_k X_k^j$  be country  $i$ 's all exports to country  $j$ ,  $X_k^i = \sum_j X_k^j$  be country  $i$ 's exports of good  $k$  to the world,  $X^i = \sum_j \sum_k X_k^j$  be country  $i$ 's exports to the world aggregated over all goods. On the export side, the RIT index measures the share of region  $j$  in  $i$ 's exports of good  $k$  relative to its share in  $i$ 's overall exports, and is given by:

$$R_k^j = \frac{X_k^j / X^i}{X^j / X^i} \tag{1.25}$$

A similar index can be calculated on the import side.

As an example<sup>30</sup> of what RIT indices can be used for, let  $i$  be the European Union (EU) and  $j$  be one of the central and eastern European countries (CEECs). Next, let  $k = I$  for intermediate goods



or F for final ones. Taking 1 and 2 as periods 1 and 2 respectively, a rise of vertical trade between western and eastern Europe would imply:

$$\frac{R_I^j(2)}{R_I^j(1)} > \frac{R_F^j(2)}{R_F^j(1)} \tag{1.26}$$

that is, a faster rise in the CEECs' share of EU intermediate-good exports than in their share of final-good exports. This is indeed what the data shows in Figure 1.6.<sup>31</sup>

### b. Trade complementarity

Trade complementarity indices (TCIs) introduced by Michaely (1996) measure the extent to which two countries are "natural trading partners" in the sense that what one country exports overlaps with what the other country imports.<sup>32</sup>

A trade complementarity index between countries *i* and *j*, say on the import side (it can also be calculated on the export side), approximates the adequacy of *j*'s export supply to *i*'s import demand by calculating the extent to which *i*'s total imports match *j*'s total exports. With perfect correlation between sectoral shares, the index is one hundred; with perfect negative correlation, it is zero. Formally, let  $m_k^i$  be sector *k*'s share in *i*'s total imports from the world and  $x_k^j$  its share in *j*'s total exports to the world. The import TCI between *i* and *j* is then:

$$c^j = 100 \left[ 1 - \sum_{k=1}^m |m_k^i - x_k^j| / 2 \right] \tag{1.27}$$

Table 1.3 shows two illustrative configurations with three goods. Both in panel (a) and (b), country *i*'s offer does not match *j*'s demand, as revealed by their exports and imports respectively. Note that these exports and imports are by commodity but relative to the world and not to each other. In panel (a), however, there is a partial match between *j*'s offer and *i*'s demand, leading to an

**Table 1.3 Complementarity indices: illustrative calculations**

(a) *i*'s offer doesn't match *j*'s demand and *j*'s offer only partly matches *i*'s demand

Goods	Dollar amount of trade			
	Country <i>i</i>		Country <i>j</i>	
	$X_k^i$	$M_k^i$	$X_k^j$	$M_k^j$
1	0	55	108	93
2	0	0	0	0
3	23	221	35	0
Total	23	276	143	93

Goods	Shares in each country's trade				Intermediate calculations			
	Country <i>i</i>		Country <i>j</i>		Cross differences		Absolute values	
	$x_k^i$	$m_k^i$	$x_k^j$	$m_k^j$	$m_k^j - x_k^i$	$m_k^i - x_k^j$	$ m_k^i - x_k^j /2$	$ m_k^j - x_k^i /2$
1	0.00	0.20	0.76	1.00	1.00	-0.56	0.50	0.28
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	1.00	0.80	0.24	0.00	-1.00	0.56	0.50	0.28
Sum	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.56
Index value							0.00	44.40

(b) *i*'s offer doesn't match *j*'s demand but *j*'s offer perfectly matches *i*'s demand

Goods	Dollar amount of trade			
	Country <i>i</i>		Country <i>j</i>	
	$X_k^i$	$M_k^i$	$X_k^j$	$M_k^j$
1	0	55	55	27
2	0	0	0	50
3	23	108	108	0
Total	23	163	163	77

Goods	Shares in each country's trade				Intermediate calculations			
	Country <i>i</i>		Country <i>j</i>		Cross differences		Absolute values	
	$x_k^i$	$m_k^i$	$x_k^j$	$m_k^j$	$m_k^j - x_k^i$	$m_k^i - x_k^j$	$ m_k^i - x_k^j /2$	$ m_k^j - x_k^i /2$
1	0.00	0.34	0.34	0.35	0.35	0.00	0.18	0.00
2	0.00	0.00	0.00	0.65	0.65	0.00	0.32	0.00
3	1.00	0.66	0.66	0.00	-1.00	0.00	0.50	0.00
Sum	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00
Index value							0.00	100.00

overall TCI equal to 44.4. In panel (b) the match between  $j$ 's offer and  $i$ 's demand is perfect, leading to a TCI of 100.<sup>33</sup>

## 5. Other important concepts

### a. Real effective exchange rate

The real effective exchange rate (REER) is a measure of the domestic economy's price competitiveness *vis-à-vis* its trading partners. The evolution of the REER is often a good predictor of looming balance-of-payments crises. It has two components: the "real" and the "effective". Let us start with the "real" part. Table 1.4 shows an illustrative calculation of the real bilateral exchange rate between two countries, home and foreign. Suppose that price indices are normalized in both countries to 100 in 2010. Inflation is 4 per cent abroad but 15 per cent at home, an inflation differential of around 11 percentage points. The exchange rate is 3.80 local currency units (LCUs) per one foreign currency unit (say, if home is Argentina, 3.80 pesos per dollar) at the start of 2010, but 3.97 at the start of 2011, a depreciation of about 4.5 per cent.

Country  $i$ 's bilateral real exchange rate with country  $j$ ,  $e^{ij}$ , is calculated as the ratio of  $i$ 's nominal exchange rate,  $E^{ij}$ , divided by the home price index relative to the foreign one ( $p^i/p^j$ ):

$$e^{ij} = \frac{E^{ij}}{p^i/p^j} = \frac{E^{ij}p^j}{p^i} \quad (1.28)$$

It can be seen in the last row of Table 1.4 that whereas the nominal exchange rate rises (the home currency depreciates by 4.51 per cent in nominal terms), the real exchange rate drops (the home currency appreciates by 4.40 per cent in real terms). That is, the home economy loses price competitiveness because of the 8.82 per cent inflation differential and regains some (4.51 per cent) through the nominal depreciation but not enough to compensate, so on net it loses price competitiveness.

Now for the "effective" part. The REER is simply a trade-weighted average of bilateral real exchange rates. That is, let  $\gamma_t^j = (X_t^j + M_t^j) / (X_t^i + M_t^i)$  be the share of country  $j$  in country  $i$ 's trade, both on the export side ( $X_t^j$  stands for  $i$ 's exports to  $j$  in year  $t$ ) and on the import side ( $M_t^j$  is  $i$ 's imports from  $j$  in year  $t$ ). Then:

$$e_t^i = \sum_{j=1}^n \gamma_t^j e_t^{ij} \quad (1.29)$$

**Table 1.4 Real exchange rate: illustrative calculations**

		2010	2011	Change (%)
Price indices	Domestic	100.00	111.00	11.00
	Foreign	100.00	102.00	2.00
	Ratio	1.00	1.09	8.82
	Nominal exchange rate	3.80	3.97	4.51
	Real exchange rate	3.80	3.64	-4.40

Source: Author's calculations

Note that the time index  $t$  is the same for the exchange rates and for the weights  $\gamma_t^j$ . However, like price-index weights they are unlikely to vary much over time and can be considered quasi-constant over longer time horizons than exchange rates.

REER calculations are time-consuming but are included in the International Monetary Fund (IMF)'s International Financial Statistics (IFS) publication, as well as in the World Bank's World Development Indicators (WDI).<sup>34</sup> Historically, episodes of long and substantial real appreciation of a currency as measured by the REER have often been advanced warnings of exchange-rate crises.

## b. Terms of trade

Terms of trade (TOT) are the relative price, on world markets, of a country's exports compared to its imports. If the price of a country's exports rises relative to that of its imports, the country improves its purchasing power on world markets. The two most common indicators are barter terms of trade and income terms of trade. Let's analyze them in turn.

## c. Barter terms of trade

The *barter terms of trade* or commodity terms of trade of country  $i$  in year  $t$ ,  $BTT_t^i$ , are defined as the ratio between a price index of country  $i$ 's exports,  $P_t^{iX}$ , and a price index of its imports,  $P_t^{iM}$ :<sup>35</sup>

$$BTT_t^i = \frac{P_t^{iX}}{P_t^{iM}} \quad (1.30)$$

where the price indices are usually measured using Laspeyres-type (fixed weights) formulas over the relevant range of exported ( $N_X$ ) and imported products ( $N_M$ ):

$$P_t^{iX} = \sum_{k \in N_X} s_{k0}^{iX} p_{kt}^{iX} \quad (1.31)$$

$$P_t^{iM} = \sum_{k \in N_M} s_{k0}^{iM} p_{kt}^{iM} \quad (1.32)$$

where  $p_{kt}^{iX}$  is the export price index of product  $k$  in year  $t$  while  $s_{k0}^{iX}$  is the share of product  $k$  in country  $i$ 's exports in the base year, and similarly for  $p_{kt}^{iM}$  and  $s_{k0}^{iM}$ .

Ideally, these calculations should be based on the individual product level data, with f.o.b. (free on board) values for export prices and c.i.f. (cost insurance freight) values for import prices. However, these data are very difficult to collect, in particular for low-income countries. Most estimates are thus based on a combination of market price quotations for a limited number of leading commodities and unit value series for all other products for which prices are not available (usually at the SITC three-digit commodity breakdown, with the well-known caveat of not controlling for quality changes). A particular case is the price of oil, which may distort the picture if not corrected to take into account the terms of agreements governing the exploitation of petroleum resources in the country.

Another caveat is the bias in the weights that may arise from shocks in the base year, which is normally corrected by replacing base year values by three-year averages around the base year.

Finally, import prices in certain countries must often be derived from (more reliable) partner country data<sup>36</sup> that are f.o.b. and therefore do not reflect changes in transport and insurance costs.

Once constructed, these country-specific TOT indices can be aggregated at the regional level (usually using a Paasche-type formula).

#### d. Income terms of trade

The *income terms of trade* of country  $i$  in year  $t$ ,  $ITT_t^i$ , is defined as the barter terms of trade times the quantity index of exports,  $Q_t^{iX}$ :

$$ITT_t^i = BTT_t^i Q_t^{iX} \quad (1.33)$$

where  $Q_t^{iX}$  is calculated as the ratio between the value index of exports (i.e. the ratio between the value of exports in year  $t$  and the value of exports in the base year) and the overall price index,  $P_{kt}^{iX}$ . The  $ITT_t^i$  index measures the purchasing power of exports. The difference between the income terms of trade and the quantity index of exports ( $ITT_t^i - Q_t^{iX}$ ) corresponds to the trading gain (or loss if negative) experienced by a given country.

## C. Data

### 1. Databases

#### a. Aggregated trade data

The IMF's Direction of Trade Statistics (DOTS)<sup>37</sup> is the primary source of aggregated bilateral trade data (by a country's "aggregate" bilateral exports we mean the sum of its exports of all products to one partner in a year).<sup>38</sup>

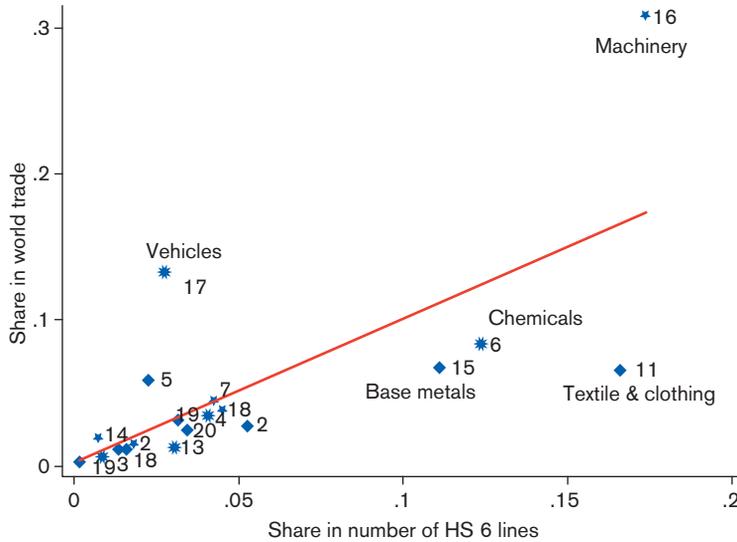
#### b. Disaggregated trade and production data

##### i. Trade classification systems

Whenever one wants to deal with trade data by commodity ("disaggregated"), the first issue is to determine which nomenclature is used in the data at hand. Several trade nomenclatures and classification systems exist, some based on essentially administrative needs and others designed to have economic meaning.<sup>39</sup>

The first and foremost of "administrative" nomenclatures is the Harmonized System (HS) in which all member countries of the World Customs Organization (WCO) report their trade data to UNCTAD. Tariff schedules and systems of rules of origin are also expressed in the HS. Last revised in January 2007, it has four harmonized levels; by decreasing degree of aggregation (increasing detail), sections (21 lines), chapters (99 lines; also called "HS 2" because chapter codes have two digits), headings (HS 4; 1,243 lines) and subheadings (HS 6; 5,052 lines including various special categories).<sup>40</sup> Levels beyond HS 6 (HS 8 and 10) are not harmonized, so the description of product categories and their number differs between countries. They are not reported by UNCTAD and must be obtained directly from member countries' customs or statistical offices.<sup>41</sup>

Figure 1.7 HS sections as a proportion of trade and subheadings



Source: Author calculations from UN Comtrade

One of the oft-mentioned drawbacks of the HS system is that it was originally designed with a view to organize tariff collection rather than to organize economically meaningful trade statistics, so traditional products like textile and clothing (Section XI both in the 2002 and the 2007 revisions) are over-represented in terms of number of subheadings compared to newer products in machinery, vehicles and instruments (Sections XVI, XVII and XVIII). Figure 1.7 shows that this is partly true. In the figure, each HS section is represented as a point with its share in the number of total subheadings (HS 6) on the horizontal axis and its share in world exports on the vertical one. If subheadings were of roughly equal size, points would be on or near the diagonal. They are not, and clearly sections XVI (machinery) and XVII (vehicles) represent a far larger proportion of world exports than of HS subheadings. The converse is true of chemicals (VI), basic metals (XV) and, above all, textiles and clothing (XI).

Trade data are also sometimes classified using the Standard International Trade Classification (SITC). Adopted by the United Nations in its March 2006 session, the SITC Rev. 4 has, like its predecessors (the system itself is quite old), five levels: sections (1 digit, 10 lines), divisions (2 digits, 67 lines), groups (3 digits, 262 lines), subgroups (4 digits, 1,023 lines) and basic headings (5 digits, 2,970 lines). A table of concordance between HS 6 2007 subheadings and SITC Rev. 4 basic headings is provided in Annex I of United Nations (2006), and a table of concordance between SITC Rev. 3 and SITC Rev. 4 is provided in Annex II.<sup>42</sup>

## ii. Production classification systems

Going from HS to the SITC nomenclatures is easy enough and entails limited information loss using concordance tables. Much more difficult is going from trade nomenclatures to production ones,

which are not, or only imperfectly, harmonized across countries. Among production nomenclatures, the most widely used until recently was the Standard Industrial Classification (SIC), which classifies goods in categories labelled A to Q at the highest degree of aggregation and in 4-digit codes at the lowest. Very close to the SIC, ISIC Rev. 4 was released by the United Nations in 2008. Its main drawback is a high degree of aggregation of service activities, reflecting a focus on manufacturing, but this may not be a major concern to trade analysts. The United Nations' Central Product Classification (CPC) was created in 1990 to remedy that problem by covering all economic activities. It defines "products" in categories going from one to five digits with boundaries designed to allow easy matching with ISIC categories. The CPC Version 2.0 was completed at the end of 2008.<sup>43</sup> The European Union created a nomenclature similar to CPC in 1993, the so-called Classification of Products by Activity (CPA).

The *Nomenclature des Activités économiques dans la Communauté Européenne* (NACE) was introduced by the EU in 1990. NACE Rev. 2, approved in 2006 (Eurostat, 2006), was phased in over 2008–9. At the one- and two-digit levels, NACE Rev. 2 categories are fully compatible with ISIC Rev. 4. NACE is harmonized across member states to four digits. Finally, the North American Industrial Classification System (NAICS; last revised in 2007) was devised in the early 1990s for common use by members of the North American Free Trade Agreement (NAFTA). Thus Mexico, Canada and the United States do not use the SIC any longer (since 1997 for the United States).

Concordance tables between these nomenclatures can be found in various places.<sup>44</sup> However, none is perfect, meaning that one typically has to jump up one or several levels of aggregation in order to match trade with production data. This has the unfortunate implication that simple indices like import-penetration ratios, which require both trade and production data, can be calculated only at fairly aggregate levels.

In addition to "administrative" nomenclatures, a number of tailor-made classifications have been designed for specific purposes. Introduced in 1970, the United Nations' Broad Economic Categories (BEC) classifies products in four categories by end use: capital goods (01), intermediate goods (02), consumer goods (03) and other (04; mainly car parts, which can be re-classified "by hand" into categories 01–03). Details can be found in United Nations (2003). James Rauch (1999) designed a reclassification of SITC four-digit categories by degree of product differentiation. The first category is made of products traded on organized exchanges such as the London Metal Exchange; the second is made of products with reference prices (listed in widely available publications like the Knight-Ridder CRB Commodity Yearbook); the third is made of differentiated products whose prices are determined by branding.<sup>45</sup>

### *iii. Databases*

The first and foremost database for trade by commodity is UN Comtrade. It is a voluminous database available online by subscription (or through the World Bank's WITS portal), covering bilateral trade flows at up to the HS 6 level for almost all countries since 1962.<sup>46</sup> Various country groupings are available on the reporter side. All trade values are in thousands of current US dollars converted from national currencies at nominal exchange rates. UN Comtrade also reports volumes (in physical units) so that unit values can, at least in principle, be calculated for each good (more on this below).

The *Base Analytique du Commerce International* (BACI) was created by CEPII (*Centre d'Etude Prospectives et d'Informations Internationales*), a Paris-based institute, to reconcile discrepancies between UN Comtrade's import and export data (see the discussion in the next section). BACI also provides "cleaned-up" unit values. Like UN Comtrade from which it derives, it is at the HS 6 level and also reports, as a by-product, estimates of freight costs derived from differences between CIF and FOB trade data. The price to pay for the analytical processing of raw trade data is that BACI trails UN Comtrade with a two-year lag (the latest version covers around 200 countries from 1995 to 2008).<sup>47</sup>

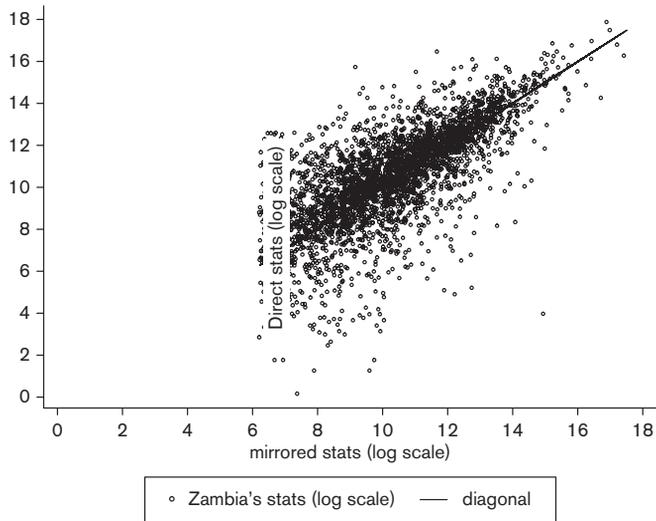
The World Bank's Trade, Production and Protection database, developed by Nicita and Olarreaga, merges trade flows, production and trade protection data available from different sources into ISIC Rev. 2 data. The availability of data varies, but the database, which updates the earlier 2001 release, potentially covers 100 developing and developed countries over 1976–2004. It includes a variety of data useful for the estimation, inter alia, of gravity equations. Perhaps one of its most useful features is the presence of input–output tables that makes it possible to trace vertical linkages.<sup>48</sup> The database can be freely downloaded from the World Bank's research department page<sup>49</sup> and details can be found in Nicita and Olarreaga (2006).

## 2. Measurement issues

Trade is measured very imperfectly, but some measures are better than others and it is important to use the right ones if one is to minimize measurement errors. Export data, which is typically not (or marginally) part of the tax base, is monitored less carefully by customs administrations than import data. Thus, even when the object of analysis is exports, one should in general prefer import data from partner countries, a technique called "mirroring". However, in countries with high tariffs and weak customs monitoring capabilities, the value of imports is sometimes deliberately underestimated by traders to avoid tariffs or the product is declared under a product heading with a lower tariff. As a result, country A reports imports from country B whose value is lower than B's reported exports to A.<sup>50</sup> In such case mirroring should be avoided.

Import data are also subject to further reporting errors. The data are typically compiled by national statistical offices and reviewed by trade ministries on the basis of raw data provided by customs administrations, but this filtering does not eliminate all aberrations. Under automated systems such as ASYCUDA,<sup>51</sup> data are increasingly entered in computer systems directly by employees of transit companies, resulting in occasional — or more than occasional — input errors. Many LDCs have benefited in recent years from technical assistance programmes designed to raise the awareness among customs administrations to provide government authorities with reliable data and to improve their capacity to do so, but progress is slow.<sup>52</sup> Figure 1.8 illustrates the problem. Each point represents an import value at the HS 6 level for Zambia in 2002. The horizontal axis measures values reported by Zambia's partners on the export side and the vertical axis measures values reported by Zambia on the import side. Along the diagonal, they are equal. It can be seen that they are correlated and roughly straddle the diagonal, suggesting no systematic bias but rather a wide variation. Figure 1.9 shows the distribution of discrepancies, which should normally have the bell shape of a Gaussian density. In contrast, it is spread out almost uniformly.

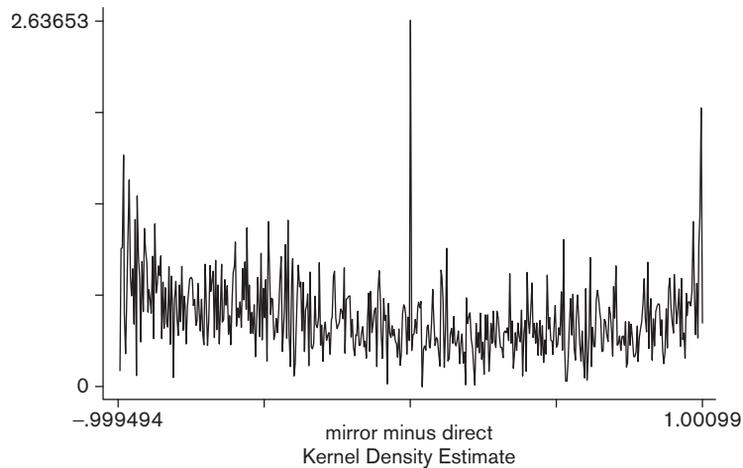
**Figure 1.8** Zambia's import statistics against mirrored statistics



Source: Cadot et al. (2005)

Note: Truncation point along horizontal axis equal to US\$ 403,000; no partner indications for annual trade values below that threshold.

**Figure 1.9** Distribution of import–export discrepancies



Source: Cadot et al. (2005)

Notes: The variable plotted is the relative discrepancy between Zambia's imports as reported directly and mirrored exports reported by partners. The unit of observation is the HS 6 tariff line (3,181 observations). Values between zero and one on the horizontal axis (i.e. to the right of the sharp peak) correspond to tariff lines where Zambia reports an import value lower than the export value reported by its trading partners, and conversely for values between minus one and zero (to the left of the peak). Observations at the extremes (mirror or direct trade value at zero) have been taken out.

Reliability problems are compounded when trade is overland and — relatedly — partly informal as it is between many developing countries. Official data on overland trade between sub-Saharan African or Central Asian countries, for instance, understates true trade by unknown but probably wide margins, making any assessment of the extent of regional trade hazardous at best.

Missing values create particular problems. First, very often lines with zero trade are omitted by national customs rather than reported with a zero value, which makes it easy to overlook them. Second, it is generally difficult to tell true zero trade from unreported trade or entry errors. Sometimes the missing data can be complemented by mirroring, which is what the IMF DOTS do. Sometimes the nature of the data suggests entry errors rather than zero trade; for instance, when a regular trade flow is observed over several years with a zero in between. In that case “interpolation” (taking the average of the previous and next entries) is valid. However, trade data at high degrees of disaggregation is typically volatile, making interpolation risky. Basically, judgment must be exercised on a case-by-case basis as to how to treat missing values.<sup>53</sup>

We mentioned that UN Comtrade provides not only trade values but also volumes. Volumes, however, are seldom used. First, they cannot be aggregated (tons of potatoes cannot be added to tons of carrots); second, volumes are badly monitored by customs for the same reason that exports are: typically they are not what trade taxes are assessed on. That said, sometimes the researcher is interested in calculating prices or, in trade parlance, “unit values”; for that, values must be divided by volumes. The result is often tricky to interpret, however, for two reasons.

First, as soon as trade categories cover several types of products (as they always do — be it only because similar goods of different qualities will be lumped together) unit values will suffer from a so-called “composition problem”: what will be observed will not be the price of a good but an average price of several (unobserved) sub-goods. Wider categories worsen composition problems. But narrower categories suffer from a second problem. Because measurement errors in volumes are in the denominator, they can have brutally nonlinear effects. Suppose, for example, that a very small volume is mistakenly entered in the system. Because the unit value is the ratio of trade value to volume, it will become very large and thus seriously bias subsequent calculations. Narrow categories are likely to have small volumes and thus be vulnerable to this problem.

One needs to strike a balance between composition problems and small-volume problems; there is no perfect solution. Calculations or statistics based on unit values must therefore start with a very serious weeding out of aberrant observations in the data. As mentioned in the previous section, however, the CEPII’s BACI database provides unit values with treatment of aberrant values.

## D. Applications

### 1. Comparing openness across countries

In order to measure correctly how much a country trades relative to how much it can be expected to, given its fundamentals, one can run a trade-openness regression of the type:

$$O_i = \alpha_0 + \alpha_1 y_{ii} + \alpha_2 LL_i + \alpha_3 R_i + u_i \quad (1.34)$$

where  $y_i$  is GDP per capita,  $LL_i$  is equal to one if country  $i$  is landlocked and zero otherwise (a so-called “dummy variable”),  $R_i$  is remoteness<sup>54</sup> and  $u_i$  is an error term. This approach goes back to the work of Leamer (1988). The equation can be estimated by OLS.

With these right-hand side (RHS) variables, note that we are already in trouble. Should GDP be measured at current values and current exchange rates or at Purchasing-Power Parity levels? We will defer a full discussion of these issues until Chapter 3, but suffice it to note here that non-trivial questions are involved in the cross-country measurement of GDPs.

The difference between  $O_i$  and its predicted value,  $\hat{O}_i$ , called the residual, can be read as a “purged” measure of country  $i$ ’s openness: positive, the country trades more than it can be expected to, given its characteristics; negative, the country trades less.

Stata do file can be found at “[Chapter1\Applications\1\\_comparing openness across countries\openness.do](#)”

```
use openness.dta, replace
xi: reg ln_open ln_gdppc i.ccode, r
xi: reg ln_open ln_gdppc pop i.ccode, r
xi: reg ln_open ln_gdppc pop ldlock i.ccode, r
xi: reg ln_open ln_gdppc pop ldlock ln_remot_head i.ccode, r
```

	(1)	(2)	(3)	(4)
	ln_open	ln_open	ln_open	ln_open
ln_gdppc	0.0990*** (0.0101)	0.0443*** (0.0112)	0.0443*** (0.0112)	0.0441*** (0.0112)
ln_pop		0.360*** (0.0301)	0.360*** (0.0301)	0.360*** (0.0301)
ldlock			-0.392*** (0.101)	-0.392*** (0.101)
ln_remot_head				0.0213 (0.0200)
Constant	3.964*** (0.121)	1.044*** (0.270)	1.044*** (0.270)	0.530 (0.542)
Observations	3,039	3,039	3,039	3,039
R-squared	0.839	0.850	0.850	0.850

Country fixed effects always included  
Robust standard errors in parentheses  
\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

The estimation results indicate that GDP per capita is positively related to openness, as shown in the descriptive statistics of Figure 1.1. A larger population is associated with a higher openness,

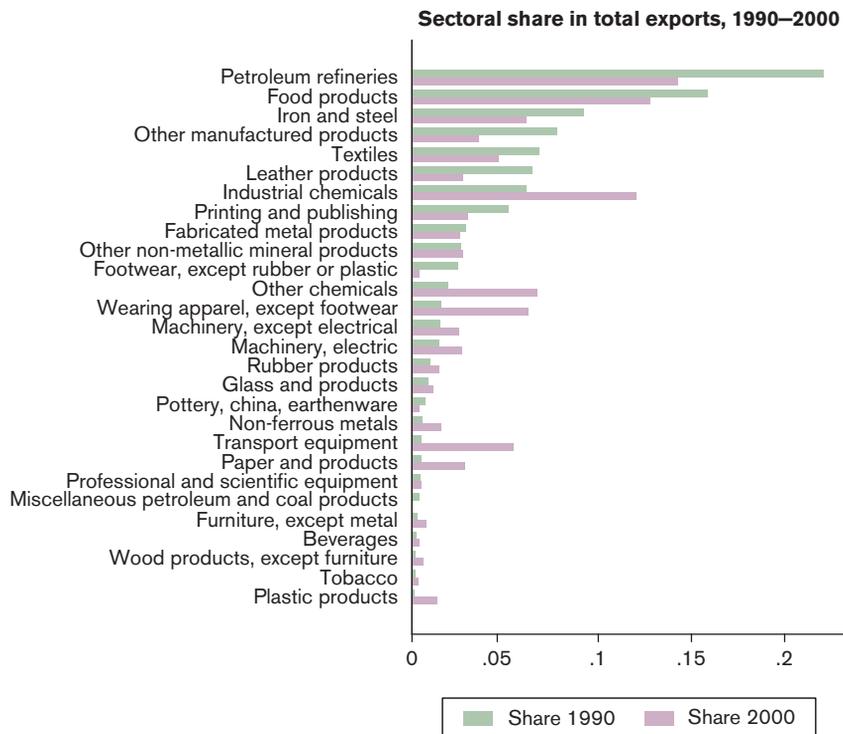
while being landlocked reduces openness. The inclusion of country fixed effects is necessary to reduce the problem of omitted variables that might be correlated with explanatory variables, introducing a bias in the estimation.

## 2. Trade composition

### a. Sectoral orientation of trade

The simplest way of portraying the sectoral orientation of a country's export is in the form of a bar graph. Figure 1.10 portrays the share of each sector (ISIC, 3 digit) in total exports of Colombia in 1990 and in 2000. The figure shows that petroleum refineries constituted the main export sector in both years, though its share in total exports declined from more than 20 per cent to less than 15 per cent between 1990 and 2000. Industrial chemicals, chemicals, apparel and transport equipment, on the other hand, all saw their share grow during the same period. The share of transport equipment in total exports, for instance, grew from less than 1 per cent to more than 5 per cent.

**Figure 1.10** Main export sectors, Colombia, 1990 and 2000



Source: Author calculations from Trade, Production and Protection Database (Nicita and Olarreaga, 2006)

Stata do file for Figure 1.10 can be found at “Chapter1\Applications\2\_trade composition\sectoral\_geographical\_orientation\_of\_trade.do”

## b. Geographical orientation of trade

The geographical orientation of a country’s exports can also be simply portrayed in the form of a bar graph. For the top twenty destination countries, Figure 1.11 depicts the share of each country in total exports of Colombia in 1990 and in 2000. The figure shows that the United States constituted the main destination country in both years, though their share in total exports declined from more than 45 per cent to around 25 per cent between 1990 and 2000. The figure also shows increases in the share of exports to neighbouring countries such as Venezuela, Ecuador and Peru.

Stata do file for Figure 1.11 can be found at “Chapter1\Applications\2\_trade composition\sectoral\_geographical\_orientation\_of\_trade.do”

## c. Growth orientation of exports

In order to assess the extent to which a country’s export orientation is favourable, i.e. to what extent it exports in sectors and toward partners that have experienced a faster import growth, one can construct a scatter plot with export shares on the horizontal axis and import growth (at sectoral- or destination country-level) on the vertical axis.

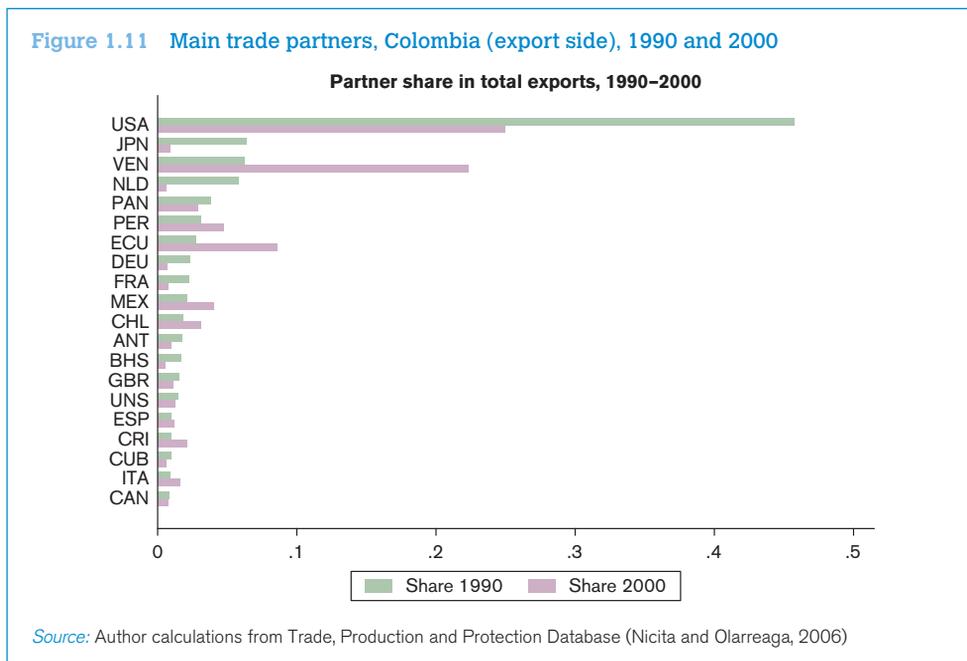
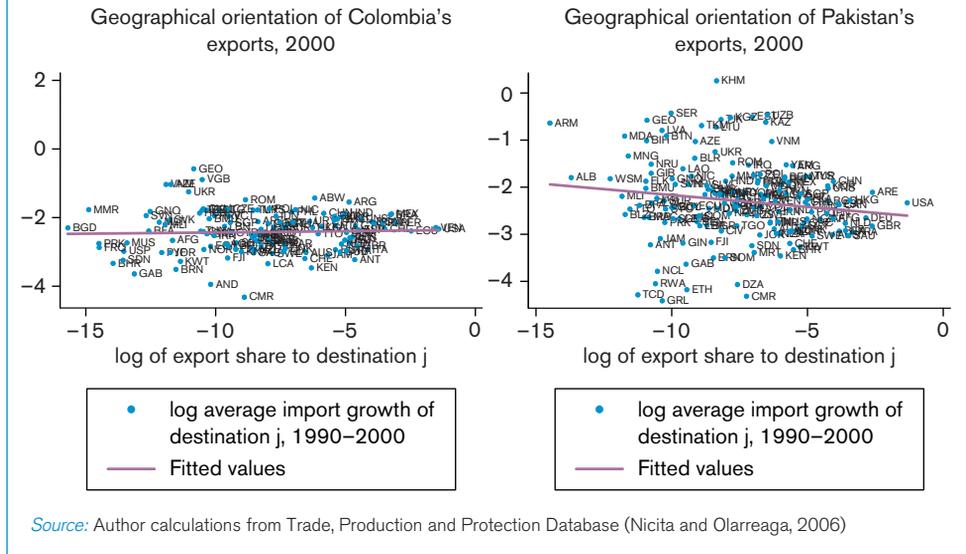


Figure 1.12 Geographical orientation of exports, Colombia vs. Pakistan, 2000

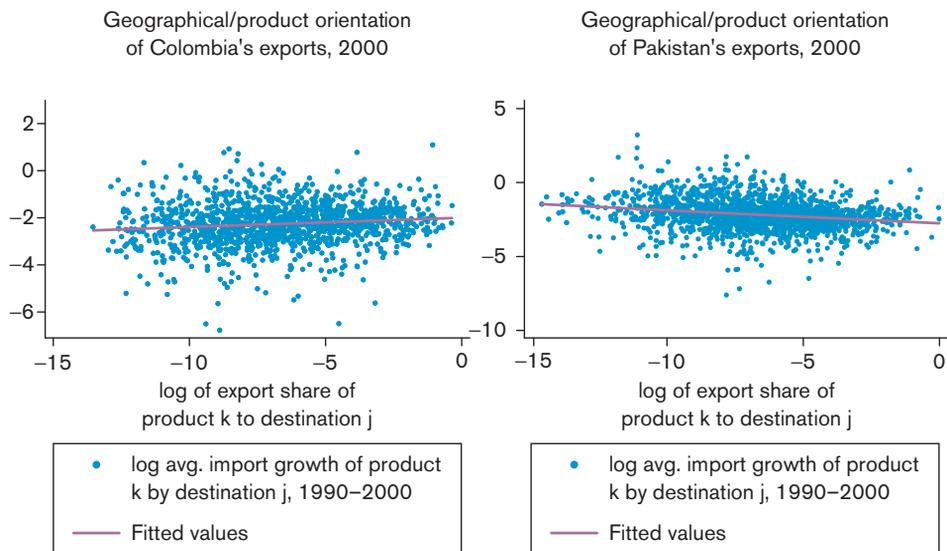


Consider the geographical dimension. Take all destination countries for home exports; calculate their share in total home exports (in logs) and call it  $x$ .<sup>55</sup> Next, record the average growth rate of total imports for each of those countries over the last ten years; call it  $y$ . Do a scatter plot of  $y$  against  $x$  and draw the regression line. If it slopes up, larger destinations have faster (slower) import growth; the orientation is favourable (unfavourable).

In Figure 1.12 we construct such a plot for Colombia (left panel) and Pakistan (right panel) for the year 2000. In the case of Colombia, the orientation is favourable.<sup>56</sup> In the case of Pakistan, it is unfavourable. This could be explained by a mixture of the country's location and policy choices like trade integration. In Pakistan's case, proximity to slow-growing Gulf and Central Asian states was joined with failure to promote trade integration with fast-growing India to produce a negative orientation.

**Stata do file for Figure 1.12 can be found at “Chapter1\Applications\2\_trade composition\growth\_orientation\_of\_exports.do”**

A similar scatter plot can be constructed combining the product- and destination-dimension. In the latter case, one would construct a scatter plot using the share of product  $k$  to destination  $j$  in home export and the rate of growth of world trade of product  $k$  to destination  $j$  (see Figure 1.13). A negative correlation, indicating positioning on slow-growing products, may provide a useful factual basis for discussions about whether government resources should be used to foster growth at the extensive margin (e.g. through sector-specific fiscal incentives).

**Figure 1.13** Geographical/product orientation of exports, Colombia vs. Pakistan, 2000

Source: Author calculations from Trade, Production and Protection Database (Nicita and Olarreaga, 2006)

Stata do file for Figure 1.13 can be found at “Chapter1\Applications\2\_trade composition\growth\_orientation\_of\_exports.do”

#### d. Intra-industry trade

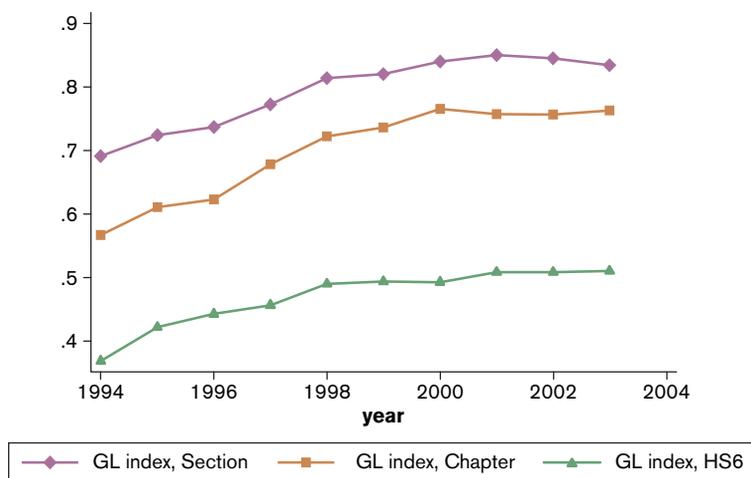
The Grubel-Lloyd (GL) index of intra-industry trade is a useful indicator of how much trade is of the Krugman-type (two-way trade of differentiated varieties). A problem with such index is that it is sensitive to the level of aggregation. Figure 1.14 plots the GL index for European Union countries (constructed using import and export data from all destinations) for different levels of aggregation. The GL index is obviously higher when the data are more aggregated.<sup>57</sup>

Stata do file for Figure 1.14 can be found at “Chapter1\Applications\2\_trade composition\intra\_industry\_trade.do”

```
use gl.dta, replace
twoway (connected gl_eu_section year, ms(D)) (connected gl_eu_chapter year, ms(S)) /*
      */ (connected gl_eu_hs6 year, ms(T)), legend(rows(1) lab(1 "GL index, Section") /*
      */ lab(2 "GL index, Chapter") lab(3 "GL index, HS6")) /*
      */ xtitle (year) ytitle("")
```

Notice that the GL index for the European Union's overall trade has been constructed by aggregating industry- or product-level GL indices, using industry or product trade shares as weights. This procedure is to be preferred to a calculation that uses total exports ( $X^j = \sum_k X_k^j$ ) and imports.

Figure 1.14 Grubel-Lloyd indexes at different level of aggregation of trade data



Source: Tumurchudur (2007)

To see why GL indexes are mechanically higher the higher the level of aggregation, consider the data in Table 1.5, which represents a situation in which Germany exports engines and gearboxes to the Czech Republic that are then assembled into cars and re-exported to Germany.

Table 1.5 Grubel-Lloyd index: illustrative calculations

	$X$	$M$	$X-M$	$X+M$	$GL$
Car parts		600	600	600	0
Assembled cars		1000	1000	1000	0
Chapter 87	1000	600	400	1600	0.75

Source: Author calculations

At the sub-heading level (first two rows), “Car parts” and “Assembled cars” are different goods, so intra-industry trade is zero (last column). At the chapter level, both “Car parts” and “Assembled cars” are part of chapter 87, so intra-industry trade is positive. Thus, in general, one can expect to observe lower measured levels of intra-industry trade at lower levels of aggregation. These values are closer to the real value of IIT, while high values at aggregate levels are statistical illusions.

### e. Decomposition of export growth

In this application we implement the decomposition of export growth proposed in equation (1.13) in the text:

$$\Delta X = \sum_{K_0 \cap K_1} \Delta X + \sum_{K_1 / K_0} X_k - \sum_{K_0 / K_1} X_k$$

**Table 1.6** Decomposition of export growth 1995–2004, selected OECD countries

Reporter	$\sum_{K_0 \cap K_1} \Delta X / \Delta X$	$\sum_{K_1 / K_0} X_k / \Delta X$	$\sum_{K_0 / K_1} X_k / \Delta X$
USA	.9784529	.0432978	.0217508
JPN	1.011665	.0137644	.0254291
DEU	1.002045	.0079661	.0100109
FRA	.9663144	.0481832	.0144976
GBR	.9772262	.1178167	.0950429
ITA	.9539621	.0632544	.0172165

*Source:* Author calculations from UN Comtrade

We will use data on overall exports by product (all destinations) for a number of exporters, using UN Comtrade data for 1995 and 2004. The results of this decomposition for six OECD countries (United States, Japan, Germany, France, United Kingdom and Italy) are presented in Table 1.6. In the table, the first column represents the percentage contribution of the intensive margin; the second column represents the percentage contribution of the new-product margin; the third column represents the percentage contribution of the product death margin.<sup>58</sup>

As one can clearly see, also in the case of OECD countries almost all of the variation in exports is explained by the expansion of existing export relationships (see main text for an explanation).

**Stata do file for Table 1.6 can be found at “Chapter1\Applications\2\_trade composition\export\_growth\_decomposition.do”**

```

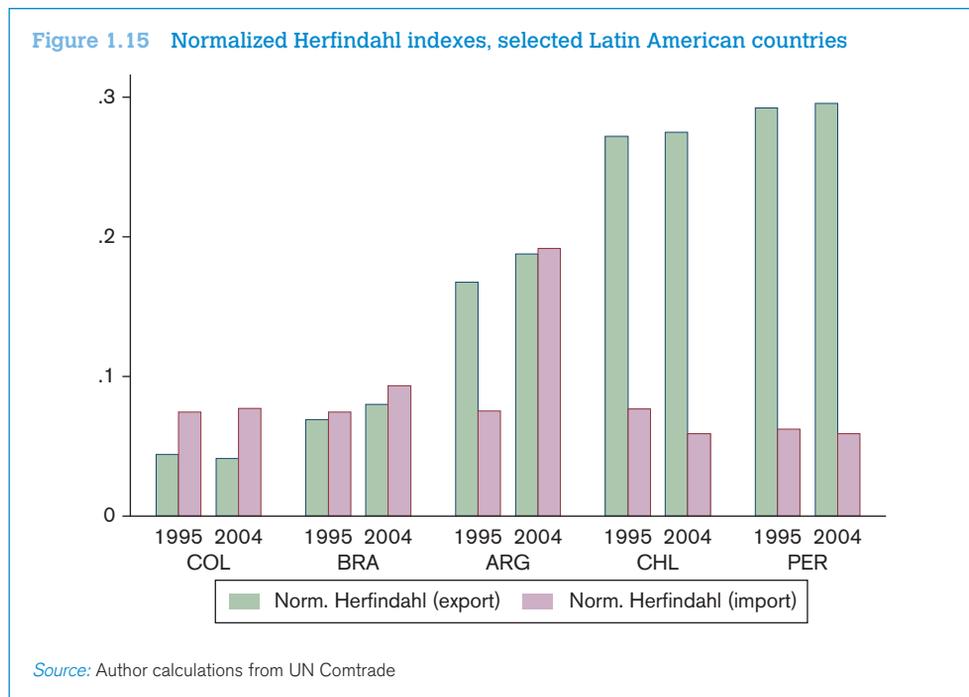
use comtrade_exports.dta, replace
reshape wide tradevalue, i(reporter product) j(year)
bysort reporter: egen tot_trade_all_6_dgt_1995 = total(tradevalue0001995)
bysort reporter: egen tot_trade_all_6_dgt_2004 = total(tradevalue0002004)
bysort reporter: g change_tot_trade_all_6_dgt = tot_trade_all_6_dgt_2004 - tot_trade_all_6_dgt_1995
g delta = (tradevalue0002004 - tradevalue0001995) if (tradevalue0002004!=. & tradevalue0001995!=.)
bysort reporter: egen t1 = total(delta) if delta!=.
egen temp1= rowtotal(tradevalue0002004 tradevalue0001995) if (tradevalue0002004!=. &
tradevalue0001995!=.)
bysort reporter: egen t2 = total(temp1) if temp1!=.
egen temp2= rowtotal(tradevalue0002004 tradevalue0001995) if (tradevalue0002004!=. &
tradevalue0001995!=.)
bysort reporter: egen t3 = total(temp2) if temp2!=.
bysort reporter: egen x1 = max(t1)
bysort reporter: egen x2 = max(t2)
bysort reporter: egen x3 = max(t3)
drop temp* t1 t2 t3
g dx = x1 + x2 - x3
g c1 = x1 / dx
lab var c1 "intensive margin contribution"
g c2 = x2 / dx
lab var c2 "new product margin contribution"
g c3 = x3 / dx
lab var c3 "product death margin"
duplicates drop

```

## f. Herfindahl index of concentration

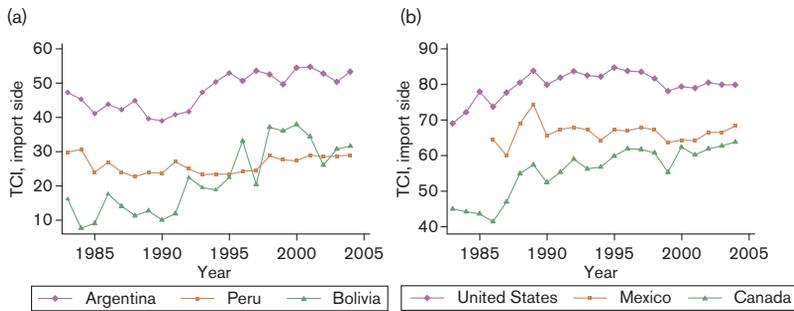
Herfindahl concentration indexes can easily be calculated from trade data and visualized as in Figure 1.15. This figure plots the normalized Herfindahl indexes, both at the export and at the import side, for five Latin American countries (Argentina, Brazil, Chile, Colombia and Peru) in 1995 and 2004. Notice that the higher the index, the more concentrated exports or imports are in a few sectors.

Observe that the indices are higher on the export side than on the import one for Chile and Peru, whose export structures are rather concentrated on mineral products.<sup>59</sup>



Stata do file for Figure 1.15 can be found at “Chapter1\Applications\2\_trade composition\trade\_concentration.do”

```
use herfindahl_index.dta, replace
keep if (ccode=="ARG" | ccode=="BRA" | ccode=="CHL" | ccode=="COL" | ccode=="PER")
keep if (year==1995 | year==2004)
graph bar    norm_herf_export norm_herf_import, over(year)                /*
*/          over(ccode, sort(1)) legend(label(1 "Norm. Herfindahl (export)") /*
*/          label(2 "Norm. Herfindahl (import)"))
```

**Figure 1.16 Chile trade complementarity index, import side**

Source: Author calculations from Trade, Production and Protection Database (Nicita and Olarreaga, 2006)

### g. Trade complementarity

Trade complementarity indices can be traced over time. Figure 1.16 shows the evolution of TCIs (on the import side) for Chile between 1983 and 2004. Panel (a) shows the index *vis-à-vis* neighbouring countries, while panel (b) shows the index *vis-à-vis* countries that are now part of NAFTA. All TCIs have increased over time; however, the indexes in panel (a) are lower than the ones in panel (b), indicating that for Chile patterns of import complementarity are more developed with North American than with neighbouring countries.

Stata do file for Figure 1.16 can be found at “Chapter1\Applications\2\_trade composition\trade\_complementarity.do”

```
use tc.dta, replace
keep if (country_a == "CHL")
twoway      (connected tci year if country_b == "ARG", ms(D))      /*
*/          (connected tci year if country_b == "PER", ms(S))      /*
*/          (connected tci year if country_b == "BOL", ms(T)),    /*
*/          legend(rows(1) lab(1 "Argentina") lab(2 "Peru")      /*
*/          lab(3 "Bolivia")) xtitle (Year) ytitle("TCI, import side")

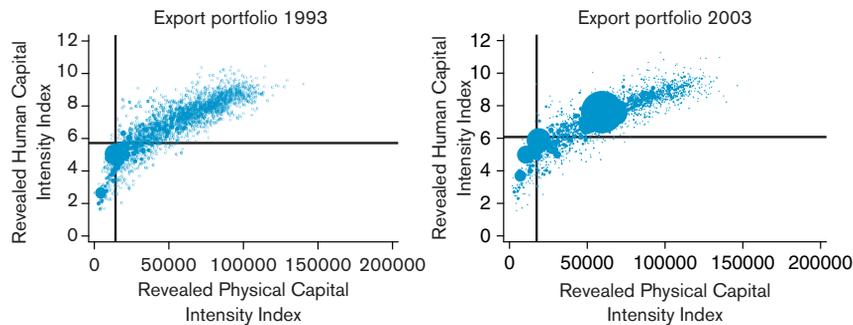
twoway      (connected tci year if country_b == "USA", ms(D))      /*
*/          (connected tci year if country_b == "MEX", ms(S))      /*
*/          (connected tci year if country_b == "CAN", ms(T)),    /*
*/          legend(rows(1) lab(1 "United States") lab(2 "Mexico") /*
*/          lab(3 "Canada")) xtitle (Year) ytitle("TCI, import side")
```

## 3. Comparative advantage

### a. Revealed factor intensities

The revealed factor intensities database developed by UNCTAD can be used to visualize how revealed factor intensity of exports relates to national factor endowments. Because the weights sum up to one, revealed factor intensities can be shown on the same graph as national factor endowments. The distance between the two is an inverse measure of comparative advantage.

Figure 1.17 Evolution of Costa Rica's export portfolio and endowment



Source: Author calculations from UN Comtrade

The two panels of Figure 1.17 show the evolution of Costa Rica's export portfolio against its endowment of physical and human capital in 1993 and in 2003. Costa Rica is an interesting case because in 1996 Intel decided to locate a US\$ 300 million semiconductor assembly and test (A&T) plant in this tiny Caribbean country.

In each panel, the horizontal axis measures capital per worker (in constant PPP dollars) and the vertical axis measures human capital (in average years of educational attainment). The intersection of the two black lines is the country's endowment point. The ink stains are the country's export items, with the size of each stain proportional to export value in the period.

The left panel shows Costa Rica before Intel. A dust of small export items in the north-east quadrant indicates exports that are typical of countries with more capital and human capital than Costa Rica has. The right panel shows the huge impact of Intel's arrival (the large stain in the NE quadrant, which corresponds to semiconductors). Note that it is located not too far from Costa Rica's comparative advantage: the reason is that semiconductor assembly (which produces the final product) is performed typically in middle-income countries. Yet, it remains the case that semiconductors exports are typical of countries with two years of educational attainment more than Costa Rica (and over twice more capital per worker).

Stata do file for Figure 1.17 can be found at “Chapter1\Applications\  
3\_comparative advantage\revealed\_factor\_intensity.do”

```
use costarica.dta, replace
twoway (scatter rhci93 rci93 if old==1 | dead==1 [aweight = Export93], /*
*/ mcolor(blue) msymbol(circle), yscale(range(0 12)) yline(5.72), /*
*/ lwidth(thick) lcolor(black)) ylabel(0(2)12) xscale(range(0 200000)) /*
*/ xline(14192, lwidth(thick) lcolor(black)) xlabel(0(50000)200000) /*
*/ legend(off) title (Export portfolio 1993)
twoway (scatter rhci03 rci03 if old==1 [aweight = Export03], /*
*/ mcolor(blue) msymbol(circle), yscale(range(0 12)) yline(6.08, /*
*/ lwidth(thick) lcolor(black)) ylabel(0(2)12) xscale(range(0 200000)) /*
*/ xline(17437, lwidth(thick) lcolor(black)) xlabel(0(50000)200000) /*
*/ legend(off) title (Export portfolio 2003)
```

## b. Revealed technology content

In this application we perform an analysis of PRODY and EXPY indices proposed by Hausmann et al. (2007). The PRODY index ranks products in terms of their implied productivity. It is constructed by taking a weighted average of the per-capita GDPs of the countries exporting a product, where the weights reflect the revealed comparative advantage of each country in that product. The EXPY index is the export-weighted average of PRODY indices of each country; it reflects the income/productivity level of a country's export portfolio.

Table 1.7 shows the five commodities with the smallest and largest PRODY. As expected, items with low PRODY tend to be primary commodities that constitute a relatively important share of the exports of low income countries. Conversely, products with the highest PRODY value constitute a substantial share of exports of high income countries in our sample.

**Stata do file for construction of EXPY and PRODY and for Table 1.7 can be found at "Chapter1\Applications\3\_comparative advantage\revealed\_technology\_content.do"**

Figure 1.18 shows a scatterplot of PRODY index against per-capita GDP for 2000. There is a strong and positive correlation between these two variables. The high correlation between PRODY and per-capita GDP can be partially explained by construction of the index, since a product's PRODY is determined by the per-capita GDPs of the countries that export this product. However, Hausmann et al. (2007) show that this relationship is not just a mechanical one: excluding a country's own exports from the calculation of the PRODY index (in this case the index becomes country specific) does not change the results much.

**Table 1.7 Largest and smallest PRODY values (2000 US\$)**

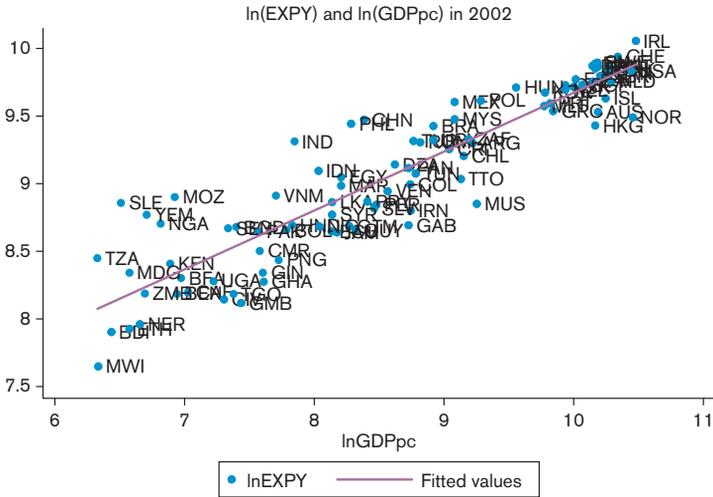
	<i>Product (k)</i>	<i>HS6</i>	<i>Prody_k</i>
1	Equine hides and skins, raw	410140	517.7
2	Sisal and agave, raw	530410	766.81
3	Cloves (whole fruit, cloves and stems)	90700	892.15
4	Vanilla beans	90500	927.77
5	Natural uranium, its compounds, mixtures	284410	982.94
4955	Nuclear reactors	840110	31565.67
4956	Railway cars, open, with sides > 60 cm high	860692	31677.95
4957	Calcium-ammonium nitrate mix, double salts pack >10 kg	310260	31783.25
4958	Vinyl chloride (chloroethylene)	290321	31826.73
4959	Leucite, nepheline and nepheline syenite	252930	32218.66

*Source:* Author calculations based on CEPII Baci and World Bank WDI

**Stata do file for Figure 1.18 can be found at "Chapter1\Applications\3\_comparative advantage\revealed\_technology\_content.do"**

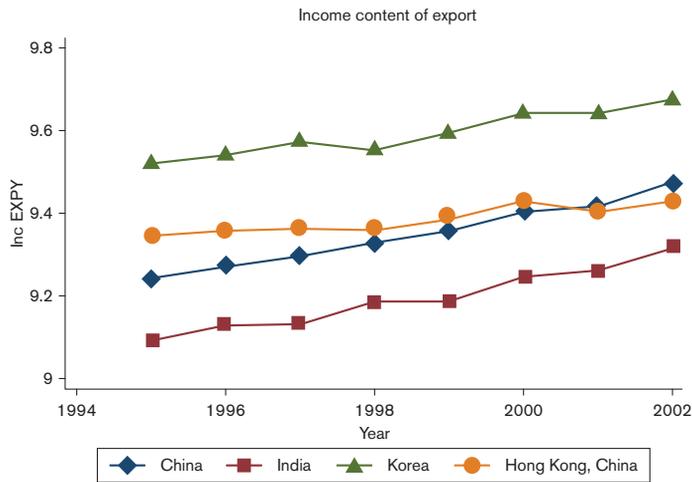
```
use prody_b_lrst.dta, replace
gen lnEXPY=ln(EXPY_i)
gen lnGDPpc=ln(GDPpc)
duplicates drop
twoway      (scatter lnEXP lnGDPpc, mlabel(ccode)) (lfit lnEXP lnGDPpc) /*
*/          if year==2002, title("ln(EXPY) and ln(GDPpc) in 2002")
```

**Figure 1.18** Relationship between per-capita GDP (in logs) and EXPY (in logs), 2002



Source: Author calculations based on CEPII Baci and World Bank WDI

**Figure 1.19** EXPY over time for selected countries



Source: Author calculations based on CEPII Baci and World Bank WDI

Figure 1.19 shows the time trend for the EXPY index for China, India, Korea and Hong Kong, China. India and China have the lowest EXPY in 1994 but their EXPY has been steadily drifting upwards. At the other side, South Korea and Hong Kong, China started with the highest EXPYs but over the time period of our sample China has significantly closed the gap with these countries. In 2001, China's EXPY has even overtaken that of Hong Kong, China even though Hong Kong, China's per capita GDP is significantly higher than China's.

**Table 1.8 Correlates of EXPY**

Dependent Variable: log EXPY in 2000

	(1)	(2)	(3)	(4)	(5)
ln_GDPpc	0.494*** (0.0264)	0.389*** (0.0465)	0.424*** (0.0407)	0.416*** (0.0410)	0.149** (0.0692)
ln_hum_cap		0.357*** (0.100)	0.290*** (0.0875)	0.301*** (0.0877)	0.0288 (0.116)
ln_pop			0.0740*** (0.0150)	0.0929*** (0.0218)	0.0465** (0.0217)
ln_area				-0.0206 (0.0172)	-0.0280* (0.0160)
ruleoflaw					0.122* (0.0618)
Constant	4.823*** (0.233)	5.094*** (0.278)	3.688*** (0.372)	3.674*** (0.371)	7.627*** (0.745)
Observations	81	72	72	72	30
R-squared	0.816	0.877	0.910	0.912	0.767

Standard errors in parentheses  
 \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Source: Author calculations based on CEPII Baci and World Bank WDI

What might other determinants be of the variation across countries in levels of EXPY beyond per-capita GDP? Table 1.8 replicates the results of Hausmann et al. (2007), who show that human capital and country size (proxied by population) are both associated positively with EXPY, after controlling for GDP per capita. In the dataset used for this application, however, institutional quality (proxied by the Rule of Law index of the World Bank<sup>60</sup>) is positively correlated with EXPY, meaning that the index also captures some broad institutional characteristics of a country.<sup>61</sup>

Stata do file for Figure 1.19 can be found at “Chapter1\Applications\3\_comparative advantage\revealed\_technology\_content.do”

```
use /prody_b_lrst.dta, replace
gen lnEXPY=ln(EXPY_i)
twoway      (connected lnEXP year if ccode=="CHN", ms(D))      /*
           */ (connected lnEXP year if ccode=="IND", ms(S))      /*
           */ (connected lnEXP year if ccode=="KOR", ms(T))      /*
           */ (connected lnEXP year if ccode=="HKG", ms(O)),     /*
           */ ytitle("")legend(rows(1) lab(1 "China")           /*
           */ lab(2 "India") lab(3 "Korea")                       /*
           */ lab(4 "Hong Kong")) xtitle (Year) ytitle("lnEXPY") /*
           */ title("Income Content of Export")
```

Stata do file for Table 1.8 can be found at “Chapter1\Applications\3\_comparative advantage\revealed\_technology\_content.do”

```
use prody_b.dta,replace
keep EXPY_i year ccode
```

```

duplicates drop
joinby ccode year using controls.dta, unsm (b) _merge (_merge)
keep if year==2000
gen area=pop/density
foreach var in hum_cap GDPpc pop area EXPY_i {
    gen ln_`var'=ln(`var')
}
reg ln_EXPY_i ln_GDPpc
reg ln_EXPY_i ln_GDPpc ln_hum_cap
reg ln_EXPY_i ln_GDPpc ln_hum_cap ln_pop
reg ln_EXPY_i ln_GDPpc ln_hum_cap ln_pop ln_area
reg ln_EXPY_i ln_GDPpc ln_hum_cap ln_pop ln_area ruleoflaw

```

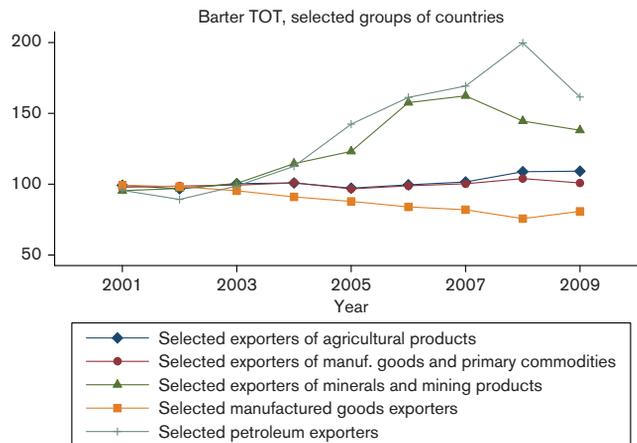
#### 4. Terms of trade

Since the beginning of the 1970s, the evolution of the terms of trade (TOT) of developing countries has been continuously measured and discussed by UNCTAD and reported in the yearly Trade and Development Report (with a special chapter on that topic in the 2005 issue<sup>62</sup>). UNCTAD collects information on the barter terms of trade (BTT), export volume (Q) and purchasing power of exports (ITT). Figure 1.20 illustrates how the TOT of developing countries exporting oil and mining products have dramatically increased since 2003, while those of agricultural products has been stagnating and those of manufacturing exporters declining.

Stata do file for Figure 1.20 can be found at “[Chapter1\Applications\3\\_comparative advantage\terms\\_of\\_trade.do](#)”

For any country or region, if you plot ITT and Q on a graph, the vertical distance between them is the trading gain (or loss if negative) experienced over the sample period.<sup>63</sup>

**Figure 1.20** Barter terms of trade of developing countries, 2001–2009



Source: UNCTAD Handbook of Statistics (various issues)

## E. Exercises

### 1. RCA, growth orientation and geographical composition

Solutions can be found at “Chapter1\Exercises\1\_RCA, growth orientation and geographical composition\trade\_flows.do”

For this exercise, use the World Bank’s Trade, Production and Protection Database: “TPP.dta”, and bilateral import–export data based on it, respectively “BilateralTrade.dta” for aggregated data and “aBilateralTrade.dta” for disaggregated data (ISIC Rev. 2, 2 digit sectors). The assignment is as follows.

1. Preliminaries
  - a. Use “TPP.dta”. Indicate what nomenclature is used and at what degree of disaggregation the data are available.
  - b. Select an OECD and a non-OECD country. Check what variables are available for those countries and for what year. [*Hint*: Some developing countries may have a large number of missing observations. Make sure you select a country for which enough information is available.]
2. Revealed comparative advantage
  - a. For the two countries of your choice, calculate the normalized RCA (NRCA) index for every year between 1983 and 1985 (included) and calculate the average for those three years. Do the same for 2002–2004.
  - b. For the two countries of your choice, draw a scatter plot in which each point represents a sector and NRCA values for 1983–1985 are on the horizontal axis and 2002–2004 values on the vertical one. Interpret the meaning of the diagonal and comment. [*Hint*: You may want to draw similar plots for other OECD and non-OECD countries and check whether the same patterns emerge.]
3. Growth orientation
  - a. For each sector, using the entire database (“TPP.dta”) calculate the average value of world trade (exports or imports) in that sector in 1983–1985 and 2002–2004. Calculate the rate of growth of world trade in each sector between these two periods.
  - b. For the two countries of your choice, draw a scatter plot in which each point represents a sector, world trade growth is on the horizontal axis, and NRCA values for 1983–1985 are on the vertical axis. Draw a regression line on the scatter plot. Comment.
  - c. Draw a similar scatter plot but using 2002–2004 NRCA values. Comment on any difference with the previous one.
4. Geographical composition
  - a. Use “aBilateralTrade.dta”. Calculate the Trade Intensity Index (TI) between your selected countries and their trade partners for 1983–1985. Do the same for 2002–2004.
  - b. Draw a scatter plot with 1983–1985 values on the horizontal axis and 2002–2004 values on the vertical one. [*Hint*: It is sometimes worth plotting the scatter with data expressed in logarithm and/or dropping zero values.]
  - c. Now use the disaggregated bilateral data: “BilateralTrade.dta”. For one of the two countries you have selected, identify partners — if any — with which this country has formed preferential trade agreements during the sample period.<sup>64</sup> Did the Yeats’ regional intensity of trade (RIT) index increase for those countries? Did it go down for other countries? Does that necessarily indicate trade diversion? Why or why not? [*Hint*: Consider two years before and after the RTA.]

## 2. Offshoring and vertical specialization

Solutions can be found at “Chapter1\Exercises\2\_Offshoring and vertical specialization\offshoring\_vs.do”

In this exercise we use the offshoring and vertical specialization measures calculated from input–output tables. Input–output tables data come from the OECD Input–Output Tables and are available at <http://www.oecd.org/sti/inputoutput/>. The selected sample covers 42 countries with data for the years 1995, 2000 and 2005 or nearest years. The assignment is as follows:

1. Descriptive statistics
  - a. Open the file “OS\_kiDeterminants.dta”. Check for which countries and years data are available.
  - a. Compute the Spearman rank correlation and the simple correlation between the different country- and sector-level offshoring measures available. Comment.
  - b. Select a country for which data are available for the years 1995, 2000 and 2005. For the country you have selected, consider the measure of offshoring that only takes into account imported goods inputs (OS\_GD\_GD). Draw a scatter plot in which each point represents offshoring in a given sector. Put 1995 values on the horizontal axis and 2000 values on the vertical axis. Do the same for 1995 and 2005. Determine which industries offshore most.
  - c. Now use “OS\_iVS\_iDeterminants.dta”. Consider all the countries available. For the variables that represent offshoring of intermediate goods inputs and vertical specialization at the country-level (respectively, OS\_Goods\_i and VS\_Goods\_i), draw a scatter plot in which each point represents 1995 values on the horizontal axis and 2000 values on the vertical axis. Do the same for 1995 and 2005. Determine which countries offshore and vertically specialize the most.
2. The determinants of offshoring / vertical specialization
  - a. In order to determine the variables that mostly affect offshoring, estimate the following equation using fixed effects and comment on the results:

$$\ln\left(\frac{OS_{it}}{1-OS_{it}}\right) = \alpha + \beta_1 \ln(GDPpc_{it}) + \beta_2 \ln(Internet_{it}) + \beta_4 \ln(Roads_{it}) + \beta_5 \ln(Rails_{it}) + \varepsilon_{it} \quad (1.35)$$

- b. In order to account for the fact that the relationship between offshoring and GDP per capita might not be linear, re-estimate the following specification and comment on the results. Determine the level of GDP per capita at which the effect of offshoring is maximized.

$$\ln\left(\frac{OS_{it}}{1-OS_{it}}\right) = \alpha + \beta_1 \ln(GDPpc_{it}) + \beta_2 \ln(GDPpc_{it})^2 + \beta_3 \ln(Internet_{it}) + \beta_4 \ln(Roads_{it}) + \beta_5 \ln(Rails_{it}) + \varepsilon_{it} \quad (1.36)$$

Do the same regressions with the vertical specialization measure. Comment.

## Endnotes

1. The address is <http://www.worldbank.org/eaptrade>.
2. We will try to reserve superscripts for countries and subscripts for commodities and time throughout.
3. The data are freely available at [http://www.graduateinstitute.ch/md4stata/datasets/penn\\_world.html](http://www.graduateinstitute.ch/md4stata/datasets/penn_world.html).
4. Note that we are already combining domestic (consumption) data with trade data, meaning that concordance tables must be used and hence that the  $\mu_{jt}$  will be calculated at a high degree of aggregation.
5. Input–output tables describe the sale and purchase relationships between producers and consumers within an economy. Data for OECD countries and some non-OECD ones for the years 1995, 2000 and 2005 can be obtained from the OECD at <http://www.oecd.org/sti/inputoutput>.
6. For an application, see Loschky and Ritter (2006).
7. This phenomenon has been termed “outsourcing” or “offshoring”, depending on the ownership structure of the foreign intermediate good producer. For a classification, see World Trade Organization (2008).
8. See Schott (2004). He proposes a list of TSUSA (1972–1988) and HTS (1989–1994) product codes containing the words part or component. The dataset is available at [http://www.som.yale.edu/faculty/pks4/files/international/parts\\_qje\\_2004\\_02\\_27.xls](http://www.som.yale.edu/faculty/pks4/files/international/parts_qje_2004_02_27.xls).
9. OECD input–output tables, for instance, report data on domestic, imported and total intermediate input usage by different sectors.
10. See Hausmann et al. (2007).
11. On this, see McKinsey Global Institute (2010).
12. See Applications 2.a, 2.b and 2.c.
13. Krugman (1979).
14. In this regard one may prefer to use marginal IIT indices, discussed in Brühlhart (2002).
15. See Application 2.d and discussion therein.
16. For a more detailed discussion see Fontagné and Freudenberg (1997).
17. See Application 2.e for the same decomposition for a sample of OECD countries.
18. The World Bank is currently exploring the causes of Africa’s low export survival. Surveys highlight the unavailability of credit as a key binding constraint not just for export entrepreneurship but for the survival of existing export relationships. See Brenton et al. (2009a and 2009b).
19. See Application 2.f. Alternative measures of concentration are the Gini index or the Theil index, which are pre-programmed in Stata (ineqerr command).
20. The World Bank is working on a concept of “export riskiness” for foodstuffs, using econometric analysis of counts of sanitary alerts at the EU and US borders. Di Giovanni and Levchenko (2010) propose a more general measure of riskiness based on the variance–covariance matrix of sectoral value added.
21. On export breakthroughs raising concentration, see Easterly et al. (2009). On the natural resource curse, see e.g. Brunnschweiler and Bulte (2009) and the contributions in Lederman and Maloney (2009).
22. The decompositions suggested by Hummels and Klenow (2005) and discussed in this box are now routinely performed by the World Bank’s WITS interface.
23. Calculating PRODY indexes from disaggregated trade data is straightforward (see Application 3.b). However, as explained by Hausmann et al. (2007), it is essential to use a consistent sample, because not reporting is likely to be correlated with income, and this could introduce a bias in the index. In “Chapter1\Applications\3\_comparative advantage\revealed\_technology\_content.do” you can see how to calculate PRODY in a balanced sample.
24. Adjustments based on the World Bank’s agricultural distortions database (Anderson et al., 2008) were also made to avoid agricultural products subsidized by rich countries (say, milk or bacon) to appear artificially capital and human-capital intensive.
25. The most updated version of the dataset can be downloaded, in Stata format, at <http://r0.unctad.org/ditc/tab/research.shtm>. See Application 3.a and discussion therein.
26. See WTO website, [http://www.wto.org/english/tratop\\_e/region\\_e/region\\_e.htm](http://www.wto.org/english/tratop_e/region_e/region_e.htm).
27. Overall, whether the members of a PTA gain or lose depends on the level of the initial MFN tariff and on the elasticities of demand and supply. See World Trade Organization (2011).
28. Figure 1.5 is constructed in Excel after manipulating the data in Stata (see “Chapter1\Applications\Other applications\intra\_regional\_trade.do”). It should be noted that three-dimensional diagrams should be reserved for three-dimensional variables (here source, destination and trade value). If the data are two-dimensional (items vs. values for those items), diagrams should be kept two-dimensional.

29. A good example of an exhaustive empirical study of the potential gains from regional integration in sub-Saharan Africa is Yeats (1998), which provides a template on how such a study should be organized and carried out.
30. This example is taken from Tumurchudur (2007).
31. Observe that Figure 1.6 also shows RIT indices on the import side.
32. The World Bank's WITS interface routinely computes TCIs.
33. Trade complementarity indices are constructed in Application 2.g.
34. Freely available at <http://www.graduateinstitute.ch/md4stata/datasets/wdi.html>. The US Department of Agriculture also provides REER data at <http://www.ers.usda.gov/Data/exchangerates/> on nominal and real exchange rates for 80 countries (plus the European Union), as well as real trade-weighted exchange rate indexes for many commodities and aggregations. All series are updated every other month. Data series start at the beginning of 1970 and run to the last available current monthly information, which is typically two months behind the current date.
35. In fact, this definition corresponds to what is more precisely known as the *net* barter terms of trade. The *gross* barter terms of trade is the ratio between the quantity index of exports and the quantity index of imports. Other extensions include adjusting TOT for changes in the productivity of exports or adjusting simultaneously for the productivity of exports and imports. As price and productivity are the two main sources of factor remuneration, those indices are respectively called the single and double *factorial* terms of trade.
36. In this case the formula becomes:  $P_t^M = \sum_{k \in N_M} s_{k0}^M p_{kt}^M$  where the partners of country  $j$  are indexed by subscript  $i$  and  $s_{k0}^M$  represents the share of product  $k$  from country  $i$  in total imports of country  $j$  in the base year.
37. <http://www2.imfststatistics.org/DOT/>. Because there is only one entry per country pair in a unit of time, the volume of data is limited.
38. UNCTAD's Comtrade, which is particularly convenient for disaggregated data analysis and which is treated in detail in the next section, can also be used to analyze data at the aggregated level.
39. Useful information on classification systems can be found at the University of Michigan's library site at <http://www.lib.umich.edu/govdocs/stectrad.html>. A *Guide to Foreign Trade Statistics* is also available at the US Census Bureau's page at <http://www.census.gov/foreign-trade/guide/index.html>.
40. Because each revision entails classification changes, care must be exercised when dealing with time series straddling revisions. In all, 17 per cent of the HS 6 lines have been introduced in successive revisions (1 in 1992, 267 in 1996, 316 in 2002, and 260 in 2007).
41. Eurostat — the European Union's statistical office — provides HS 8 trade statistics in the (expensive) COMEXT database (on CD-ROM). The data requires very careful handling as product classifications are erratic: from one year to the next, one HS 6 category will be split into several HS 8, then re-grouped, then moved to some different code, etc. HS 10 data are not communicated to the public. For the US, building on Robert Feenstra's early work, John Romalis and Jeffrey Schott compiled a "cleaned-up" database of US exports and imports between 1989 and 2001 at the HS 10 level (see Feenstra et al. 2002). The database can be downloaded from <http://www.nber.org/data> together with concordance tables between various nomenclatures, tariff data and more. See also the University of California, Davis' site at <http://www.internationaldata.org>.
42. More information can be found at <http://unstats.un.org/unsd/trade/sitcrev4.htm>.
43. See <http://unstats.un.org/unsd/cr/registry/cpc-2.asp>.
44. The United Nations' list of concordance tables is at <http://unstats.un.org/unsd/cr/registry/regot.asp?Lg=1>. The EU's "metadata" server RAMON provides tables at [http://ec.europa.eu/eurostat/ramon/index.cfm?TargetUrl=DSP\\_PUB\\_WELC](http://ec.europa.eu/eurostat/ramon/index.cfm?TargetUrl=DSP_PUB_WELC). Jon Haveman and Raymond Robertson have a particularly useful page with industry concordance tables (as well as a whole lot of other useful trade data) at <http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeConcordances.html>.
45. The data can be found on Jon Haveman and Raymond Robertson's page at <http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/TradeData.html#Rauch>.
46. See <http://comtrade.un.org>.
47. BACI data are downloadable here: <http://www.cepii.fr/anglaisgraph/bdd/baci.htm>. Details about the dataset can be found in Gaulier and Zignago (2009).
48. Unfortunately, those linkages cannot be related to trade because the input–output tables do not distinguish between domestic and imported inputs.

49. See <http://go.worldbank.org/EQW3W5UTP0>.
50. On this, see Anson et al. (2006) who analyze the effect of pre-shipment inspection on tariff avoidance.
51. ASYCUDA (Automated SYstem for CUsoms DAta) is an UNCTAD initiative that can be visited at <http://www.asycuda.org>.
52. A full – and somewhat depressing – discussion of the reliability of trade statistics can be found in Rozanski and Yeats (1994).
53. When we get to the parametric (econometric) analysis of trade flows later in this handbook, how missing values are handled will become especially important since omitting the information carried by zero trade lines (when they really represent zero trade) may result in biased estimates of the relationship between trade and its determinants. For the sake of the concepts treated in this chapter, it should be observed that industry or country averages may not be very meaningful in the presence of many missing observations because they will then correspond to different time periods or refer to different countries in different years.
54. If remoteness is thought of as a weighted average of the distance to a country's trading partners, it is not really a physical characteristic of the country since it is the result of trading decisions. A simple average of distance to all other countries would be closer to a "natural" or exogenous characteristic but it would have the drawback of assigning the same weight, say, to both China and Lesotho. An alternative is to use GDP as weights although there is no perfect fix to this problem.
55. Logs will be negative because shares are less than one. That is not a problem.
56. Notice, however, that the regression line is almost flat.
57. In the HS nomenclature, there are 21 sections, 96 chapters and around 5,000 (depending on the year and the concordance) HS 6 products. GL indexes are highest for sections, lowest for products.
58. By construction,  $\sum_{K_{ij}/K_i} \Delta X / \Delta X + \sum_{K_i/K_j} X_k / \Delta X - \sum_{K_{ij}/K_i} X_k / \Delta X = 1$ .
59. Notice that Herfindahl concentration indexes are even larger for countries heavily depending on oil exports. For instance, as you can check in the data, the (normalized) index for Nigeria in 2003 was 0.63.
60. Freely available at [http://www.graduateinstitute.ch/md4stata/datasets/wwgov\\_en.html](http://www.graduateinstitute.ch/md4stata/datasets/wwgov_en.html).
61. In Hausmann et al. (2007), the Rule of Law index is uncorrelated with EXPY. The difference in results might be driven by the year used for the regressions (we do not have data for 2001, the year used by them).
62. See [http://archive.unctad.org/en/docs/tdr2005\\_en.pdf](http://archive.unctad.org/en/docs/tdr2005_en.pdf).
63. You can find the Stata command that does this for the group of developing economies (excluding China) in the file "Chapter1\Applications\3\_comparative advantage\terms\_of\_trade.do".
64. The WTO provides this information at <http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx>.

## References

- Anderson, K. and Valenzuela, E. (2008), "Estimates of global distortions to agricultural incentives, 1955 to 2007", Policy Research Working Paper 4612, Washington D.C.: The World Bank.
- Anson, J., Cadot, O. and Olarreaga, M. (2006), "Tariff evasion and customs corruption: does PSI help?", *Contributions to Economic Analysis and Policy* 5(1): Art. 33.
- Bacchetta, M., Grether, J.-M. and de Melo, J. (2003), Introduction to the World Economy: A Course with Emphasis on Transition Economies, CD-ROM, CERDI.
- Balassa, B. (1965), "Trade liberalisation and 'revealed' comparative advantage", *The Manchester School* 33: 99–123.
- Brander, J. and Krugman, P. (1983), "A 'reciprocal dumping' model of international trade", *Journal of International Economics* 15(3–4): 313–21.
- Brenton, P. and Newfarmer, R. (2007), "Watching more than the Discovery channel: export cycles and diversification in development", Policy Research Working Paper 4302, Washington D.C.: The World Bank.
- Brenton, P., Pierola, M. D. and von Uexküll, E. (2009a), "The life and death of trade flows: understanding the survival rates of developing-country exporters", in Newfarmer, R., Shaw W. and Walkenhorst, P. (eds.), *Breaking into New Markets: Emerging Lessons for Export Diversification*, Washington D.C.: The World Bank.
- Brenton, P., Pierola, M. D. and von Uexküll, E. (2009b), "What explains the low survival rate of developing country export flows?", Policy Research Working Paper 4951, Washington D.C.: The World Bank.
- Brühlhart, M. (1994), "Marginal intra-industry trade: measurement and relevance for the pattern of industrial adjustment", *Weltwirtschaftliches Archiv* 130: 600–13.
- Brühlhart, M. (2002), "Marginal intra-industry trade: towards a measure of non-disruptive trade expansion", in Lloyd, P. J. and Lee, H. H. (eds.), *Frontiers of Research on Intra-Industry Trade*, Hampshire: Palgrave Macmillan.
- Brunnschweiler, C. N. and Bulte, E. H. (2009), "Natural resources and violent conflict: resource abundance, dependence, and the onset of civil wars", *Oxford Economic Papers* 61(4): 651–74.
- Cadot, O., de Melo, J. and Yagci, F. (2005), *An Effective Strategy for Zambia's Regional Trade Agreements*, Washington D.C.: The World Bank.
- Cadot, O., Carrère, C. and Strauss-Kahn, V. (2011), "Export diversification: what's behind the hump?", *Review of Economics and Statistics* 93(2): 590–605.
- Di Giovanni, J. and Levchenko, A. (2009), "International trade and aggregate fluctuations in granular economies", University of Michigan, Research Seminar in International Economics, Working Paper 585.
- Easterly, W., Reshef, A. and Schwenkenberg, J. (2009), "The power of exports", Policy Research Working Paper 5081, Washington D.C.: The World Bank.
- Eurostat (2006), "NACE Rev. 2: structure and explanatory notes".
- Feenstra, R. C. and Hanson, G. (1996), "Globalization, outsourcing, and wage inequality", *American Economic Review* 86(2): 240–5.
- Feenstra, R. C., Romalis, J. and Schott, J. (2002), "U.S. imports, exports and tariff data, 1989–2001", National Bureau of Economic Research Working Paper 9387, Cambridge, MA: NBER.
- Frankel, J. A. and Romer, D. (1996), "Trade and growth: an empirical investigation", National Bureau of Economic Research Working Paper 5476, Cambridge, MA: NBER.
- Gaulier, G. and Zignago, S. (2010), "BACI: international trade database at the product level. The 1994–2007 version", Working Paper 2010–23, Paris: CEPII.
- Grigoriou, C. (2007), "Landlockedness, infrastructure and trade in Central Asia", Policy Research Working Paper 4335, Washington D.C.: The World Bank.

- Grubel, H. G. and Lloyd, P. J. (1975), *Intra-Industry Trade: The Theory and Measurement of International Trade in Differentiated Products*, New York: Wiley.
- Hausmann, R., Hwang, J. and Rodrik, D. (2007), "What you export matters", *Journal of Economic Growth* 12(1): 1–25.
- Hummels, D., Ishii, J. and Yi, K.-M. (2001), "The nature and growth of vertical specialization in world trade", *Journal of International Economics* 54(1): 75–96.
- Krugman, P. (1979), "Increasing returns, monopolistic competition, and international trade", *Journal of International Economics* 9(4): 469–79.
- Laursen, K. (2000), *Trade Specialisation, Technology and Economic Growth: Theory and Evidence from Advanced Countries*, Cheltenham: Edward Elgar.
- Leamer, E. (1988), "Measures of openness", in *Trade Policy Issues and Empirical Analysis*: 145–204, Chicago: University of Chicago Press.
- Lederman, D. and Maloney, W. F. (2008), "In search of the missing resource curse", Policy Research Working Paper 4766, Washington D.C.: The World Bank.
- Lipsey, R. (1960), "The theory of customs unions: a general survey", *Economic Journal* 70: 498–513.
- Loschky, A. and Ritter, L. (2006), "Import content of exports", presented at the 7th International Trade Statistics Expert Meeting, Paris, 11–14 September 2006.
- Michaely, M. (1996), "Trade preferential agreements in Latin America: an ex ante assessment", Policy Research Working Paper 1583, Washington D.C.: The World Bank.
- Nicita, A. and Olarreaga, M. (2006), "Trade, production and protection 1976–2004", *World Bank Economic Review* 21(1): 165–71.
- Organisation for Economic Co-operation and Development (OECD) (2007), "Offshoring and employment", Paris: OECD.
- Rauch, J. E. (1999), "Networks versus markets in international trade", *Journal of International Economics* 48: 7–35.
- Rozanski, J. and Yeats, A. J. (1994), "On the (in)accuracy of economic observations: an assessment of trends in the reliability of international trade statistics", *Journal of Development Economics* 44: 103–30.
- Schiff, M. (1999), "Will the real 'natural trading partner' please stand up?", Policy Research Working Paper 2161, Washington D.C.: The World Bank.
- Shirotori, M., Tumurchudur, B. and Cadot, O. (2010), "Revealed factor intensity indices at the product level", Policy Issues in International Trade and Commodities Study Series, No. 44, Geneva: UNCTAD.
- Tumurchudur, B. (2007), "Rules of origin and market access in the Europe agreements: preferences undermined", unpublished.
- United Nations (2003), *Classifications by Broad Economic Categories*, New York: UN-DESA.
- United Nations (2006), "Standard International Trade Classification, Revision 4", ST/ESA/STAT/SER.M/34/REV.4.
- United Nations Conference on Trade and Development (UNCTAD) (2005), *Trade and Development Report 2005 – New Features of Global Interdependence*, New York and Geneva: UNCTAD.
- World Trade Organization (WTO) (2008), *World Trade Report 2008: Trade in a Globalizing World*, Geneva: WTO.
- World Trade Organization (WTO) (2011), *World Trade Report 2011: Preferential Trade Agreements*, Geneva: WTO.
- Yeats, A. J. (1997), "Does Mercosur's trade performance raise concerns about the effects of regional trade arrangements?", Policy Research Working Paper 1729, Washington D.C.: The World Bank.
- Yeats, A. J. (1998), "What can be expected from African regional trade arrangements?", Policy Research Working Paper 2004, Washington D.C.: The World Bank.

## CHAPTER 2: Quantifying trade policy

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### TABLE OF CONTENTS

A. Overview and learning objectives	63
B. Analytical tools	63
1. Tariffs	64
2. Non-tariff measures (NTMs)	72
3. Trade policy stance	77
C. Data	79
1. The WTO's TAO and TDF	79
2. WITS	80
3. Market Access Maps	81
4. Other data sources	82
D. Applications	84
1. Generating a tariff profile	84
2. Assessing the value of preferential margins	90
E. Exercises	93
1. Tariff profile	93
2. <i>Ad valorem</i> equivalents of non <i>ad valorem</i> tariffs	93
3. Tariff analysis	94
Endnotes	96
References	98

## LIST OF FIGURES

Figure 2.1.	Bias of trade-weighted average tariffs	68
Figure 2.2.	Applying the price-gap method to the EU banana market	74

## LIST OF TABLES

Table 2.1.	Simple vs. trade-weighted average tariffs: illustrative calculations	67
Table 2.2.	Zambia's MFN and preferential tariffs, by HS section	69
Table 2.3.	Effective rates of protection: illustrative calculation	71
Table 2.4.	ERPs and escalating tariff structures	72
Table 2.5.	International classification of non-tariff measures	73
Table 2.6.	Price-gap calculations compared: EU bananas	75
Table 2.7.	Coverage ratio: illustrative calculation	77
Table 2.8.	Summary statistics	88
Table 2.9.	Frequency distribution	89
Table 2.10.	Tariffs and imports by product groups	90
Table 2.11.	Trade restrictiveness indexes and relative preference margins	92

## LIST OF BOXES

Box 2.1.	Calculation of <i>ad valorem</i> equivalents of specific tariffs	65
Box 2.2.	Simple and import-weighted averages	67
Box 2.3.	Applying the price-gap method to the EU banana market	74
Box 2.4.	OTRI and MA-OTRI	78
Box 2.5.	Simulating WTO tariff reduction commitments	81

## A. Overview and learning objectives

This chapter introduces you to the main techniques used for trade policy quantification. More precisely, it presents the tools used to describe, synthesize and quantify trade policies. Original tariff data may be cumbersome as they need to be aggregated and specific tariffs have to be converted into *ad valorem* equivalent. Three common issues that arise when characterizing tariff structures, namely the calculation of effective rates of protection, the related tariff escalation phenomenon and the under-representation of high tariffs when using import-weighted averages at the aggregate level, are discussed. Regarding non-tariff measures (NTMs), their measurement is more complex given their variety and the difficulty of assessing their stiffness.

We first introduce you to a number of approaches used to characterize various aspects of a trade-policy stance. We start with simple tariff profiles and briefly explain how various tariff indicators can be calculated. We then take a close look at NTMs and how their incidence and effects on trade can be estimated using import-coverage ratios and price-gap methods. We next look at recent attempts to define and calculate overall trade restrictiveness indices. Following this discussion of analytical tools, we take you on a tour of the main sources of data on tariff and NTMs. Finally, in the third part of the chapter, we illustrate how the indicators introduced in the first part can be calculated with the STATA software using the data sources presented in the second part.

The chapter does not discuss the effects of trade measures. Partial and/or general equilibrium analysis of the effects of tariffs, quotas and subsidies on trade and welfare in perfect or imperfect competition can be found in most undergraduate international economics textbooks.

In this chapter, you will learn:

- how to present a tariff profile that summarizes the salient features of a country's tariff structure
- how to aggregate tariffs into simple and weighted averages and what biases are possibly created by aggregation
- how to define and calculate Effective Rates of Protection
- how to measure and interpret tariff escalation
- how to calculate non-tariff measures (NTM) import coverage ratios and what biases are possibly involved in their calculation
- how to calculate the *ad valorem* tariff equivalent of a quantitative restriction (QR) using the price-gap method
- how to assess the overall trade restrictiveness of a trade policy stance
- how tariff and NTM data are presented in the main databases available.

After reading this chapter you will be able to perform a trade-policy analysis that will draw on the appropriate type of information, will be presented in an informative but synthetic way and, like the trade-flow analysis of Chapter 1, will be easy to digest by both specialists and non-specialists alike.

## B. Analytical tools

Trade policies are the policies that governments adopt toward international trade. These policies may involve a variety of different actions and make use of a number of different instruments. Among

those are taxes on imports or exports, quantitative restrictions of international transactions, subsidies and many other measures that for convenience are often divided into two broad categories: tariffs and non-tariff measures (NTMs). Governments typically apply different combinations of measures to each of the thousands of products imported or exported. Moreover, the same measure, for example a tariff, can be set at different levels with sometimes very different effects depending on the products, for example on trade. This chapter explains how a country's trade policy can be summarized and described in synthetic terms in such a way as to make sure that the summary statistics capture and reflect the most important features of the trade policies in place. The challenge is one of aggregating both across products and across very different measures.

While economists typically recognize that trade policies can serve all sorts of purposes, they often focus on their restrictiveness. Why do they care about the restrictiveness of a country's trade policy? The textbook argument is that openness to trade brings gains from pure exchange and from specialization (Ricardo's wine-and-drape demonstration). This argument, however, is awkward because it is essentially static. Static gains from trade opening are of an order of magnitude of less than 5 per cent of GDP spread over a ten-year adjustment period, and they are dwarfed by the rates of growth currently observed in developing countries.<sup>1</sup> So the argument must lie elsewhere — in the association between trade reform and *growth*, not in that between trade reform and static welfare. Because theory has relatively little to say on that relationship,<sup>2</sup> the question is in essence an empirical one.

However, the quest for a robust statistical association between trade openness and growth has proved to be laborious. The first problem was to come up with a measure of openness that would reflect policy stances in a comparable way. We will return to this question below, but suffice it to note here that Sachs and Warner (1995) proposed the earliest comprehensive index based on observed measures.<sup>3</sup> Alternative measures (e.g. Leamer, 1988) were based on regression analysis ("policy openness" being measured by the residual from a regression of observed openness on its exogenous determinants as discussed in Chapter 1).

First-generation studies using cross-sections of countries (see Edwards, 1998 and references therein) generated correlations between openness and growth that proved to be unstable and unconvincing. For instance, Rodriguez and Rodrik (1999) showed that the pure trade components of the Sachs-Warner index — conditions (i) and (ii) as explained in footnote 3 — played little role in the index's overall association with growth. However, more recent studies, in particular Wacziarg and Welsh's (2008) paper, have shown that panel-data techniques (i.e. techniques using both the cross-section and time-series dimensions of data where several countries are observed over several years) generate a more robust correlation between trade openness and growth.<sup>4</sup> Essentially, the additional information comes from a careful identification of *when* trade liberalization took place in each country. Once this is done, large differences between pre- and post-liberalization growth rates are observed. So we are justified in analyzing trade policy from a normative angle where more openness is taken to be better for growth.

## 1. Tariffs

### a. Concepts

A tariff is a tax levied on imports, or more rarely on exports, of a good at the border. Its effect is to raise the price of the imported (exported) product above its price on the world (domestic) market.

Tariffs are usually collected by customs authorities and can be either *ad valorem* or specific. An *ad valorem* tariff is expressed as a percentage of the value of the imported (exported) good (usually as a percentage of the Cost Insurance and Freight import value), while a specific tariff is stated as a fixed currency amount per unit of the good.

*Ad valorem* tariffs are much more widely used than specific tariffs. One reason for this is that they are easier to aggregate and to compare and are thus more transparent, which is important in particular when countries negotiate tariff commitments. Specific tariffs are more difficult to compare across products since they depend on the units in which products are measured. One way to compare them, however, is to calculate their *ad valorem* equivalent (see Box 2.1).

### Box 2.1 Calculation of *ad valorem* equivalents of specific tariffs

*Ad valorem* equivalents (AVEs),  $\tau_{AVE}$ , of specific tariffs can be calculated by dividing the monetary amount per ton (say),  $\tau_{specific}$ , by the international price of a ton of the good,  $p$  (and multiplying by one hundred to get a percentage). That is,

$$\tau_{AVE} = 100 \frac{\tau_{specific}}{p} \quad (2.1)$$

However, this is often easier said than done. The international price ( $p$ ) can be calculated by dividing trade values by volumes, but the result often varies across time and countries, not just because prices themselves vary, but also because of composition effects, i.e. lumping goods of different value per unit. Moreover, systematic biases are likely. A tariff of, say,  $x$  euros per unit is stiffer as a proportion of price for a lower-priced good (say of inferior quality or sophistication) than for a higher-priced one. If poorer countries export, on average, goods of lower quality and hence price – Schott (2004) showed that they do – then, even if they face the same specific tariff as higher-priced exports, their exports face higher protection in AVE terms than these higher-priced exports.

The WITS software (see below) proposes four different methods for the calculation of AVEs. The first approach consists in using (1) import unit values for the reporter calculated at the national tariff line level (8–10 digits), and if those are not available to replace them with (2) import unit values for the reporter calculated at the HS six-digit level and finally, if neither (1) nor (2) are available, to use (3) import unit values for OECD countries. The second approach consists in using only (3), i.e. import unit values for OECD countries. The third approach is based on the methodology for the calculation of AVEs of agricultural non *ad valorem* duties referred to in the draft modalities for agriculture that are currently negotiated at the WTO.<sup>5</sup> Finally, the fourth methodology is the methodology for the calculation of AVEs of non agricultural non *ad valorem* duties referred to in the draft modalities for non agricultural market access currently under negotiation at the WTO.<sup>6</sup> Market access maps (MAcMaps; see below) also calculate AVEs but use unit values computed as the ratios of values to volumes for five specific reference groups defined by cluster analysis in terms of income and openness (using large country groups instead of country pairs reduces the scope for measurement errors).

A characteristic of tariff regimes that should not be overlooked is the possible existence of exemptions by end-use (special projects, categories of users with special status such as multinational companies in export processing zones (EPZs), international organizations and so on). In addition to exemptions “on the books”, governments sometimes grant ad hoc exemptions whose existence can be learned only by investigation on the ground. When exemptions are important, overlooking them leads to over-estimation of the rate of protection. One possible fix consists of calculating the rate of protection as the ratio of collected duties to declared import value (more on this in Chapter 6).<sup>7</sup> However, by averaging over-exempted and non-exempted goods, this leads to under-estimation of the rate of protection on non-exempted goods.

Two further distinctions that relate more specifically to the GATT/WTO need to be taken into account when establishing a country's tariff profile. The first distinction is between most-favoured nation (MFN) tariff rates and preferential tariff rates. MFN tariffs are the ones that WTO members commit to accord to imports from all other WTO members with which they have not signed a preferential agreement. Preferential tariffs are the ones accorded to imports from preferential partners in free trade agreements (FTAs), customs unions or other preferential trade agreements and are more likely than others to be at zero.

The second distinction is between bound and applied tariffs. When governments negotiate tariff reductions in the GATT/WTO, their commitments take the form of MFN tariff bindings. Bound MFN tariff levels, which are listed in a country's tariff schedule, indicate the upper limit at which the government is committed to set its applied MFN tariff.<sup>8</sup> For a given tariff line, the bound tariff must thus be higher than or equal to the applied MFN tariff, which should be higher than or equal to the preferential tariff, if any.

For developed countries, bound tariffs are typically identical or very close to applied tariffs. For developing countries, however, there is often “water” in the tariff, which means that bound rates are typically above applied tariffs and have therefore limited effects on trade flows, even if they are fundamental in WTO negotiations. It is important in applied analysis to apply the right tariffs to the right imports (e.g. not to apply MFN tariffs to imports from preferential partners). However, there is often considerable uncertainty regarding the extent to which preferential tariffs are actually applied in regional integration agreements, especially in South–South agreements.

## b. Empirical tools

### i. *Tariff profiles*

#### Averages

Tariff schedules are typically defined at the HS eight-digit level of disaggregation or higher levels (up to HS 12), meaning that for a given country there are always more than 5,000 tariff lines (the number of HS six-digit sub-headings) and often many more than that.<sup>9</sup> Tariffs can be aggregated in different ways: by simple averaging or by using some weighting scheme. Simple averages are straightforward to calculate by adding the tariffs on all lines and dividing by the number of those tariff lines. As for weighted averages, they take the form:

$$\bar{\tau} = \sum_k w_k \tau_k \quad (2.2)$$

where  $k$  indexes imported goods and  $w_k$  is the weight given to tariff  $k$  in the average (the Greek letter  $\tau$  is used in place of  $t$  to avoid confusion with time indices). A widely used approach is to weigh goods with their share in the country's overall imports.

While both simple and import-weighted averages have the advantage of being relatively easy to calculate, these two methods have drawbacks that are illustrated in Box 2.2. Simple averages give the same weight to products that are not imported and to products that are imported in large amounts. As for import-weighted averages, they correct this bias to some extent but under-weigh high tariffs and would give zero weight to prohibitive tariffs.

### Box 2.2 Simple and import-weighted averages

Consider a country that imports three goods: good 1, whose tariff varies between zero and 500 per cent going down Table 2.1; good 2, with a tariff of 40 per cent; and good 3, with a tariff of 5 per cent. Import demands are given by

$$M_k = a_k e^{-\tau_k / 100} \quad (2.3)$$

with  $a_1 = a_2 = 1,000$  and  $a_3 = 10$ . As a result, imports of good 3 are very small. Simple averaging gives equal weight to all three tariffs. Therefore, it gives excessive weight to good 3. For instance, when the tariffs on goods 1 and 2 are respectively at 50 and 40 per cent, the simple average tariff is 31.7 per cent: it is “pulled down” by good 3 even though the reality is that there is a 40 or 50 per cent tariff on almost all goods that are imported.

**Table 2.1 Simple vs. trade-weighted average tariffs: illustrative calculations**

Good 1		Good 2		Good 3		Total imports	Simple average tariff	Weighted average tariff
Tariff	Imports	Tariff	Imports	Tariff	Imports			
0	1000	40	670	5	10	1680	15.0	15.99
50	607	40	670	5	10	1286	31.7	44.46
100	368	40	670	5	10	1048	48.3	60.75
150	223	40	670	5	10	903	65.0	66.81
200	135	40	670	5	10	815	81.7	66.16
250	82	40	670	5	10	762	98.3	62.19
300	50	40	670	5	10	730	115.0	57.29
350	30	40	670	5	10	710	131.7	52.72
400	18	40	670	5	10	698	148.3	48.97
450	11	40	670	5	10	691	165.0	46.11
500	7	40	670	5	10	687	181.7	44.03

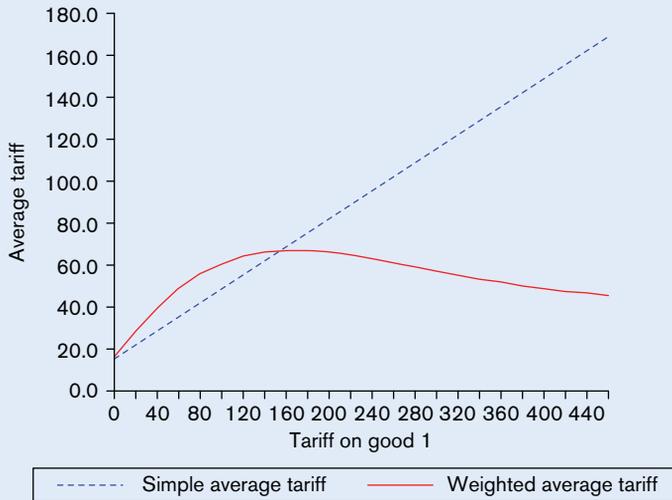
This suggests the use of a weighted average instead. Indeed, in the same line the weighted-average tariff is a more reasonable 44.46 per cent. But then look at what happens when

(Continued)

**Box 2.2 (Continued)**

the tariff on good 1 increases: imports of good 1 decrease and then so does its weight. When the tariff on good 1 rises to almost prohibitive levels (bottom of the table), the weighted average *decreases* and converges to the 40 per cent tariff on good 2. This effect, which is shown graphically in Figure 2.1, is a known important bias of weighted averages that “under-represent” high tariffs.<sup>10</sup>

**Figure 2.1 Bias of trade-weighted average tariffs**



Source: Author calculations based on Table 2.1

The theoretical fix to this problem would be to use unrestricted (free-trade) import levels as weights, but those are unobservable. Leamer (1974) proposed using world trade, but this does not properly represent the unrestricted trade structure of each country. Another approach is to strike a compromise between “national” and “global” weights by defining reference country groups on the basis of income levels. Yet another weighting scheme is proposed by Kee et al. (2005). Their weights are an increasing function of import shares and elasticities of import demand at the tariff line level, which capture the importance that restrictions on these goods would have on the overall restrictiveness (see below). Alternatively, both the simple and weighted averages can be reported as in Table 2.2, which displays MFN tariffs (applied, not bound) and preferential tariffs applied on imports from SADC and COMESA countries. Table 2.2 shows that depending on the products either the simple average or the weighted average can be higher.

### Dispersion

Tariff averages only provide a partial picture of a given tariff structure. The dispersion of tariffs around the mean also matters from an economic point of view: in general, the higher the dispersion,

**Table 2.2** Zambia's MFN and preferential tariffs, by HS section

HS section	Description	# lines	Simple averages			Trade-weighted averages		
			MFN	COMESA	SADC	MFN	COMESA	SADC
1	Live animals	232	20.7	8.3	3.0	23.2	9.3	8.1
2	Vegetables	332	18.1	7.2	3.6	13.2	5.3	7.2
3	Fats & oils	50	16.0	6.4	3.4	19.1	7.6	3.7
4	Food, bev. & tobacc.	203	20.8	8.3	4.3	16.3	6.5	4.5
5	Mineral products	167	9.8	3.9	3.4	10.2	4.1	4.6
6	Chemicals	1109	7.4	2.9	0.8	7.5	3.0	2.6
7	Plastics	495	10.1	4.0	1.9	14.1	5.6	2.8
8	Leather	74	20.3	8.1	3.8	24.6	9.8	5.0
9	Wood	88	23.3	9.3	3.9	24.6	9.8	4.9
10	Pulp & paper	163	13.9	5.6	1.9	16.9	6.8	2.2
11	Textile & clothing	921	18.7	7.5	6.0	19.6	7.8	10.3
12	Footwear	56	23.1	9.3	14.5	24.3	9.7	22.4
13	Stone, glass, cement	149	14.5	5.8	2.4	15.4	6.2	3.0
14	Jewelry	56	19.2	7.7	4.9	21.5	8.6	5.0
15	Base metals	612	11.5	4.6	1.6	10.7	4.3	1.5
16	Machinery	812	10.7	4.3	2.5	10.8	4.3	2.0
17	Transport. equip.	159	11.7	4.7	5.6	15.8	6.3	12.4
18	Optics	270	14.2	5.7	3.4	12.3	4.9	3.3
19	Arms	18	22.4	9.0	5.0	23.3	9.3	4.8
20	Miscellaneous	132	1.9	0.8	0.0	0.0	0.0	0.0
21	Works of art	8	14.3	5.7	2.8	12.8	5.1	3.3
Average			13.6	5.4	3.1			
Standard deviation			9.6	3.8	4.9			
Minimum			0.0	0.0	0.0			
Maximum			25.0	10.0	25.0			

Source: Cadot et al. (2005) using COMTRADE

the more distortion. The dispersion of tariffs can be captured using various statistics. A first option is to present a table of frequencies or a histogram. A second option is to calculate either the standard deviation or the coefficient of variation of tariff rates around the average. The standard deviation is defined as:

$$\sigma = \sqrt{\frac{1}{N} \sum_{k=1}^N (\tau_k - \bar{\tau})^2} \quad (2.4)$$

The coefficient of variation is defined as the standard deviation divided by the average tariff  $\bar{\tau}$ . A third option is to measure the proportion of so-called "peak" tariffs, i.e. the tariffs that exceed a certain benchmark. Two statistics have been used in the literature. The first is the share of tariff items (lines or sub-headings) subject to duties higher than 15 per cent and the second is the share of tariff items subject to duties larger than three times the national average.

In general, the best solution to describe a tariff profile is probably to report a battery of tariff statistics including the averages (simple and weighted) as well as the share of duty free lines, the share of peaks, the minima and maxima and standard deviations, by HS section and overall.<sup>11</sup>

Note that minima, maxima and the measures of dispersion can be calculated either by section or overall, but in any case they should be calculated directly from HS six-digit data or even better from the national tariff line level (often eight digits or more) rather than from aggregates because otherwise they would tend to be underestimated. HS chapters (two digits) represent a good compromise between total aggregation (large information loss) and excessive disaggregation (loss of synthetic value).

## ii. *Effective protection and tariff escalation*

As already mentioned, a tariff provides protection from imports by allowing domestic producers to raise both the price and the production of import-competing domestic products. This, however, is not the end of the story. Domestic producers may be using imported inputs which might be subject to tariffs. Such tariffs on imported inputs would raise the costs for domestic producers and lower their output.<sup>12</sup> This means that if one is interested in the net “protective” effect of tariffs on producers in a particular sector, all tariffs need to be taken into account. This is exactly what the effective tariff does. The concept of effective protection captures the positive or negative stimulus afforded to domestic value-added in a particular sector. Value-added is the difference between the value of output and the cost of purchasing intermediate inputs, which corresponds to the value of output that is available for payments to primary inputs. Thus, effective protection measures the net protective effect of the whole tariff structure on domestic producers in a particular sector.

In general, with several inputs the formula for the effective rate of protection (ERP) is:

$$\tau_j^E = \frac{\tau_j \dot{p}_j - \sum_i a_{ij} \tau_i \dot{p}_i}{\dot{p}_j - \sum_i a_{ij} \dot{p}_i} \quad (2.5)$$

where  $j$  stands for the final good,  $i$  indexes inputs (intermediate goods),  $\dot{p}_j$  and  $\dot{p}_i$  designate their world prices,  $\tau_j$  and  $\tau_i$  their nominal tariffs (zero if the inputs are sourced or the output sold domestically), and  $a_{ij}$  is the value of input  $i$  used in the production of one unit of good  $j$ .

ERPs are difficult to calculate. Input–output coefficients are available only for a few countries for manufactured goods and at high degrees of aggregation (SIC three digits) from the World Bank’s Trade, Protection and Production database. Two choices must then be made. First, how these coefficients are to be divided up between the more disaggregated categories for which ERPs are to be calculated. The simplest method consists of dividing equally the  $a_{ij}$  among the product categories included in the relevant SIC-3 category, but this can only be an approximation. Second, what proportion of each input is imported. Again, this necessarily involves an approximation, and the simplest method is to use import-penetration ratios also calculated at higher degrees of aggregation (since they require domestic production data; see Chapter 1). As the reader has guessed by now, so many approximations are involved that the result is unlikely to be very informative. ERPs would be better calculated using firm-level data from specifically designed questionnaires.

An illustrative calculation is shown in Table 2.3 for a shirt made with only one input, fabric, that is entirely imported.<sup>13</sup> Suppose that the Nominal Rate of Protection (NRP) on the shirt is 15 per

**Table 2.3** Effective rates of protection: illustrative calculation

	<i>Domestic sales</i>	<i>Export to preferential market</i>	<i>Export to world market</i>
Value of a shirt			
At world price	100	100	100
At domestic/applicable price	115	105	100
<i>NRP on shirts (%)</i>	<i>15.0</i>	<i>5.0</i>	<i>0.0</i>
Value of fabric used			
At world price	60	60	60
At domestic/applicable price	66	66	66
<i>NRP on fabric (%)</i>	<i>10.0</i>	<i>10.0</i>	<i>10.0</i>
Value added			
At world price	40	40	40
At domestic/applicable price	49	39	34
<i>ERP (%)</i>	<i>22.5</i>	<i>-2.5</i>	<i>-15.0</i>

*Source:* Author calculations

cent (this is just the tariff rate) while that on imported fabric is 10 per cent.<sup>14</sup> In addition, the table assumes that, at world prices, fabric would account for 60 per cent of the shirt's value, a 40 per cent rate of value added.

For a producer selling on the domestic market, it can be seen from the first column that the tariff on shirts more than compensates for the extra cost due to the tariff on fabrics, resulting in an Effective Rate of Protection (ERP) of 22.5 per cent (the increase in value added from what it would be at world prices). For a producer exporting to a preferential market with a preference margin of 5 per cent, however, the ERP becomes -2.5 per cent because value added at the combined domestic/preferential market price is less than at world prices (the 5 per cent preferential margin fails to compensate for the 10 per cent tariff on fabric). For export to non-preferential markets where no protection applies to shirts the result is even worse, with an ERP of -15 per cent. This illustrates how protection of inputs penalizes exporters of final goods.

Among the many mechanisms devised by governments to avoid negative ERPs, "tariff escalation", by which is meant higher tariff rates for final goods than for intermediate ones, figures prominently.<sup>15</sup> Table 2.4 shows that when all goods have equal nominal tariff rates, ERPs are equal to the common nominal rate (middle column). When final goods have lower rates than intermediate products, ERPs are lower than the nominal rates on final goods (last column); when they have higher rates — the escalating case — ERPs are higher (first column).

The first column shows that moderate differences in nominal rates can result in high ERPs, which explains why economists and international financial institutions (IFIs) have limited enthusiasm for escalating structures. Many customs unions have recently adopted four-band tariff structures with rates between 0–5 per cent and 15–25 per cent differentiated only by end-use (capital goods, raw materials, intermediate goods and final goods). When tariff structures are not as transparent as

**Table 2.4 ERPs and escalating tariff structures**

	<i>Case 1 (escalating)</i>	<i>Case 2 (neutral)</i>	<i>Case 3 (de-escalating)</i>
Value of a shirt			
At world price	100	100	100
At domestic/applicable price	120	110	105
<i>NRP on shirts (%)</i>	<i>20.0</i>	<i>10.0</i>	<i>5.0</i>
Value of fabric used			
At world price	60	60	60
At domestic/applicable price	66	66	66
<i>NRP on fabric (%)</i>	<i>10.0</i>	<i>10.0</i>	<i>10.0</i>
Value added			
At world price	40	40	40
At domestic/applicable price	54	44	39
<i>ERP (%)</i>	<i>35.0</i>	<i>10.0</i>	<i>-2.5</i>

*Source:* Author calculations

this, classifications like the BEC (see Chapter 1) can be used to assess whether a tariff structure is escalating or not.

## 2. Non-tariff measures (NTMs)

### a. Concepts

NTMs are policy measures other than ordinary customs tariffs that affect international trade in goods at the border by changing quantities traded, prices or both. NTMs include a wide range of instruments such as quotas, licences, technical barriers to trade (TBTs), sanitary and phytosanitary (SPS) measures, export restrictions, custom surcharges, financial measures and anti-dumping measures. The more neutral term NTMs has been preferred to the term non-tariff barriers (NTBs) because it leaves open the judgment of whether a given measure constitutes a trade barrier. NTMs may be intrinsically protectionist but they may address market failures as well, such as externalities and information asymmetries between consumers and producers. NTMs which address market failures may restrict trade while at the same time improving welfare. Other NTMs such as certain standards or export subsidies may expand trade. Identifying a measure as an NTM does not imply a prior judgment as to its actual economic effect, its appropriateness in achieving various policy goals or its legal status under the WTO legal framework or other trade agreements. The qualification of NTMs as NTBs can only be done as a result of analysis based on comprehensive data.

Various taxonomies of NTMs/NTBs have been proposed, none of which can be complete since NTMs are defined in terms of what they are not.<sup>16</sup> The recently revised international classification of NTMs includes the categories listed in Table 2.5.<sup>17</sup>

**Table 2.5 International classification of non-tariff measures**

A	Sanitary and phytosanitary measures
B	Technical barriers to trade
C	Pre-shipment inspection and other formalities
D	Price control measures
E	Licences, quotas, prohibitions and other quantity control measures
F	Charges, taxes and other para-tariff measures
G	Finance measures
H	Anti-competitive measures
I	Trade-related investment measures
J	Distribution restrictions*
K	Restrictions on post-sales services*
L	Subsidies (excluding export subsidies)*
M	Government procurement restrictions*
N	Intellectual property*
O	Rules of origin*
P	Export-related measures*

Source: UNCTAD (2010)

Whereas some NTMs such as quotas or voluntary export restraints for example are being progressively phased out, other forms are moving to the forefront. For example, because manufactured products are of increasing complexity, carrying potential health risks and other hazards, the number of product standards can be expected to rise. Similarly, rising traceability demands for foodstuffs mean increasingly complex regulations for foodstuff imports. With the advent of environmental concerns linked to climate change, NTMs will likely assume even greater importance.

## b. Empirical tools

Quantifying NTMs is a challenge because of their heterogeneous nature and because of the lack of data (see below).<sup>18</sup> Most measurement methods use a simple partial equilibrium framework to develop a tariff equivalent to the NTM that reflects by how much supply, demand or trade are affected by the measure. Measurement typically focuses on the change in import price associated with the introduction of the NTM, the resulting import reduction, the change in the price elasticity of import demand or the welfare cost of the NTM. A relatively common approach is to calculate *ad valorem* equivalents of NTMs, i.e. the *ad valorem* tariff rate that would induce the same level of imports as the NTM in question. This is relatively straightforward in the case of quotas as, under perfect competition, their price and quantity effects can be replicated by appropriately chosen taxes on trade. In this subsection we present two of the most common approaches to the measurement of NTMs: the price-gap approach, which aims at deriving a tariff/tax equivalent to the NTM as discussed, and inventory-based frequency measures. These measures have in common that they do not require the use of econometric techniques. Another more sophisticated approach requiring the use of econometric techniques is discussed in Chapter 3.

### i. Price gaps

The so-called “price gap” or “price wedge” method measures the impact of NTMs on the domestic price of a good in comparison to a reference price. The idea behind this method is that NTMs raise the domestic price above what it would be in their absence. The price gap is the difference between the price prevailing in the NTM-constrained market (the “internal price”) and the price prevailing

outside (the “external price”) corrected for the influence of other factors which may influence prices. A simple expression of the tariff equivalent of a given NTM would be:<sup>19</sup>

$$TE_{NTM} = (p_d / p_w) - (1 + \tau + c) \quad (2.6)$$

where  $p_d$  is the internal price, net of wholesale and retail margins,  $p_w$  is the world price, net of wholesale and retail margins,  $\tau$  is the tariff expressed in *ad valorem* terms and  $c$  is the international transport margin (c.i.f./f.o.b. margin) expressed in *ad valorem* terms. This expression is simple because the prices used have already been adjusted for other factors that influence prices, such as wholesale and retail distribution, rents or profits, other taxes than tariffs and subsidies. These factors must be subtracted from the price difference before the mark-up can be attributed to NTMs.

A price gap is a very simple concept which, however, can be difficult to implement. Difficulties in its implementation come from the variety of ways of calculating internal and external prices, which give rise to widely divergent estimates.<sup>21</sup> The external price is often taken as the one prevailing in a comparable but unconstrained market. However, rarely does one have a fully comparable market. In the case of EU bananas (see Box 2.3) for instance, Norway would be a good comparator because shipping distances are comparable and it had no quota when the EU did. But Norway being a very small market, the conditions of competition are not quite comparable. The United States is a better comparator from the point of view of size but it has lower freight rates. The variety of possible comparators generates very different external price estimates. As for the internal price, in principle it should be easier to estimate but in practice this is not necessarily so. For instance, list prices on the domestic wholesale market may have little to do with prices practised in actual transactions; or when importers and distributors are owned by the same firm, transfer prices may be unobservable or uninformative. Table 2.6 shows a few examples of how scattered price-gap estimates can be in practice.

The first three columns report estimates that vary because the external price taken as reference is calculated in three different ways: using (a) the US price, (b) Norway’s price and (c) the EU’s CIF (cost, insurance, freight) price before duty and purchase of import licences. The fourth column comes from a different study. But note that all three estimates give a price gap that is lower than the in-quota tariff of €75/ton, which implies a negative price for import licences. These are clearly unrealistic estimates. The fifth column, by contrast, gives a very high estimate because the external price is unrealistically low.

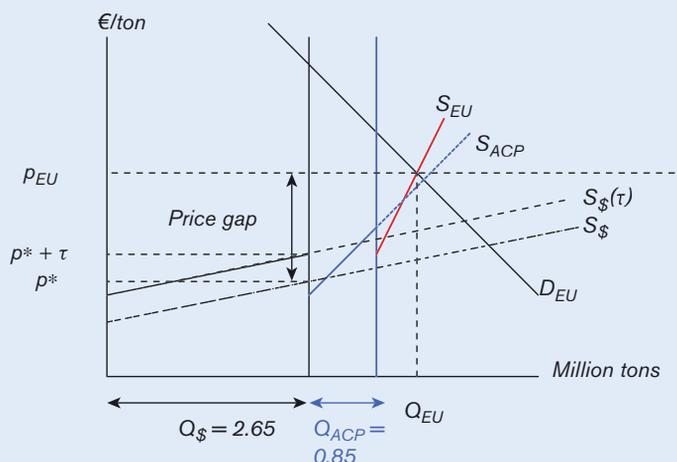
These examples show that price-gap calculations, while conceptually straightforward, can yield results that vary widely with the methods used to calculate internal and external prices. As we have already discussed, it is much easier to work on trade flows than on prices because unit-value data are typically erratic. As an alternative to the calculation of unit values from COMTRADE for commodities, the World Bank regularly publishes price information in its “pink sheet”. This information is typically fairly reliable but comes from private companies that tend to report list prices rather than real-life transaction prices; the difference can be substantial. For food and agricultural products, the FAO also publishes price series but their reliability is uneven.

The price-wedge method suffers from a number of drawbacks. First, in the presence of several different NTMs it only provides an aggregate measure of their effects but does not allow assessment

**Box 2.3 Applying the price-gap method to the EU banana market**

Figure 2.2 shows an application of the price-gap method to the EU banana market under EC Regulation 404, where different quotas were applied to bananas of different origins.

**Figure 2.2 Applying the price-gap method to the EU banana market**



The first step consists of ordering supply curves from different sources by increasing order of costs (lowest-cost to the left, highest-cost to the right).<sup>20</sup> Following this principle the first supply curve is that of so-called “dollar” bananas, imported from Latin American countries under the MFN regime. The supply curve is drawn upward-sloping to reflect the fact that the EU is a large importer and is vertically shifted up by the in-quota specific tariff of €75/ton, up to the quota of 2.6 million tons. The MFN supply curve cuts the vertical quota line at the world or “external” price (because MFN suppliers must be indifferent to the alternatives of selling the marginal banana on the EU market or selling it elsewhere). Next comes the ACP supply, up to the quota of 850,000 tons, followed by the domestic supply (shifted down vertically by the amount of subsidies). The latter’s intersection with the EU demand curve determines the internal price.

**Table 2.6 Price-gap calculations compared: EU bananas**

	Raboy			Borrel-Bauer	NERA
	(a)	(b)	(c)		
Internal price	631	631	631	624	521
External price	563	627	579	560	262
Price gap	68	4	52	64	259

Sources: Borrel and Bauer (2004), NERA Economic Consulting and Oxford Policy Management (2004) and Raboy (2004)

Note: All prices are in current euros.

of the respective contributions of each of the NTMs. Second, quality differences would need to be taken into account but they are hard to quantify. Various extensions of the price-gap approach to calculating tariff-equivalent estimates of NTMs have been proposed in the literature. Some account explicitly for commodity heterogeneity and perceived quality of substitutes and/or trading costs.<sup>22</sup> These extensions sometimes require the use of econometric techniques.

Recent econometric approaches to estimating NTM effects are either price-based or quantity-based. Price-based methods examine international price differences and assess the extent to which NTMs cause certain domestic prices to be higher than they would be in their absence.<sup>23</sup> They extend the intuition behind the price-gap method to many countries and products simultaneously (Ferrantino, 2006). Quantity-based methods, by contrast, are gravity based most of the time, i.e. they use some form of the gravity model (see Chapter 3). The decision to use a price- or quantity-based method is often based on the availability of data. As data on trade flows are abundant even at a highly disaggregated level, while price data are more problematic, quantity analysis is often preferred to price analysis.

## *ii. Inventory-based frequency measures*

Frequency or coverage ratios provide a simple but crude way of assessing the importance of NTMs in a country's trade based on inventories of NTMs such as those presented in Section C below. Frequency ratios are calculated as the share of tariff lines in a certain product category subject to selected NTMs. Similarly, coverage ratios are calculated as the share of imports of a certain category of products subject to NTMs.

Table 2.7 shows an illustrative calculation. Suppose that in HS 87 (transportation equipment), the home country has NTMs in place in HS four-digit categories 8703 (passenger cars) and 8711 (motorcycles) in order to protect a domestic car and motorbike assembly industry. The first step in calculating the automobile sector's coverage ratio consists in "marking" HS four-digit categories with a binary variable equal to one for those categories (8703 and 8711) that have NTMs and zero otherwise. The second step consists of multiplying this binary variable by the import share of each category and taking the sum. This gives a coverage ratio of 32.35 per cent in our example (31.28 per cent + 1.07 per cent).<sup>24</sup> The same calculation can be carried out for a country's entire trade, producing a summary measure of the incidence of NTMs.

However, assessing the effect of NTMs this way is crude because it does not take into account the measures' stiffness. That is, an NTM that barely reduces trade volumes is treated in the same way as one that reduces them drastically (by the nature of the binary coding). Worse, the end-result is subject to the same bias as that shown for average tariffs. That is, a prohibitive quota reducing imports of a certain category of goods to a very low level mechanically reduces the category's share in total imports, resulting in a low coverage ratio. As for frequency indexes, they would give the same weight to products that are not imported and to products that are imported in large amounts. A third drawback is that NTM inventories may be incomplete and their coverage of measures may differ across measures and countries. In spite of these well-known drawbacks, coverage ratios have been widely used as summary measures of the incidence of NTMs. Frequency measures have also been used in gravity equations to identify the effects of NTMs on trade flows (see Chapter 3).

**Table 2.7 Coverage ratio: illustrative calculation**

HS code	Import		NTM	Description
	Import value (US\$ 1,000)	share (%)		
87	58,827,533			Vehicles other than railway or tramway rolling stock
8701	1,975,665	3.36	0	Tractors (other than tractors of heading 87.09)
8702	264,003	0.45	0	Motor vehicles for the transport of ten or more persons, including the driver ...
8703	18,400,000	31.28	1	Motor cars and other motor vehicles principally designed for the transport ...
8704	5,658,077	9.62	0	Motor vehicles for the transport of goods
8705	418,058	0.71	0	Special purpose motor vehicles, other than those principally designed for t ...
8706	435,047	0.74	0	Chassis fitted with engines, for the motor vehicles of headings 87.01 to 87 ...
8707	172,346	0.29	0	Bodies (including cabs), for the motor vehicles of headings 87.01 to 87.05
8708	28,600,000	48.62	0	Parts and accessories of the motor vehicles of headings 87.01 to 87.05
8709	211,767	0.36	0	Works trucks, self-propelled, not fitted with lifting or handling equipment ...
8710	622,752	1.06	0	Tanks and other armoured fighting vehicles, motorized
8711	628,913	1.07	1	Motorcycles (including mopeds) and cycles fitted with an auxiliary motor
8712	62,290	0.11	0	Bicycles and other cycles (including delivery tricycles), not motorized
8713	54,315	0.09	0	Carriages for disabled persons
8714	363,429	0.62	0	Parts and accessories of vehicles of headings 87.11 to 87.13
8715	28,653	0.05	0	Baby carriages and parts thereof
8716	932,218	1.58	0	Trailers and semi-trailers
HS 87 Cov. ratio (%)			32.35	

### 3. Trade policy stance

The discussion in subsection 2 has emphasized the diversity of measures taken by governments that affect trade, whether on the import or on the export side. These forms of trade policy measures differ in several dimensions including how distortionary they are and the extent to which their use is constrained by WTO disciplines. Given the diversity of trade policy measures, summarizing the stance of a trade policy in a way that aggregates across goods and is comparable across countries is a non-trivial task. Many dimensions of policy must be covered, and a good template of how this should be done is provided by the WTO's Trade Policy Reviews (TPRs) available on the WTO's website. The TPRs provide a comprehensive description of WTO members' trade policies and practices. Depending on their share in world trade, members are subject to review every two (for the four largest members), every four (for the next 16) or every six years (for other members). TPRs are composed of a report by the member under review plus another report by the Secretariat of the WTO. The format of the TPR is decided upon by the Trade Policy Review Body. The report by the WTO Secretariat is in four parts:

- Economic environment
- Trade policy regime: framework and objectives
- Trade policies and practices by measure
- Trade policies by sector

Another more quantitative and synthetic approach to the assessment of a trade policy stance consists in calculating so-called trade restrictiveness indexes (TRIs), i.e. indexes that synthesize the effect of all trade restrictions (tariffs and NTMs). The construction of a TRI raises two challenges. First, a single measure of the trade restrictiveness of a 10 per cent tariff, a 1,000 tons quota and a US\$ 1 million

subsidy must be found. Second, all the information from several thousand different tariff lines must be summarized in one aggregate measure. A first generation of TRIs proposed a solution to the first problem. The IMF, for example, developed an index based on a number of observation rules. Countries were given a score for each type of trade barrier: average tariff, proportion of tariff lines covered by QRs, and so on, after which scores were averaged for each country, giving a Trade Restrictiveness Index going from one (most open) to ten (least open). The TRI, the design of which is explained in detail in IMF (2005), was used in IMF research papers but was not indicated in staff reports.

These first generation TRIs brought different types of trade policy instruments to a common metric but they did this using ad-hoc criteria with no economic basis. It is not clear why a 3 per cent average tariff should be equivalent to a 5 per cent NTM coverage. A second generation of TRIs was then developed which proposes a more analytical solution to the first problem but also solves the second problem by using theoretically sound aggregation procedures. Anderson and Neary (1994, 1996) used the equivalence between tariffs and quotas results (see above) to convert QRs into tariffs and to construct a TRI embodying the effects of both tariff and quantitative restrictions. The TRI resulting from their procedure is the uniform *ad valorem* tariff on imports that would be equivalent to the set of existing tariff and quantitative restrictions in terms of the importing country's welfare.

More recently, Kee et al. (2006) constructed a similar Overall Trade Restrictiveness Index (OTRI) defined as the uniform *ad valorem* tariff on imports that would result in the same *import volume* as the set of existing tariff and non-tariff measures (see Box 2.4). Thus both the TRI and the OTRI are based on sound aggregation across instruments. Kee et al. also proposed a mirror image of the OTRI, the uniform *ad valorem* tariff that would be equivalent to the set of existing measures affecting a country on its export market, and called it the MA-OTRI (MA for market access). They also estimated all three indices for a wide range of countries using econometric estimates of import-demand elasticities from a previous paper of theirs (Kee et al., 2004).

#### Box 2.4 OTRI and MA-OTRI

OTRI and MA-OTRI are simply given by a weighted sum of tariffs and AVEs of NTBs at the tariff line level. Weights are an increasing function of import shares and elasticities of import demand at the tariff line level, which capture the importance that restrictions on these goods would have on the overall restrictiveness. The logic of giving less weight to products with a less elastic demand is that a change in the tariff of those products would have less effect on the overall volume of trade. Note that the weights of the OTRI do not solve all the problems of import-weighted averages mentioned above as they continue to take the value of zero in the presence of prohibitive tariffs.

In order to compute the aggregate measure of trade restrictiveness, one needs information on tariffs but more importantly AVEs of NTBs and elasticities of import demand at the tariff line level. These were estimated in two background papers. Kee et al. (2005) provide estimates of import demand elasticities at the tariff line level for 117 countries. The methodology follows closely that of Kohli (1991) and Harrigan (1997) where imports are treated as inputs into domestic production, given exogenous world prices, productivity and endowments.

In a world where a significant share of growth in world trade is explained by vertical specialization, the fact that imports are treated as inputs into the GDP function – rather than as final consumption goods as in most of the previous literature – seems an attractive feature of this approach.

Kee et al. (2006) provide estimates of AVEs of core NTBs (price and quantity control measures, technical regulations, as well as monopolistic measures such as single channel for imports) and agricultural domestic support at the tariff line level for 104 countries. They first measure the impact of NTBs on imports following Leamer's (1990) comparative advantage approach (see also Harrigan, 1993 and Trefler, 1993). The logic of this approach is to predict imports using factor endowments and observe its deviations when NTBs are present. This is done for each HS six-digit tariff line in which at least one country has some type of NTB (around 4,800 tariff lines). The impact of NTBs on imports varies by country (according to country-specific factor endowments). Kee et al. then convert the quantity impact of NTBs on imports into a price equivalent (or AVE) by simply moving along the import demand curve using the import demand elasticities estimated earlier.

## C. Data

There are three main portals through which users can access tariff data and, for the time being, primarily one that gives access to a broad range of non-tariff measures. The WTO provides access to bound, applied and preferential tariffs through two different facilities: the Tariff Analysis Online (TAO) facility and the Tariff Download Facility (TDF). It also provides access to a number of databases containing information on NTMs notified to the WTO by its members. The World Integrated Trade Solutions (WITS) portal provides access to bound, applied and preferential tariffs as well as to the only truly global NTMs database (TRAINS). Finally, the Market Access Map (MAcMap) portal gives access to bound, applied and preferential tariffs and to tariff-quotas, anti-dumping duties and rules of origin. Note that all three portals also give access to trade data. In addition to those three main portals, there are a number of other databases that are accessible online and that provide information on specific measures or specific sectors.

### 1. The WTO's TAO and TDF

The WTO's TAO is one of the two interfaces offered by the WTO to access official tariff data provided or approved by its members. These tariff data are stored in two databases: the Integrated Data Base (IDB) and the Consolidated Tariffs Schedules (CTS) database. The IDB is the repository of the tariff and trade information that WTO members have committed to report to the WTO. Since 2010 this information has been complemented with data provided through other organizations and approved by members. The IDB has contained MFN-applied tariffs and imports of WTO members at the tariff-line level, which often means eight digits or sometimes even ten digits, since 1996. Country coverage depends on the years, reaching upto 90 per cent. Information on *ad valorem* equivalents of specific tariffs as well as preferential tariffs is available for a subset of the countries for which applied tariffs are available. The CTS database contains the bound tariffs of all WTO members. Access is free of charge through the same facilities as IDB.

The TAO interface allows people to generate a variety of reports on bound, applied or preferential tariffs for one country at a time. Users can select information by user-defined tariff and trade criteria, compile 12 reports (including tariff line level reports and summary reports) and export report information to the desktop. The application, in English, French or Spanish, can be accessed at:

<http://tariffanalysis.wto.org/>

The TAO is a complement to the TDF (<http://tariffdata.wto.org/>), which contains information at the level of Harmonized System (HS) six-digit codes. It is planned to merge the two applications in the future. Also, IDB and CTS data will soon be accessible through the WTO's Integrated Trade Intelligence Portal (I-Tip) which is currently developed by the WTO Secretariat to provide unified access to all information on trade and trade policy measures available at the WTO.

## 2. WITS

The WITS software was developed by the World Bank in close collaboration with the United Nations Conference on Trade and Development (UNCTAD). It provides access to five trade and tariffs databases:

- the WTO's **IDB** and **CTS** databases (see above)
- UNSD's **COMTRADE** database (see Chapter 1)
- UNCTAD's **TRAINS** database
- CEPII and IFPRI's **MAcMapHS6v2** database (see below)
- the **AMAD** database.

The TRAINS database (for TRade Analysis and INformation System) contains data on MFN (applied) and preferential tariffs, non-tariff measures (NTMs) and imports at the national tariff line level, starting in 1988.<sup>25</sup> Country coverage depends on the years, reaching up to 140 countries for some years.<sup>26</sup> NTM data are collected from official data sources. These data are complemented with information collected through firm surveys and a web portal, and stored in a distinct database.

Data on NTMs is organized and reported in TRAINS in the form of incidence at the national tariff line level. That is, each NTM is coded in binary form at the level at which measures are reported by national authorities (one if there is one, zero if there is none), allowing for estimating coverage ratios, i.e. the proportion of tariff lines coded as ones in the total number of tariff lines in a given aggregate.

Besides the controversial question of what is a barrier to trade and what is not (see above), one limitation in the reporting of NTMs is their binary form, which does not distinguish between mild and stiff measures. For instance, a barely binding quota is treated the same way as a very stiff one. Unfortunately, there is no perfect fix for this problem and the binary form is probably the best compromise between the need to preserve as much information as is possible and that of avoiding errors in reporting (the more detailed the coding, the larger the scope for errors).

WITS offers the possibility to run quick searches as well as multi-country and multi-product queries. It allows downloading of any number of tariff lines or even entire tariff structures at the national tariff line level and allows this for more than one country at a time. WITS provides two sorts of

tariffs. First, most-favoured nation (MFN) tariffs are reported under the code “MFN”. Note that these are applied, not bound, tariffs (see Section 2 (a) above for definitions). Second, effectively applied tariffs, which may vary across partner countries depending on preferences granted and RTAs, are reported under the code “AHS”.<sup>27</sup> WITS calculates *ad valorem* equivalents of non *ad valorem* tariffs. WITS also provides utilities such as classifications and concordances between different classifications as well as a tariff and trade simulation tool. This tool allows assessment of the impact of tariff cutting proposals on bound and applied tariffs (see Box 2.5) and on trade and welfare using a partial equilibrium model (for more details see Chapter 5).

WITS is free. However, access to databases themselves can be fee-charging depending on one's status.<sup>28</sup> See the WITS information web page for more information at:

<http://wits.worldbank.org/>

#### Box 2.5 Simulating WTO tariff reduction commitments

As part of the negotiations on market access, WTO members need to agree on the modalities they want to use to reduce their tariffs. Regarding these modalities, they have to decide whether they want to apply a tariff cutting formula or some other approach. If they decide to use a formula, they will further have to choose the formula they want to use and the tariffs to which they want to apply it. If, as in the current round of negotiations, they decide to apply a non-linear formula to the bound rates, there will be a need to assess the effect of such cuts on the applied tariff rates. This is because the level of the bound rate after the cut can be higher, equal to or lower than the level of the currently applied tariff. Only if the bound level is lower than the level of the applied rate will the applied tariff need to be lowered to the level of the binding.

The tariff and trade simulations section of the WITS software (see above) and the detailed analysis menu of the Market Access Maps software propose a simulation tool that allows assessment of the effects of the various tariff cutting proposals on both bound and applied tariffs. It is obviously also possible to simulate the tariff cutting proposals using STATA, but that would require ad hoc programming.

### 3. Market Access Maps

The Market Access Maps (MAcMap) facility, developed jointly by the International Trade Centre (ITC) and the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII), provides access to a database of current applied MFN and preferential tariffs and trade at the tariff line level as well as to the bound tariffs from the WTO's CTS database. The MAcMap database provides *ad valorem* equivalents (AVEs) of all non *ad valorem* tariffs. MAcMap also includes a treatment of tariff-rate quotas (the original data being from AMAD).<sup>29</sup> The methodology used in MAcMap is discussed in detail in Bouët et al. (2005).

The MAcMap facility allows the extraction of one or several tariffs at a time for one or more countries. It also proposes various reports on trade regimes or on a country's trade and tariffs as well as a tool to simulate tariff cuts. Its main limitation is that it does not allow downloading of

complete tariff structures at the national tariff line level. Since 1 January 2008, access to Market Access Maps is free of charge for developing countries at:

<http://www.macmap.org/>

Two further databases are by-products of the MACMap dataset. The first one is the MACMapHS6 database, which is a harmonized version of the MACMap database available for the years 2001 and 2004. It provides bilateral tariffs at the HS six-digit level for 163 reporters and 208 partners. MACMapHS6v2 for 2004, which was developed by CEPII and IFPRI, can be downloaded free of charge through WITS (see above). The second one is the MACMap for GTAP database, which is an aggregated version of MACMapHS6 using the GTAP nomenclature. This version of the MACMapHS6 database is ready to use with the GTAP model and software. It is freely available from CEPII.

## 4. Other data sources

### a. Global anti-dumping database

This rich database, put together by Chad Bown with funding from the World Bank, provides detailed information on more than 30 different national governments' use of the anti-dumping trade policy instrument as well as all WTO members' use of safeguard measures. It includes determination and affected countries, product category (at the HS eight-digit level), type of measure, initiation, final imposition of duties, revocation dates, and even information on the companies involved. The database is available for free online at:

[http://people.brandeis.edu/~cbown/global\\_ad/](http://people.brandeis.edu/~cbown/global_ad/)

### b. AMAD

The Agricultural Market Access Database (AMAD) resulted from a cooperative effort of Agriculture Canada, the EU Commission, the US Department of Agriculture, the FAO (Food and Agricultural Organization), the OECD (Organisation for Economic Co-operation and Development) and UNCTAD. It includes data on agricultural production, consumption, trade, unit values, tariffs and "tariff-quotas" (tariffs applied only on limited quantities, after which they jump to typically higher levels). Fifty countries were covered from 1995 to the mid-2000s. Some of the tariff-quotas are reported at the HS four-digit level rather than the HS six level. The AMAD portal provides free access to a user guide and a self-study guide, the MS-Access database and a guide that explains how to convert the Access files into Excel format.

<http://www.amad.org/>

### c. World Bank TPP database

The World Bank's Trade, Production and Protection (TPP) database merges trade flows, production and trade protection data available from different sources into a common classification: the International Standard Industrial Classification (ISIC), Revision 2. Data availability varies, but the

database potentially covers 100 developing and developed countries over the period 1976–2004. This database updates the earlier release made available in Nicita and Olarreaga (2001). It can be downloaded for free at:

<http://go.worldbank.org/EQW3W5UTP0>

#### d. World Bank TBT database

In 2004, John Wilson and Tsunehiro Otsuki at the World Bank completed a survey on technical barriers to trade (TBTs) and standards of 689 firms in 17 developing countries. The resulting database includes information on both mandatory technical regulations (e.g. costs of meeting standards and technical barriers required in major export markets) as well as the use of voluntary standards, and can be freely downloaded from the World Bank's Research page.

#### e. WTO notifications databases

A number of databases containing information from WTO members' notifications can be accessed online. WTO members have committed to report various measures under a number of agreements. For example, Article 7 of the SPS Agreement requires members to report changes in their sanitary and phytosanitary measures. As compliance with these requirements is not always satisfactory, notifications-based data should be interpreted with caution. Information from notifications submitted under the SPS Agreement is freely accessible through the SPS Information Management System (SPSIMS) (see WTO website). Similarly, information from notifications submitted under the TBT Agreement is accessible through the TBT Information Management System (TBTSIMS). Information from notifications will soon be accessible through the I-Tip portal.

#### f. Country or region specific databases

The TARIC database provides all information on tariffs of the European Union, including seasonal tariffs, exclusions, additional duties for agricultural components of processed products, etc. This database is freely accessible online but does not allow extractions beyond a very small number of data.

[http://ec.europa.eu/taxation\\_customs/dds2/taric/taric\\_consultation.jsp?Lang=en&redirectionDate=20110224](http://ec.europa.eu/taxation_customs/dds2/taric/taric_consultation.jsp?Lang=en&redirectionDate=20110224)

The Asia Pacific Economic Cooperation (APEC) tariff database contains detailed (HS eight-digit level) tariff information of most of the APEC member economies.<sup>30</sup>

<http://www.apec.org/Groups/Committee-on-Trade-and-Investment/Rules-of-Origin/WebTR.aspx>

The United States International Trade Commission (USITC) interactive tariff and trade database provides international trade statistics and US tariff data to the public free of charge. US import statistics, US export statistics, US tariffs and future tariffs as well as US tariff preference information are accessible through a user-friendly interface.

<http://dataweb.usitc.gov/>

## D. Applications

### 1. Generating a tariff profile

Objective: Generate the tariff profile of Canada.<sup>31</sup>

The tariff profile includes a summary table with bound and applied tariff averages for both agricultural and non-agricultural products, the distribution of tariffs by duty ranges and a number of tariff statistics at the product group level.

#### a. Downloading the data

Bound and applied tariffs and imports of Canada for the year 2008 will be downloaded at the national tariff line level. In the case of Canada, the national tariff lines are defined at the eight and sometimes ten digit level.

Note: If you do not have an Excel or STATA file with the list of all agricultural tariff lines, you may download the data in two (or three, under option 2 below) groups, i.e. WTO agriculture and WTO non-agriculture under option 1 and WTO agriculture and WTO industrial plus WTO petroleum under option 2.

#### *Option 1: Download data from the World Trade Organization's Tariff Analysis Online (TAO) website*

Note: TAO does not provide *ad valorem* equivalents for the non *ad valorem* tariffs, which means that tariff lines with non *ad valorem* duties will be excluded from the calculation of tariff averages.

Go to <http://tao.wto.org/>

The data needed for this application can be downloaded in four different files: two compressed files containing the agricultural and non-agricultural applied tariffs and import flows respectively and two compressed files containing the agricultural and non-agricultural bound tariffs. The first two compressed files contain three text files: one with the applied tariffs (DutyDetails.txt), one with the imports (TradeDetails.txt) and one with product definitions and other information (TariffDetails.txt). The two other compressed files each include only one text file with the bound rates.

The first compressed file can be downloaded from the TAO website in the following way:

On the home page of TAO, click:

Make selection

select "Applied Duties and Trade (IDB)"

select the relevant country and year

Click the "Additional criteria" button on the bottom of the window

in the new window, choose the "selected products (required)" thumbnail

in the "select product group" dropdown menu

select <New Product Group>

in the "Classification" dropdown menu

select "HS – WTO Agricultural Products Definition"

click the "check all" button

Click the "Download Data" button on the left hand side of the screen

in the "Select Report" dropdown menu

choose "Tariff Line Duties"

select "Text" as "File Type" and pick a name (e.g. CAN08\_AG)

click the "Export" button on the right hand side.

check the status of your download and click on "refresh"

For the other files follow the same steps.

*Option 2: Download data from the WITS portal*

Note: You may download information from either the IDB or the TRAINS database; note that *ad valorem* equivalents are provided in TRAINS only. The IDB/CTS data that you can download through WITS are exactly in the same format as the IDB/CTS information that we just downloaded through TAO.

Here we download information from the TRAINS database.

Go to <http://wits.worldbank.org/>

The data needed for this application can be downloaded in three different files but you need files with the list of all agricultural products according to the WTO definition in all relevant nomenclatures (made available with this guide). You first download the bound rates, and then you download the applied tariffs; finally you download the bilateral imports.

On the WITS home page, click:  
Quick Search  
select "Tariff-View and Export Raw Data"  
select "WTO-CTS" as data source  
select the relevant market  
Click the "Download" button  
select "Text" as "File Type"  
Click the "Download" button

For the applied rates:

select "Tariff – View and Export Raw Data"  
select data type: Trains-Total (incl. AVE)  
select reporter and year  
select Duty code: MFN rates  
select Estimation method: . . .  
Click the "Download" button  
select "Text" as "File Type"

For the trade flows:

select "Trade – View and Export Tariff line imports"  
select data source: Trains  
select reporter and year  
select Partners: World  
select Product code: All Product Code  
. . .

Note that if the trade data provided by TRAINS is not in the same nomenclature as the tariff data, you can use trade data from the WTO.

**b. Importing the data into STATA***Option 1: Import data downloaded from TAO*

Note: As explained earlier, the data downloaded from TAO is in eight different text files, four for agricultural products and four for non-agricultural products. For both agricultural and non-agricultural products, three of the four files include information on applied tariffs and trade and one includes the bound rates.

We want to append the file containing the agricultural tariffs with the one containing the non-agricultural tariffs. To do this we first import the text (or comma separated values) file containing applied agricultural tariffs and we save it in STATA format (.dta).<sup>32</sup>

```
insheet using CAN08_AG_DutyDetails_TL.txt, clear tab names
save CAN_AG_DutyDetails.dta, replace
```

Three options are used with the “insheet” command: “clear” cleans the memory of STATA, “tab” specifies that the delimiter used is the tabulation, and “names” assigns the first row as the variable name. The “replace” option allows us to overwrite a file that would have the same name.

We do the same with the file containing the non-agricultural applied tariffs. Having done this, we append the two datasets:

```
use CAN_AG_DutyDetails.dta, clear
append using CAN_NAG_DutyDetails.dta
save CAN_DutyDetails.dta
```

We then do the same with the two files containing the bound rates, those containing the imports, and those containing the definitions.

Note: You should not forget to browse the data files to make sure that there are no problems with the structure of the dataset. Be aware that problems may occur in the files containing the bound rates as some observations may not be imported appropriately. A STATA commands file which addresses some of these import-related issues is provided with this guide.

This leaves us with four STATA data (.dta) files:

```
CAN_DutyDetails.dta;
CAN_TradeDetails.dta;
CAN_TariffDetails.dta;
CAN_Bounds.dta;
```

We also need the relevant HS nomenclature in order to calculate certain statistics (e.g. the binding coverage). We thus merge the HS1996 nomenclature with the bound tariff schedule.

```
merge hs6 ag using HS96Complete.dta
```

Finally, we create three dummy variables. The first one takes the value 1 for agricultural tariff lines and the value 0 for non-agricultural tariff lines. The second takes the value 1 if the duty is non *ad valorem* (NAV) and zero otherwise, while the third one takes the value 1 when the duty is bound and zero otherwise.

```
gen ag = 0 if productclassification == "HS - WTO Non-agricultural Products Definition"
replace ag = 1 if productclassification == "HS - WTO Agricultural Products Definition"
gen nav = 0
replace nav = 1 if bounddutyrate ~="A"
gen bind = 1
replace bind = 0 if bounddutybindingstatus ~="B"
```

Remark: “A” stands for *ad valorem* and “B” stands for binding.

*Option 2: Import data downloaded from WITS*

Note: The file containing the bound tariffs is exactly the same as the one that can be downloaded from TAO, which means that all the caveats regarding the importation mentioned under option 1 apply. The STATA commands for the importation are the same as under option 1, only (a) the names of the variables in the applied duties and trade files are different, and (b) you need to merge all three files with the nomenclature files that also allow for distinguishing agricultural from non-agricultural products.

**c. Summary of tariffs and imports***Bound tariffs*

We start with the calculation of the simple average of bound tariffs (“bounddutyav”) for agricultural, non-agricultural and all products. Note that the calculation is done in four stages. Before doing any calculations we drop the lines with non *ad valorem* tariffs which appear as missing values and are thus treated as zeros when using the “collapse” STATA command. When the tariff lines are defined at the ten-digit level, we calculate averages at the eight-digit level (“t1”). We then calculate averages at the six-digit level. And finally, these averages are used to calculate the aggregate averages.

```
drop if bounddutyav == .
collapse(mean) bounddutyav nav bind, by(t1 hs6 ag)
collapse(mean) bounddutyav nav bind, by(hs6 ag)
egen Total = mean(bounddutyav)
bys ag: egen boundbyAgNAg= mean(bounddutyav)
```

We calculate next the overall binding coverage and the binding coverage for agricultural and non-agricultural tariff lines. The binding coverage is calculated as the share of all six-digit sub-headings which do not include at least one bound tariff line.

```
egen binding = sum(bind)
gen BindingCoverage = binding / _N * 100
bys ag: egen binding_byag = sum(bind)
bys ag: gen BindingCoverageNAg = binding_byag / _N * 100
```

where `_N` represents the number of observations (tariff lines).

We also compute the share of NAV duties. When only part of the HS six-digit sub-heading is subject to NAV duties, the percentage share of these tariff lines is used.

```
egen nrt1 = count(nav)
egen TotalNAV = sum(nav)
gen TotalNAVshare = TotalNAV / nrt1 * 100
```

*Simple and weighted averages of applied tariffs*

We first calculate the corresponding simple averages for applied tariffs using the same commands as for the bound rates.

Having done this, we calculate the import-weighted average of applied tariffs. This requires matching import and applied tariff data. Import data downloaded from the WTO website for Canada is by country of origin but only total imports need to be kept. Import and tariff data are matched at the national tariff line level.

```
use CAN_DutyDetails.dta, clear
collapse(mean) avdutyrate , by(t1 hs6 ag)
sort t1
merge t1 using CAN_TradeDetails.dta
```

Weighted averages are first calculated at the six-digit level and then aggregated.

```
drop if avdutyrate == .
collapse (mean) avdutyrate (sum) value, by(hs6 ag)
egen Mtot = total(value)
bys ag: egen MtotAgNonAg = total(value)
egen Totaltwav = total( avdutyrate * value)/Mtot
bys ag: egen AgNonAgtwav = total( avdutyrate * value)/MtotAgNonAg
```

The last step consists in generating the table displaying the results (see the STATA command file in the annex).

**Table 2.8 Summary statistics**

Summary	Total	Ag	Non-Ag
Simple average final bound	5.14	3.64	5.35
Share of non <i>ad valorem</i> duty in bound duty	2.91	17.78	0.65
Simple average MFN applied	3.60	3.21	3.66
Share of non <i>ad valorem</i> duty in MFN applied	0.02	12.69	0.05
Trade weighted average MFN applied	2.73	3.20	2.70
Imports in billion US\$	397.09	26.14	370.95
Share of non <i>ad valorem</i> duty in imports	0.02	11.66	0.06

Reminder: non *ad valorem* duties are not taken into account in the calculation of average tariffs. Given that they account for 17 per cent of bound and 13 per cent of applied duty sub-headings in agriculture, the tariff averages for agriculture need to be interpreted with caution.

#### d. Frequency distribution of tariffs and imports by duty ranges

We also wish to present the tariffs and imports by duty ranges at the tariff line level. To do this, we first define the ranges.

```
gen range = "Duty-free" if bounddutyav == 0
replace range = "0 <= 5" if bounddutyav > 0 & bounddutyav <= 5
...
replace range = "> 100" if bounddutyav > 100
replace range = "N.A." if bounddutyav == .
```

Then we calculate the frequency distribution for the bound tariffs:

```
collapse (mean) bounddutyav , by(range hs6 tl ag)
bys range ag: gen freqbnd = _N
bys ag: gen freqBndAgNonAg = freqbnd / _N * 100
```

Note that each ten-digit tariff line is individually allocated to one single range. We then do the same for the applied tariffs and import flows. Finally, we generate the table displaying the results.

**Table 2.9** Frequency distribution

	Agricultural products			Non-agricultural products		
	Final bound	MNF applied	Imports	Final bound	MNF applied	Imports
Duty-free	33.08	39.04	50.86	34.54	53.82	59.04
0 <= 5	11.19	10.67	5.94	9.93	11.47	5.38
5 <= 10	18.33	15.86	15.11	41.16	22.88	31.70
10 <= 15	5.49	5.41	10.03	8.69	6.21	0.95
15 <= 25	0.69	0.73	0.12	5.03	5.45	2.91
25 <= 50	0.48	0.51	2.00	0.00	0.00	0.00
50 <= 100	0.14	0.15	0.00	0.00	0.00	0.00
> 100	0.27	0.29	0.00	0.00	0.00	0.00
NAV	0.00	27.34	15.94	0.00	0.17	0.01

### e. Tariffs and imports by product groups

For each of 22 product groups (10 for agriculture and 12 for non-agricultural products), and for both bound and applied tariffs, we want to present the simple average tariff, the share of duty-free tariff lines, the maximum tariff and the share of bound rates. We also want to calculate the share of imports (total and duty-free only) by product group. Starting with the bound rates, we merge the tariff information with the definition of the product groups.

```
use CAN_Bounds.dta, clear
merge hs6 ag using ProdGrp_hs96at6dig.dta
```

Having done this we can compute the maximum rate among bound duties, the average, the percentage of bound duty-free sub-headings in the total number of six-digit sub-headings and the share of bound sub-headings in the total number of six-digit sub-headings.

```
gen dutyfree = 1 if bounddutyav == 0
bys grpname: egen maxbndduty = max(bounddutyav)
collapse(mean) bounddutyav maxbndduty bind nav dutyfree, by(hs6 ag grpname)
bys grpname: egen avbndduty = mean(bounddutyav)
bys grpname: egen nrdutyfree = sum(dutyfree)
bys grpname: gen shbnddutyfree = nrdutyfree / _N*100
bys grpname: egen totbind = sum(bind)
bys grpname: gen binding = totbind / _N*100
```

Note that the “collapse” command computes the shares as *pro rata* of the tariff lines.

Similar calculations can be done for the applied rates and for the shares of imports by product groups. The results are presented in Table 2.10.

Table 2.10 Tariffs and imports by product groups

Groups	Bound Duties				Applied MFN Duties			Imports			
	Average	Max.	Duty-Free	NAV	Average	Max.	Duty-Free	Share	Duty-Free	NAV	
			Share				Share		Share		
Animal products	4.89	238.3	49.77	100	29.70	3.98	238	67.97	0.56	53.98	12.84
Dairy products	7.46	11.2	0.00	100	77.50	7.41	11	0.00	0.11	0.00	84.75
Fruits, vegetables, plants	2.74	19.1	58.73	100	10.50	2.74	19	58.63	1.73	82.28	2.12
Coffee, tea	1.81	8	55.00	100	23.06	1.38	6	76.04	0.55	67.79	0.00
Cereals and preparations	7.64	94.7	15.59	100	38.86	6.35	94.5	31.29	1.23	25.72	9.51
Oilseeds, fats & oils	3.78	11.2	51.08	100	1.17	3.49	11	53.29	0.48	66.18	0.00
Sugars and confectionery	7.09	12.8	7.81	100	38.76	4.30	12.5	28.13	0.22	6.48	49.51
Beverages and tobacco	4.99	16	26.84	100	27.84	4.65	16	34.42	1.19	26.86	51.60
Cotton	0.80	8	90.00	100	0.00	0.50	5	90.00	0.00	84.20	0.00
Other agricultural products	1.69	16	67.37	100	2.62	0.99	10.5	78.95	0.51	54.80	1.21
Fish and fish products	1.25	11.3	76.97	100	0.88	0.94	11	81.09	0.51	74.79	0.00
Minerals and metals	2.71	15.7	49.82	99.46	1.22	1.72	15.5	68.70	13.68	72.61	0.00
Petroleum	6.78	8	0.00	51.67	48.33	2.69	8	58.67	10.54	98.72	0.00
Chemicals	4.49	15.7	26.68	100	0.13	2.81	15.5	50.55	11.23	47.15	0.10
Wood, paper, etc.	1.50	15.7	77.26	100	0.00	1.15	15.5	83.15	4.74	77.94	0.00
Textiles	10.74	18.2	9.66	100	0.00	6.54	18	47.22	1.64	16.35	0.05
Clothing	17.23	18	0.85	100	0.00	16.92	18	3.04	1.87	0.28	0.00
Leather, footwear, etc.	7.38	20	23.83	100	0.00	5.34	20	40.88	1.97	18.83	0.00
Non-electrical machinery	3.44	14.3	45.78	100	0.04	1.49	9.5	74.65	15.23	77.98	0.00
Electrical machinery	4.33	11.3	35.51	100	0.00	2.53	11	53.83	8.94	65.11	0.00
Transport equipment	5.67	15.7	24.71	93.22	6.78	5.79	25	41.13	16.90	16.39	0.00
Manufactures, n.e.s.	3.91	18.2	41.66	99.55	1.13	3.04	18	52.18	6.17	70.29	0.00

## 2. Assessing the value of preferential margins

This application presents the computation of two market access measures. The first one captures direct market access conditions, i.e. the overall tariff faced by exports. The second captures relative market access conditions, i.e. the overall tariff faced by exports relative to that faced by competitors. The index capturing the restrictiveness of the tariffs faced by exports is based on the work of Kee et al. (2009). As explained above, in the aggregation of tariff lines less weight is given to products with a less elastic import demand because for those products a change in tariff would have less effect on the overall volume of trade. Fugazza and Nicita (2011) call this index the “tariff trade restrictiveness index” (TTRI). In formal terms, the TTRI faced by country  $j$  in country  $k$  can be written as:

$$TTRI_{jk} = \frac{\sum_{hs} \exp_{jk,hs} \varepsilon_{k,hs} T_{k,hs}^j}{\sum_{hs} \exp_{jk,hs} \varepsilon_{k,hs}}$$

where  $\exp$  are exports,  $\varepsilon$  is the elasticity of the demand for imports,  $T$  is the applied tariff and  $hs$  are HS six-digit categories.

The second index measures the tariff advantage (or disadvantage) provided to the actual exports of country  $j$  in country  $k$ , given the existing structure of preferences. It is defined as the difference

between the tariff faced by a determined basket of goods when imported from the given country relative to the tariffs faced by the same goods when imported from any other country. In formal terms, the relative preferential margin (RPM) measuring the advantage that exporters of country  $j$  have when they export their goods to country  $k$  can be written as:

$$RPM_{jk} = \frac{\sum_{hs} \exp_{jk,hs} \epsilon_{k,hs} (T_{k,hs}^w - T_{k,hs}^j)}{\sum_{hs} \exp_{jk,hs} \epsilon_{k,hs}}, j \neq k,$$

With

$$T_{k,hs}^w = \frac{\sum_v \exp_{vk,hs} T_{k,hs}^v}{\sum_v \exp_{vk,hs}}$$

where  $v$  are countries competing with country  $j$  in exporting to market  $k$  and where  $T_{k,hs}^w$  is the average HS six-digit (trade weighted) tariff applied by country  $k$  to imports originating from each country  $v$ .

We will now compute the TTRI for Mexico, i.e. the overall trade restrictiveness of Mexican tariffs *vis-à-vis* its trading partners.

We start by opening the PMA\_MEX.dta file provided with this guide.<sup>33</sup> We calculate the numerator and the denominator and calculate the ratio of the former to the latter.

```
bys ccode year pcode: egen num = sum(exp * eps * T)
bys ccode year pcode: egen den = sum(exp * eps)
gen TTRI = num / den
```

where *ccode* is the reporter (Mexico), *pcode* is the partner, *exp* is exports, *eps* is import demand elasticity and *T* is tariff.

We next compute the RPM for Mexico, i.e. the relative preference margin faced by Mexico's trading partners when they export to Mexico. To do this we calculate the trade-weighted average tariff for competitors at the HS level ( $T_{k,hs}^w$ ).

```
bys ccode year hs6: egen TotalexpT = sum(exp * T)
bys ccode year hs6: egen Totalexp = sum(exp)
gen Twc = (TotalexpT - exp * T) / (Totalexp - exp)
```

Having done this, we calculate the sum across products of the numerator and denominator of the weighted averages for the tariff of competitors ( $T_{k,hs}^w$ ) and we compute the ratio of the two. After that, we subtract the ratio for the country's own tariff ( $T_{k,hs}^j$ ), which corresponds to the TTRI that we have already computed.

```
bys ccode year pcode: egen num2 = sum(exp * eps * Twc)
gen TTRI_others = num2 / den
gen RPM = TTRI_others - TTRI
```

The last step consists of summarizing the bilateral TTRI and RPM measures through simple or trade weighted average for each period. In the TTRI case, this can be done as follows:

```
bys ccode year: egen TTRI_avg = mean(TTRI)
bys ccode year: egen Totalexports = sum(exp)
bys ccode year: egen TTRI_wavg = total((TTRI * exports) / Totalexports)
```

Table 2.11 displays the results.

**Table 2.11 Trade restrictiveness indexes and relative preference margins**

<i>year</i>	<i>ccode</i>	<i>TTRI simple avg.</i>	<i>TTRI weighted avg.</i>	<i>RPM simple avg.</i>	<i>RPM weighted avg.</i>
2000	MEX	0.13	0.02	-0.09	0.04
2007	MEX	0.09	0.02	-0.05	0.01

## E. Exercises

### 1. Tariff profile

Objective: Compute the tariff profile of the Philippines.

1. Preliminaries
  - a. Download bound and applied tariffs and imports for the Philippines (year 2008) at the national tariff line level from the WTO's TAO website.
  - b. Import the data into STATA, import the relevant HS nomenclatures and create three dummy variables: one indicating whether the line is bound or not, one indicating whether the product is agricultural or non-agricultural and one indicating whether the duty is *ad valorem* or not.
2. Summary and duty ranges of tariffs and imports:
  - a. Report in a table the simple average final bound, average MFN applied, trade weighted average and total imports in billion US\$. Do the same for agricultural and non-agricultural products.
  - b. Determine the binding coverage in total and in agricultural products.
  - c. Determine the share of non *ad valorem* duties overall and for non-agricultural products.
  - d. Determine the frequency distribution of bound and applied duties as well as imports for agricultural and non-agricultural products. The following ranges are considered: duty free;  $0 \leq 5$ ;  $5 \leq 10$ ;  $10 \leq 15$ ;  $15 \leq 25$ ;  $25 \leq 50$ ;  $50 \leq 100$ ;  $>100$ .
3. Tariffs and imports by product groups
  - a. For each product group (10 agriculture and 12 non-agriculture groups), determine the simple average of the final bound and MFN applied duties. Compute the share of duty-free six-digit sub-headings in the total number of sub-headings in the product group for bound and MFN tariffs. Determine the highest *ad valorem* duty within the product group for both tariffs. In addition, for bound duties compute the share of bound HS six-digit sub-headings containing at least one bound tariff line.
  - b. Compute the share of each product group in total imports. Compute the share of MFN duty-free imports in total imports for each product group.
4. Major suppliers and impact of the product mix on the level of duties
  - a. Select the five major suppliers of agricultural and non-agricultural products in terms of total bilateral imports.
  - b. For each of these suppliers, compute the simple and trade-weighted average MFN duty based only on tariff lines with imports. Determine the duty-free imports in terms of tariff lines as a percentage of all traded tariff lines and in terms of share of duty-free trade in per cent of all bilateral trade flows.

### 2. *Ad valorem* equivalents of non *ad valorem* tariffs

Objective: Compare aggregate tariff statistics for South Africa including the *ad valorem* equivalents of NAV tariffs or not including them.

1. Download the data from WITS
  - a. Download applied tariffs for South Africa (2008) from WITS. You will need all the different sets of applied tariffs: one set including only *ad valorem* tariffs and three sets including *ad valorem* equivalents of non *ad valorem* tariffs estimated using the various methods proposed by WITS (UNCTAD 1 and 2 and WTO).
  - b. Examine the tariff data. Are non *ad valorem* equivalents provided for all tariff lines? Which is the nomenclature used for the applied rates?
2. Preliminaries
  - a. Before doing any calculations, the data need to be imported into STATA and reformatted. If you have downloaded the applied tariffs in three different files containing respectively the agricultural lines, the industrial lines and the petroleum lines, you will need to append these three files.
  - b. You will also need to create a dummy variable taking the value 1 for agricultural products and zero otherwise. The tariff line code is considered by STATA as a scalar and needs to be converted into a string of characters (command `tostring`) while the opposite is true for import data which need to be converted into scalars (command `destring`).
  - c. Finally, the data need to be reshaped into three columns each containing a set of tariffs with *ad valorem* equivalents calculated using a different method, plus one without *ad valorem* equivalents.
3. Share of non *ad valorem* duties and duty averages
  - a. Having done all this, calculate the share of non *ad valorem* rates at the HS six-digit level. When only part of the HS six-digit sub-heading is subject to non *ad valorem* duties, the percentage share of these tariff lines is used. Calculate the same statistic for agricultural and non-agricultural products.
  - b. Next, for each of the four sets of tariffs compute the simple average of applied tariffs, first at the HS six-digit level and then overall, for agricultural and for non-agricultural products.
4. Frequency distribution of tariff lines
  - a. The second part of the exercise consists in computing the frequency distribution of tariff lines by duty range respectively for agricultural and non-agricultural products. Remember that the shares by duty range in the frequency distribution are based on the pro-rata shares of tariff line level duties in the standard HS six-digit sub-headings. Start by defining the ranges of your choice, remembering that tariffs can take high positive values (> 100). Include a duty-free category.
  - b. Compute the shares and comment.

### 3. Tariff analysis

Objective: Provide a statistical description of tariffs and NTBs and examine their determinants.

For this exercise, use the World Bank's Trade Production and Protection (TPP) Database (available at "Chapter2\Datasets"). The assignment is as follows:

1. Preliminaries
  - a. Select one country (correction is provided for Colombia and Japan). Check what variables are available for the selected country for what years.
  - b. Indicate what nomenclature is used and at what degree of disaggregation the data are available.
2. Average tariffs and their determinants
  - a. Report in a table descriptive statistics for the tariffs: simple and weighted averages of effectively applied (i.e. taking preferences into account) and MFN applied tariffs along with corresponding median, standard deviation, minimum and maximum, all calculated for the 28 three-digit sub-headings provided in the database.
  - b. Draw a histogram of tariffs and comment on their distribution.
3. Tariffs and NTBs
  - a. Draw a scatter plot where each point is a sector, tariffs are on the horizontal axis and NTB *ad valorem* equivalents (AVE) are on the vertical one. On the basis of your scatter plot, are tariffs and NTBs complements or substitutes? Explain. [*Hint*: When the number of zero values is high, it is best to drop them from the plot to see a clearer picture.]
4. Determinants of tariffs
  - a. Calculate import-penetration ratios for each sector and their change between the first and last three years of the sample. [*Hint*: If there are too many missing observations for the period 2002–2004, consider 1999–2001 or 1998–2000 as the end period.]
  - b. Calculate the average establishment size as the ratio of employees to establishments, the proportion of female workers and wages per employee for each sector.
  - c. Regress average tariffs and NTBs on these variables and comment on your results.

Data sources: All data are from the Trade, Production and Protection 1976–2004 database constructed by the World Bank (Nicita and Olarreaga, 2006), and are available at <http://www.worldbank.org>. They only refer to manufacturing industries.

## Endnotes

1. See for example Piermartini and Teh (2005).
2. See however Grossman and Helpman (1991) for an integrated – if difficult – treatment of the relationship between trade, innovation and growth.
3. The Sachs-Warner index (SW) was a binary one equal to zero (closed economy) if any of the following five conditions were met: (i) an average tariff at or above 40 per cent; (ii) an NTB coverage ratio at or above 40 per cent; (iii) a black-market premium on foreign exchange at or above 20 per cent for a decade; (iv) an export monopoly; or (v) a socialist economy. If none of these conditions was met, the economy was deemed to be open (SW equal to one). The binary nature of this summary measure meant that a lot of information was lost (differences between, say, moderately closed and very closed economies) but minimized the risk of misclassification.
4. Wacziarg and Welsh (2008) showed that correlations that held for the 1970s broke down in the 1980s and 1990s. See also the overview of the literature in the WTO's World Trade Report 2008.
5. The methodology is set out in Annex A to WTO document TN/AG/W/3 of 12 July 2006.
6. The methodology is outlined in WTO document TN/MA/20.
7. This has the additional advantage of correcting for undervaluation of imports, widely used for tariff avoidance. The degree of undervaluation can be inferred by comparing the CIF (cost, insurance, freight) import value declared at destination customs with the FOB (free on board) export value declared at origin customs. The difference between the two should be positive and reflect insurance and freight costs. However, for many developing countries and for many goods it is negative, reflecting undervaluation at destination.
8. WTO members' schedules also list their commitments with regard to "other duties and charges" (ODCs). GATT Article II:1(b) stipulates that the products described in the schedules of commitments "*shall be exempt from other duties or charges of any kind imposed in excess of those imposed at the time a concession was granted*". In the Uruguay Round, members agreed to include any other duty or charge existing on 15 April 1994 in their Schedules and to eliminate all those that had not been notified. ODCs, which are covered in the NTM classification, include all taxes levied on imports in addition to the customs duties which are not in conformity with Article VIII (Fees and Formalities) of GATT 1994. Article VIII stipulates that such taxes should be limited in amount to the approximate cost of services rendered and shall not represent an indirect protection to domestic products or a taxation of imports or exports for fiscal purposes.
9. Note that under the Harmonized System (HS) convention, contracting parties are obliged to base their tariff schedules on the HS nomenclature. To ensure harmonization, they must employ all four- and six-digit provisions without deviation but are free to adopt additional subcategories. This means that while tariff schedules are often defined at a higher level of disaggregation, comparability across countries is not ensured beyond the HS six-digit level.
10. On this, see inter alia Anderson and Neary (1999).
11. See the World Tariff Profiles publication from the WTO, ITC and UNCTAD for a good example. See also the application in subsection D below which explains how the statistics presented in the World Tariff Profiles ([http://www.wto.org/english/res\\_e/reser\\_e/tariff\\_profiles\\_e.htm](http://www.wto.org/english/res_e/reser_e/tariff_profiles_e.htm)) can be calculated.
12. New research suggests that high import tariffs also limited the choice of inputs for producers in India which constrained the introduction of new products (Goldberg et al., 2010).
13. A good discussion of the issues with illustrations can be found in Flatters (2005).
14. It may seem strange to protect the domestic fabric industry with a 10 per cent tariff if it produces nothing that shirt makers can use, but let us suppose for the sake of the argument that it produces another type of fabric, say for bed linen, while the tariff covers *all* types.
15. Several institutional mechanisms have been put in place to prevent negative ERPs for exporters. These include tariff exemptions on inputs (possibly as part of EPZ arrangements) or "duty drawbacks" (refund of tariff payments on justification of export of the final good). South Korea successfully ran a complex system of duty drawbacks for many years, but sub-Saharan countries typically have poorly managed systems where exporters fail to get the refunds or get them very late. In high inflation environments, delays in refunds can be penalizing. Notwithstanding these differences in implementation, such systems should be taken into account whenever possible.

16. See the authoritative paper by Deardorff and Stern (1998) who discuss the definition and propose a taxonomy with five categories.
17. This new classification was elaborated as part of a joint project by international institutions led by a Group of Eminent Persons to improve the collection and dissemination of information on non-tariff barriers (NTBs) (see UNCTAD, 2010). Categories J to P (marked with “”) are included in the classification to collect information from private sectors through survey and web-portals. Note that a classification of procedural obstacles has also been elaborated for the same purpose.
18. Ferrantino (2006) provides a comprehensive survey of recent progress in the quantification of NTMs.
19. This is a basic formula (from Moroz and Brown, 1987 and Linkins and Arce, 2002) as presented in Ferrantino (2006) who also presents three other, more sophisticated price-gap formulae.
20. Only this way of ordering individual supply curves ensures that the price obtained at the intersection of the marginal supplier's curve with the domestic demand is the correct one.
21. Under Annex V of the WTO's Agricultural Agreement, external and internal prices are to be calculated as follows: “External prices shall be, in general, actual average CIF unit values for the importing country. Where average CIF unit values are not available or appropriate, external prices shall be either appropriate average CIF unit values of a near country; or estimated from average FOB unit values of (an) appropriate major exporter(s) adjusted by adding an estimate of insurance, freight and other relevant costs to the importing country. [...] The internal price shall generally be a representative wholesale price ruling in the domestic market or an estimate of that price where adequate data are not available.” (Guidelines for the Calculation of Tariff Equivalents for the Specific Purpose Specified in Paragraphs 6 and 10 of this Annex, Annex 5, WTO Agriculture Agreement, p. 71.)
22. See Ferrantino (2006) and Yue et al. (2006).
23. See for example Dean et al. (2005).
24. The frequency index would be equal to  $2/16 = 0.125$ , i.e. 12.5 per cent.
25. WITS calculates *ad valorem* equivalents of non *ad valorem* tariffs.
26. Gawande et al. (2005) note that the correlation between IDB and TRAINS tariffs is 0.93.
27. TRAINS also reports bound tariffs under the code “BND”.
28. While access to COMTRADE is subject to a fee, imports at the tariff line level are available for a relatively large number of countries in TRAINS or IDB.
29. The treatment is as follows. Suppose that a tariff rate of 20 per cent is levied on imports within a quota of 10,000 tons a year, and a tariff of 300 per cent on any additional quantities, if applicable. First, import volume data are compared with the quota to determine if the latter is binding or not. If binding (import volume above 10,000 tons), the out-of-quota tariff of 300 per cent is used as the tariff equivalent; if not, the in-quota tariff of 20 per cent is used.
30. Australia, Chile, Hong Kong (China), Korea (Republic of), New Zealand, the Philippines, Thailand, Brunei Darussalam, China, Indonesia, Malaysia, Papua New Guinea, Russia, United States, Canada, Chinese Taipei, Japan, Mexico, Peru, Singapore, Viet Nam.
31. The computed profiles correspond broadly to parts A1 and A2 of the Country Profile Tables of the World Tariff Profiles publication. The World Tariff Profiles use data from different years depending on data availability. In addition, there have been several revisions with the data, which makes direct comparison with the tables almost impossible.
32. Problems may arise (STATA may fail to import the full dataset) with the txt files when they are imported into STATA. The problems can be solved by converting the .txt file into a .csv file and importing the latter.
33. Data for this application are sourced from several databases. Bilateral exports are from UN COMTRADE; tariff data are from UNCTAD TRAINS; import demand elasticities are from Kee et al. (2008). See Fugazza and Nicita (2011).

## References

- Anderson, J. and Neary, P. (1994), "Measuring the restrictiveness of trade policy", *World Bank Economic Review* 8: 151–69.
- Anderson, J. and Neary, P. (1996), "A new approach to evaluating trade policy", *Review of Economic Studies* 63: 107–25.
- Anderson, J. and Neary, P. (2003), "The Mercantilist Index of Trade Policy", *International Economic Review* 44: 627–49.
- Borrel, B. and Bauer, (2004), "EU banana drama: not over yet", Canberra and Sydney: Center for International Economics.
- Bouët, A., Decreux, Y., Fontagné, L., Jean, S. and Laborde, D. (2005), *A Consistent, Ad-Valorem Equivalent Measure of Applied Protection across the World: The MacMap-HS6 Database*, Paris: CEPII.
- Cadot, O., de Melo, J. and Yagci, F. (2005), *An Effective Strategy for Zambia's Regional Trade Agreements*, Washington D.C.: The World Bank.
- Dean, J., Feinberg, R. and Ferrantino, M. (2005), "Estimating the tariff-equivalent of NTMs", in Dee, P. and Ferrantino, M. (eds.), *Quantitative Measures for Assessing the Effect of Non-Tariff Measures and Trade Facilitation*, Singapore: World Scientific Ltd. for APEC, 289–310.
- Deardorff, A. and Stern, R. (1998), *Measurement of Non-Tariff Barriers: Studies in International Economics*, Ann Arbor: University of Michigan Press.
- Edwards, S. (1998), "Openness, productivity and growth: what do we really know?", *Economic Journal* 108: 383–98.
- Ferrantino, M. (2006), "Quantifying the trade and economic effects of non-tariff measures", Trade Policy Working Paper 28, Paris: OECD.
- Flatters, F. (2005), *Measuring the Impacts of Trade Policies: Effective Rates of Protection*, New York: Mimeo.com, Inc.
- Fugazza, M. and Nicita, A. (2011), "On the importance of market access for trade", United Nations Conference on Trade and Development (UNCTAD) Blue series Paper No. 51, Geneva: UNCTAD.
- Gawande, K., Krishna, P. and Olarreaga, M. (2005), "Lobbying competition over trade policy", National Bureau of Economic Research Working Paper 11371, Cambridge, MA: NBER.
- Goldberg, P., Khandelwal, A., Pavcnik, N. and Topalova, P. (2010), "Imported intermediate inputs and domestic product growth: evidence from India", *Quarterly Journal of Economics* 125(4): 1727–67.
- Grossman, G. and Helpman, E. (1991), *Innovation and Growth in the Global Economy*, Cambridge, MA: MIT Press.
- Harrigan, J. (1993), "OECD imports and trade barriers in 1983", *Journal of International Economics* 35(1): 91–111.
- Harrigan, J. (1997), "Technology, factor supplies and international specialization: estimating the neoclassical model", *American Economic Review* 87(4): 475–94.
- International Monetary Fund (IMF) (2005), "Review of the IMF's Trade Restrictiveness Index", Background Paper to the Review of Fund Work on Trade, Washington D.C.: IMF.
- Kee, H. L., Nicita, A. and Olarreaga, M. (2005), "Import demand elasticities and trade distortions", Policy Research Working Paper 3452, Washington D.C.: The World Bank, published in *The Review of Economics and Statistics* (2008) 90(4): 666–82.
- Kee, H. L., Nicita, A. and Olarreaga, M. (2006), "Estimating trade restrictiveness indices", Policy Research Working Paper 3840, Washington D.C.: The World Bank, published in *Economic Journal* (2009) 119(534): 172–99.

- Kohli, U. (1991), *Technology, Duality and Foreign Trade: The GNP Function Approach to Modeling Imports and Exports*, Ann Arbor: University of Michigan Press.
- Leamer, E. (1974), "Nominal tariff averages with estimated weights", *Southern Economic Journal* 41: 34–46.
- Leamer, E. (1988), "Measures of openness", in Baldwin, R. (ed.), *Trade Policy and Empirical Analysis*, Chicago: Chicago University Press.
- Leamer, E. (1990), "Latin America as a target of trade barriers erected by the major developed countries in 1983", *Journal of Development Economics* 32: 337–68.
- Linkins, L. A. and Arce, H. M. (2002), "Estimating tariff equivalents of non-tariff barriers", US International Trade Commission Office of Economics Working Paper 94-06-Ar, Washington D.C.: USITC.
- Moroz, A. W. and Brown, S. L. (1987), "Grant support and trade preferences for Canadian industries", Government of Canada, Report for the Dept. of Finance, the Dept. of External Affairs and the Dept. for Regional Industrial Expansion, processed.
- NERA Economic Consulting and Oxford Policy Management (OPM) (2004), "Addressing the impact of preference erosion in bananas on Caribbean countries", Report for the UK Department for International Development (DFID), London and Oxford: NERA Economic Consulting and OPM.
- Nicita, A. and Olarreaga, M. (2006), "Trade, production and protection 1976–2004", *World Bank Economic Review* 21(1): 165–71.
- Piermartini, R. and Teh, R. (2005), "Demystifying modeling methods for trade policy", World Trade Organization Discussion Paper No. 10, Geneva: WTO.
- Raboy, D. (2004), *Calculating the Tariff Equivalent to the Current EU Banana Regime*, Washington D.C.: Patton Boggs, LLP.
- Rodriguez, F. and Rodrik, D. (1999), "Trade policy and economic growth: a skeptic's guide to the cross-national evidence", National Bureau of Economic Research Working Paper 7081, Cambridge, MA: NBER.
- Sachs, J. and Warner, A. (1995), "Economic reform and the process of global integration", *Brookings Papers on Economic Activity* 1995(1): 1–118.
- Schott, P. (2004), "Across-product versus within-product specialization in international trade", *Quarterly Journal of Economics* 119: 647–78.
- Trefler, D. (1993), "Trade liberalization and the theory of endogenous protection: an econometric study of US import policy", *Journal of Political Economy* 101: 138–60.
- United Nations Conference on Trade and Development (UNCTAD) (2010), *Non-Tariff Measures: Evidence from Selected Developing Countries and Future Research Agenda*, *Developing Countries in International Trade Studies*, Geneva: UNCTAD.
- Wacziarg, R. and Welch, K. H. (2008), "Trade liberalization and growth: new evidence", *World Bank Economic Review* 22: 187–231.
- Yue, C., Beghin, J. and Jensen, H. (2006), "Tariff equivalent of technical barriers to trade with imperfect substitution and trade costs", *American Journal of Agricultural Economics* 88(4): 947–60.



## CHAPTER 3: Analyzing bilateral trade using the gravity equation

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### TABLE OF CONTENTS

A. Overview and learning objectives	103
B. Analytical tools	103
1. The gravity equation: theoretical equation	103
2. Estimation methods	105
3. Advanced gravity modelling issues	112
4. Data sources	119
C. Applications	120
1. Building a database and estimating a gravity model	120
2. Measuring the effect of NTBs	127
D. Exercises	131
1. Estimating the impact of a regional trade agreement	131
2. Calculating tariff equivalent	132
Endnotes	133
References	135

## LIST OF TABLES

Table 3.1.	Excerpt from an illustrative gravity database	125
Table 3.2.	Gravity estimates, banana market	129

## LIST OF BOXES

Box 3.1.	Estimating trade creation and trade diversion with gravity models	109
Box 3.2.	A cautionary note on gravity models with disaggregated data	114

## A. Overview and learning objectives

This chapter will introduce the gravity model, a work-horse of international trade analysis. After a brief overview of the theoretical foundation of gravity models, we will guide you through possible alternative estimation methods of the “mother” gravity equation. We will then turn to the discussion of advanced issues on gravity modelling such as how to handle zero-trade flows and how to calculate tariff equivalents of non-tariff barriers. Data sources for gravity analysis and instructions on how to build a gravity database will be provided at the end of this section.

Equipped with these analytical tools, we will review the debate over the impact of the WTO membership on trade. This application will allow us to show the importance of a correct specification of the estimation equation for unbiased results, to explain to the reader how to interpret the results of a regression analysis (including inferences on trade diversion and trade creation) and to discuss a number of potential estimation problems such as endogeneity and heteroskedasticity.

Exercises are provided at the end of the chapter. Data and do files for the solution of these exercises can be downloaded from the web/DVD.

In this chapter, you will learn:

- what are the logical foundations of the gravity equation
- where to find the data needed to estimate it
- what are the main measurement issues you should be aware of
- what are the main econometric estimation issues you should be aware of
- how to present and interpret the results
- how to build the database and run a regression to estimate a standard gravity model
- how to calculate the tariff equivalent (*ad valorem* or specific) of a quantitative restriction (QR) using gravity models.

After reading this chapter, with some knowledge of econometrics and familiarity with STATA, you will be able to run a properly formulated gravity equation using STATA and to interpret it with the key caveats in mind.

## B. Analytical tools

### 1. The gravity equation: theoretical equation

It has been known since the seminal work of Jan Tinbergen (1962) that the size of bilateral trade flows between any two countries can be approximated by a law called the “gravity equation” by analogy with the Newtonian theory of gravitation. Just as planets are mutually attracted in proportion to their sizes and proximity, countries trade in proportion to their respective GDPs and proximity.<sup>1</sup> Initially the gravity equation was thought of merely as a representation of an empirically stable relationship between the size of economies, their distance and the amount of their trade. Prominent models of international trade at that time included the Ricardian model, which relies on differences in technology across countries to explain trade patterns, and the Heckscher-Ohlin

(HO) model that relies on differences in factor endowments among countries as the basis for trade. It was assumed then that standard Ricardian and HO models were incapable of providing a foundation for the gravity model. In the HO model, for example, country size has little to do with the structure of trade flows.

The extraordinary stability of the gravity equation and its power to explain bilateral trade flows prompted the search for a theoretical explanation for it. Whereas empirical analysis predated theory, we know now that most trade models require gravity in order to work. The first important attempt to provide a theoretical basis for gravity models was the work of Anderson (1979). He did so in the context of a model where goods were differentiated by country of origin (the so-called Armington assumption) and where consumers have preferences defined over all the differentiated products. This structure would imply that, whatever the price, a country will consume at least some of every good from every country. All goods are traded, all countries trade and, in equilibrium, national income is the sum of home and foreign demand for the unique good that each country produces. For this reason, larger countries import and export more. Trade costs are modelled as "iceberg" costs, that is, only a fraction of the good shipped arrives to destination, the rest having melted in transit. Clearly, if imports are measured at the CIF value, transport costs reduce trade flows.

Subsequent elaborations have shown that, far from being a purely econometric tool without a theoretical basis (an early criticism against the gravity model), gravity models can arise out of a range of trade theories.<sup>2</sup> In particular, Bergstrand (1985 and 1989) shows that a gravity model is a direct implication of a model of trade based on monopolistic competition developed by Paul Krugman (1980). In this model, identical countries trade differentiated goods because consumers have a preference for variety. Models with monopolistic competition overcome the undesirable feature of Armington models whereby goods are differentiated by location of production by assumption. Firm location is endogenously determined and countries are specialized in the production of different sets of goods. Deardorff (1998) shows that a gravity model can arise from a traditional factor-proportions explanation of trade. Eaton and Kortum (2002) derive a gravity-type equation from a Ricardian type of model, and Helpman et al. (2008) and Chaney (2008) obtained it from a theoretical model of international trade in differentiated goods with firm heterogeneity.<sup>3</sup>

In its general formulation, the gravity equation has the following multiplicative form:

$$X_{ij} = GS_i M_j \phi_{ij} \quad (3.1)$$

where  $X_{ij}$  is the monetary value of exports from  $i$  to  $j$ ,  $M_j$  denotes all importer-specific factors that make up the total importer's demand (such as the importing country's GDP) and  $S_i$  comprises exporter-specific factors (such as the exporter's GDP) that represent the total amount exporters are willing to supply.  $G$  is a variable that does not depend on  $i$  or  $j$  such as the level of world liberalization. Finally,  $\phi_{ij}$  represents the ease of exporter  $i$  to access of market  $j$  (that is, the inverse of bilateral trade costs).

The contribution of recent research concerning the theoretical foundation of the gravity equation is to have highlighted the importance of deriving the specifications and variables used in the gravity model from economic theory in order to draw the proper inferences from estimations using the

gravity equation. Particularly important has been in this respect the contribution of Anderson and van Wincoop's (2003) paper, where they show that controlling for relative trade costs is crucial for a well-specified gravity model. Their theoretical results show that bilateral trade is determined by *relative* trade costs, i.e. the propensity of country  $j$  to import from country  $i$  is determined by country  $j$ 's trade cost toward  $i$  relative to its overall "resistance" to imports (weighted average trade costs) and to the average "resistance" facing exporters in country  $i$ ; not simply by the absolute trade costs between countries  $i$  and  $j$  (Anderson and van Wincoop, 2003). The rationale for including these "multilateral trade-resistance" (MTR) terms, as they are called, is that, *ceteris paribus*, two countries surrounded by other large trading economies, say Belgium and the Netherlands bordered by France and Germany respectively as well as by each other, will trade less between themselves than if they were surrounded by oceans (such as Australia and New Zealand) or by vast stretches of deserts and mountains (such as the Kyrgyz Republic and Kazakhstan).

In particular, Anderson and van Wincoop show that in a context of world of  $N$  countries and a variety of goods differentiated by the country of origin a well-specified theoretically founded gravity equation takes the form:

$$X_{ij} = \frac{Y_i Y_j}{Y} \left( \frac{t_{ij}}{\Pi_i P_j} \right)^{1-\sigma} \quad (3.2)$$

where  $Y$  denotes world GDP,  $Y_i$  and  $Y_j$  the GDP of countries  $i$  and  $j$  respectively,  $t_{ij}$  (one plus the tariff equivalent of overall trade costs) is the cost in  $j$  of importing a good from  $i$ ,  $\sigma > 1$  is the elasticity of substitution and  $\Pi_i$  and  $P_j$  represent exporter and importer ease of market access or country  $i$ 's outward and country  $j$ 's inward *multilateral resistance* terms. They are low if a country is remote from world markets, remoteness being determined by physical factors such as physical distance from large markets as well as policy factors such as high tariff barriers or other trade costs. This result highlighted the severe mistake made in estimating gravity models by those studies that proxy  $S_i$  and  $M_j$  in equation (3.1) with exporting and importing country GDPs without controlling for multilateral resistance terms.

For simplicity we have omitted time indexes from equation (3.1). However, all variables in equation (3.1) can vary over time. Furthermore, we only considered aggregate data, but gravity models can also be run using sectoral data as well (see Box 3.2).

## 2. Estimation methods

Given the multiplicative nature of the gravity equation, the standard procedure for estimating a gravity equation (3.1) is simply to take the natural logarithms of all variables and obtain a log-linear equation that can be estimated by ordinary least squares regression (clearly easier than non-linear estimation methods). This yields the estimation equation:

$$\ln X_{ij} = \ln G + \ln S_i + \ln M_j + \ln \phi_{ij} \quad (3.3)$$

or more specifically in the case of the Anderson and van Wincoop model:

$$\ln X_{ij} = a_0 + a_1 \ln Y_i + a_2 \ln Y_j + a_3 \ln t_{ij} + a_4 \ln \Pi_i + a_5 \ln P_j + \varepsilon_{ij} \quad (3.4)$$

where  $a_0$  is a constant,  $a_3 = 1 - \sigma$  and  $\varepsilon$  is the error term.

In practice, the gravity equation relates the natural logarithm of the monetary value of trade between two countries to the log of their respective GDPs, a composite term measuring barriers and incentives to trade between them, and terms measuring barriers to trade between each of them and the rest of the world. This specification allows in addition an easy interpretation of the estimated parameters: the parameters of an equation estimated in logarithms are elasticities. For example, the estimated parameter for the GDP in a gravity equation estimated in logarithms is the elasticity of trade to GDP, indicating the percentage variation in trade following a 1 per cent increase in GDP.

A number of variables are generally used to capture trade costs  $\phi_{ij}$ . Typically, empirical studies proxy trade costs with bilateral distance. However, a number of additional variables are also customarily used. These include dummies<sup>4</sup> for islands, landlocked countries and common borders. They are used to reflect the hypotheses that transport costs increase with distance and that they are higher for landlocked countries and islands but are lower for neighbouring countries. Dummies for common language, adjacency or other relevant cultural features such as colonial history are used to capture information costs. Search costs are probably lower for trade between countries whose business practices, competitiveness and delivery reliability are well known to one another. Firms in adjacent countries, countries with a common language or other relevant cultural features are likely to know more about each other and to understand each other's business practices better than firms operating in less-similar environments. For this reason, firms are more likely to search for suppliers or customers in countries where the business environment is familiar to them. Tariff barriers are generally included in the form of dummies for the existence of regional trade agreements. Very few studies use information on bilateral tariffs, one reason being the lack of data over time.

The problem with estimating equation (3.4) is that the so-called multilateral resistance terms (MRTs) are not directly observable. Several alternative ways of proxying for MTRs are possible. One is to use iterative methods to construct estimates of the price-raising effects of barriers to multilateral trade (Anderson and van Wincoop, 2003). However, this procedure is not frequently used since it requires a non-linear least square (NLS) program to obtain an estimate. A simpler alternative, often used, is to use a proxy for these indexes called a "remoteness" variable. An even simpler – and widely used – method consists of using country fixed effects for importers and exporters (Rose and van Wincoop, 2001; Feenstra, 2004; Baldwin and Taglioni, 2006). The next subsection will focus on these two simple approaches.<sup>5</sup>

### a. Controlling for the multilateral trade resistance (MTR)

An important factor in the choice of the estimation method for the multilateral resistance terms is the specific research interest.

*i. Case a: Interest of the research focuses on the coefficient of a bilateral variable*

Unbiased estimates of the impact of distance and other bilateral variables on bilateral trade flows can be obtained by replacing the multilateral resistance indexes in equation (3.4) with importer and exporter dummies (Anderson and van Wincoop, 2004), or country effects.<sup>6</sup> These country dummies are binary (0,1) variables that will capture all country-specific characteristics and will control for a country's overall level of imports/exports. In a gravity equation, one such variable will be set to one whenever the *exporting* country is, say, Kazakhstan and zero otherwise. Another one will be set to one whenever the *importing* country is Kazakhstan and zero otherwise, and so on for each country.

For a cross section, that is, when information on variables of interest is available only for one specific year, the empirical gravity equation estimated using fixed effects in its baseline form is:

$$\ln X_{ij} = a_0 + a_1 I_i + a_2 I_j + a_3 \ln t_{ij} + \varepsilon_{ij} \quad (3.5)$$

where  $\ln t_{ij}$  is the logarithm of trade costs between two countries  $i$  and  $j$ ,  $I_i$  is a dummy variable equal to one when the country is  $i$  and zero otherwise. In a cross section with  $n$  countries, if one-way trade flows are not combined, there are  $2n^2$  country pairs (the unit of observation) but only  $2n$  such fixed effects, so estimation is still possible.

In the gravity literature it is in general assumed that trade costs take the form:

$$t_{ij} = d_{ij}^{\delta_1} \cdot \exp(\delta_2 \text{cont}_{ij} + \delta_3 \text{lang}_{ij} + \delta_4 \text{ccol}_{ij} + \delta_5 \text{col}_{ij} + \delta_6 \text{landlock}_{ij} + \delta_7 \text{RTA}_{ij}) \quad (3.6)$$

where  $d_{ij}$  is bilateral distance, and  $\text{cont}_{ij}$ ,  $\text{lang}_{ij}$ ,  $\text{ccol}_{ij}$ ,  $\text{col}_{ij}$ ,  $\text{landlock}_{ij}$  and  $\text{RTA}_{ij}$  are dummy variables denoting respectively whether the two countries have a common border, common language and common colonizer, whether one was a colony of the other at some point in time, whether one of the two is a landlocked country (including when both countries are landlocked), or whether the two countries are members of a regional trade agreement (Box 3.1 discusses more extensively the issue of estimating the impact of trade agreements on trade). All these variables have been found to be significant determinants of bilateral trade.

In STATA

```
* generate importer and exporter dummies
tab (importer), gen(importer_)
tab (exporter), gen(exporter_)
reg lnexports lndist cont lang ccol col landlock RTA importer_* exporter_*, robust
```

alternatively

```
xi: reg lnexports lndist cont lang ccol col landlock RTA i.importer i.exporter, robust
```

**Note** that a gravity equation deals with observations that may be heterogeneous in a variety of ways. The assumption of homoskedasticity of the error term — under which all disturbances affecting individual observations are drawn from a common distribution — being likely to be violated, robust standard errors should be used systematically.<sup>7</sup>

When information is also available over time, the gravity equation in its baseline form is:

$$\ln X_{ijt} = a_0 + a_1 l_{it} + a_2 l_{jt} + a_3 \ln t_{ijt} + a_4 l_t + u_{ijt} \quad (3.7)$$

where  $l_t$  designates a dummy variable for a specific year one per year. Suppose, for instance, that our sample period spans 2001–2006. We would define a variable  $l_1 = 1$  if year = 2001 and 0 otherwise and similarly for 2002, ..., 2006, giving us six such dummy variables that could be nonzero only one at a time.<sup>8</sup>  $l_{it}$  and  $l_{jt}$  are importer and exporter time-varying individual effects. For a sample of  $T$  periods there are  $T$  of these variables. Note that  $l_{it}$  are importer time-varying effects; they therefore allow us to take into account the fact that MRT may change over time. There is a set of  $2nT$  of these variables.

The use of panel data (over time bilateral trade data) also has the advantage of mitigating the bias generated by heterogeneity across countries. While in a single cross section, country-pair propensity to trade can only be controlled for by observed country-pair characteristics (such as common language, common currency), in a panel country-pair heterogeneity can be controlled for by using country-pair fixed effects. Note, however, that if the interest of the research focuses on estimating the coefficient of a bilateral time-invariant coefficient, the fixed effect estimation is not a viable option because of perfect collinearity. The researcher may want to control with random effects in this case. The Hausman test can be used to test whether the random effect model is a suitable option.

In STATA

```
tab (year). gen (year_)
gen impyear = group(importer year)
gen expyear = group(exporter year)
tab (impyear). gen (impyear_)
tab (expyear). gen (expyear_)
xtreg lnexports Indist cont lang ccool col landlock RTA impyear_* expyear_* year_*, robust
```

or with random effects

```
xtreg lnexports Indist cont lang ccool col landlock RTA impyear_* expyear_* year_*, re robust
```

If the bilateral variable of interest is time-varying as in the case of a dummy denoting whether countries belong to the same regional trade agreement (RTA; also see Box 3.1), you can control for fixed effects (country-pair effects)

```
xtreg lnexports RTA impyear_* expyear_* year_*, fe robust
```

or with random effects

```
xtreg lnexports Indist cont lang ccool col landlock RTA impyear_* expyear_* year_*, re robust
```

**Note:** for relatively short time periods you may want to use non-time-varying exporter and importer country effects and control for country-specific factors such as importer and exporter GDP. See section below.

**Box 3.1 Estimating trade creation and trade diversion with gravity models**

The gravity equation provides a way of looking for evidence of trade diversion through the ex-post analysis of trade flows. Suppose that countries  $i$  and  $j$  belong to a common RTA, whereas country  $k$  does not. If, after the RTA's formation,  $i$  imports more from  $j$  and less from  $k$ , trade diversion is likely. If, in contrast, country  $i$  imports more from  $j$  and  $k$ , trade creation is likely. We will see here how to make this conjecture empirically testable.

Suppose we are interested in finding out whether MERCOSUR is trade diverting or trade creating. Then, letting  $M$  denote MERCOSUR, we will construct two dummy variables:

$BothinM = 1$  if  $i$  and  $j$  are both members of MERCOSUR at time  $t$  and 0 otherwise

$OneinM = 1$  if the importer ( $i$ ) belongs to MERCOSUR but the exporter ( $j$ ) does not.

Then we estimate the augmented gravity equation:

$$\ln X_{ijt} = \beta_0 + \beta_1 I_{it} + \beta_2 I_{jt} + \beta_3 \ln(\text{dist}_{ij}) + \beta_4 \text{cont}_{ij} + \beta_5 \text{lang}_{ij} + \beta_6 \text{ccol}_{ij} + \beta_7 \text{col}_{ij} + \beta_8 \text{landlock}_{ij} + \beta_9 \text{OneinM}_{ijt} + \beta_{10} \text{BothinM}_{ijt} + \varepsilon_{ijt} \quad (3.8)$$

A positive (and significant) coefficient on both  $\beta_9$  and  $\beta_{10}$  is suggestive of trade creation; a positive on the first but negative on the second is suggestive of trade diversion.

Two important limitations related to using gravity models for estimating the impact of a RTA should be mentioned. First, RTAs may be endogenous variables. That is, the causal link between the formation of a RTA and trade flows may proceed from the latter to the former; thus RTAs are determined by rather than determine trade flows. This affects traditional gravity-based estimates and the extent of the bias may be quite large (see subsection 3.d). Second, recent literature is replete with models in which regional integration agreements are formed in the pursuit of other, non-trade goals (see, for instance, Limao, 2006) or in which they have “non-traditional” gains (see Ethier, 1998). Indeed, South–South agreements have been rather more successful in non-trade dimensions like the management of common resources than in the dimension of pure trade-liberalization. Thus a complete analysis of RTAs should avoid limiting itself to measuring trade diversion and creation, although these are important issues for the welfare of member countries.

**ii. Case b: When the interest of the research relies on the country-specific variable**

The country effects approach discussed above provides unbiased estimates of the coefficients of the gravity model but it has a notable drawback: it precludes direct estimation of the partial effects of country-specific explanatory variables. For instance, numerous gravity studies attempt to estimate the impact on trade of quality of infrastructure, quality of institutions or of the regulation system. These variables would be perfectly collinear with country-specific dummies.<sup>9</sup> In this section

we will discuss two options for addressing this problem: using time invariant exporter and importer dummies in a short sample period and calculating the remoteness variable.

### Exporter and importer dummies in a short sample period

Let's assume, for example, that we are interested in testing the relevance of a country GDP in determining trade flows.

$$\ln X_{ijt} = a_0 + a_1 \ln(\text{GDP}_{it}) + a_2 \ln(\text{GDP}_{jt}) + a_3 \ln(t_{ij}) + a_4 I_i + a_5 I_j + a_6 I_t + u_{ijt} \quad (3.9)$$

This is not perfect, however, if MRTs vary over time, which is likely – say because the geographical composition of a country's trade varies. Nevertheless, they may not vary tremendously over a reasonably short sample period (see the discussion in Baldwin and Taglioni, 2006). Note that one can add a whole lot of control variables and other variables of interest to this basic equation such as the quality of institutions and the quality of infrastructure.

```
STATA
gen lnGDPexp= ln (GDPexp)
gen lnGDPimp= ln (GDPimp)
xtreg lnexports lnGDPexp lnGDPimp lndist importer_* exporter_* year_*, robust
```

### Measuring remoteness

A method frequently used to control for the multilateral resistance terms for exporting and importing countries is to include a proxy for these indexes called “remoteness”. This is often calculated as:

$$Rem_i = \sum_j \frac{dist_{ij}}{GDP_j / GDP_w} \quad (3.10)$$

a formula that measures a country's average weighted distance from its trading partners (Head, 2003), where weights are the partner countries' shares of world GDP (denoted by  $GDP_w$ ).

There are two criticisms usually made of using this procedure: one is that it is not theoretically correct, since the only type of trade barrier that it captures is distance (Anderson and van Wincoop, 2003). The other one relates to the appropriate measure of internal distance, as the summation requires us to specify also a country's distance from itself (Head and Mayer, 2000 suggest using the square root of the country's area multiplied by about 0.4).

Recently, Baier and Bergstrand (2009) suggest estimating a linear approximation (by means of a first order Taylor series expansion) of the multilateral resistance terms, thus avoiding the non-linear procedure used in Anderson and van Wincoop (2003). Following this approach, the OLS reduced-form gravity equation is:

$$\ln X_{ij} = \beta_0 + \ln GDP_i + \ln GDP_j - (\sigma - 1) \ln t_{ij} + (\sigma - 1) \left[ \sum_j \theta_j \ln t_{ij} - \frac{1}{2} \sum_i \sum_j \theta_i \theta_j \ln t_{ij} \right] + (\sigma - 1) \left[ \sum_i \theta_i \ln t_{ij} - \frac{1}{2} \sum_i \sum_j \theta_i \theta_j \ln t_{ij} \right] \quad (3.11)$$

where time indexes have been omitted for simplicity and  $\theta$  denotes GDP shares and  $t$  trade costs. The terms in square brackets are the linear approximation of the MRTs. Intuitively, the first term in the bracket is a form of remoteness term (rather than only geographical distance the term reflects overall trade costs); the second term is a measure of world trade costs. Most importantly, this linearization shows that bilateral trade between  $i$  and  $j$  depends on the level of bilateral relative to multilateral trade costs and multilateral relative to world trade costs. Note that Bergstrand and Baier estimate equation (3.11) proxying trade costs with distance and border and  $\theta$  with  $1/N$  (where  $N$  is the number of countries).

How to calculate remoteness in STATA?

- Compute the share of GDP in world GDP

```
bys exporter year: egen gdptotal = sum(gdp)
gen gdpshare = gdp / gdptotal
```

- Compute the spatially weighted GDP share

```
bys exporter year: egen remoteness = total(dist*gdpshare)
```

- Compute the spatially weighted GDP share according to Head (2003)

```
bys exporter year: egen Remoteness_head=total(dist/gdpshare)
```

**Note:** the same procedure applies to the importer.

## b. Lessons learnt

The recent effort of economic theory to derive a theoretically founded gravity equation has identified three typical mistakes in the traditional approach. Baldwin and Taglioni (2006) call these errors the gold, silver and bronze mistakes, respectively.

**Gold medal mistake:** Traditionally, the gravity equation uses log GDPs (and possibly other variables) as proxies for the  $\ln S_i$  and  $\ln M_j$  and omits what Anderson and van Wincoop call the multilateral resistance terms or Head (2003) and Baier and Bergstrand (2007) call “remoteness”. These omitted terms are correlated with trade costs. Hence, estimations are biased.

**Silver medal mistake:** Averaging the reciprocal trade flows. The theoretically founded gravity model suggests that trade should preferably be treated separately each way (exports from  $i$  to  $j$  at time  $t$  being one observation, and exports from  $j$  to  $i$  at time  $t$  another).

**Bronze medal mistake:** Inappropriate deflation of trade flows, typically by the US aggregate price index. Gravity is an expenditure function allocating nominal GDP into nominal imports; therefore inappropriate deflation probably creates biases via spurious correlations. Note, however, that time dummies or country effects take this into account. Therefore, if you take care of the gold medal mistake, you cannot get bronze.

### 3. Advanced gravity modelling issues

#### a. The issue of zero-trade flows

A much-discussed issue is how to handle zero trade in a given year between two given countries. This is as much an estimation issue as a measurement one and affects all gravity estimation exercises. The problem stems from the fact that the standard way of estimating a gravity model is to take logarithms and estimate its log-linear version. Therefore, zero trade flows will be dropped out of the estimation as the log of zero is not defined.

Traditionally, three alternative approaches have been used to handle zero trade: (i) truncating the sample by dropping the observations with zero trade; (ii) adding a small constant (1 dollar, say) to the value of trade before taking logarithms; or (iii) estimating the model in levels.

The first methodology is correct if the zeros are randomly distributed, e.g. when zeros are random missing data or random rounding errors. The intuition for this is that these zeros are not informative, therefore they can be dropped.

However, if zero trade reported in the data is really zero trade or if it reflects systematic rounding errors associated with very small trade flows, throwing zero trade flows out of the sample will result in a loss of useful information and will yield inconsistent results. For example, if zero trade reflects, say, prohibitive transportation costs due to distance or landlockedness or the smallness of the economies involved, a density mass of observations at zero is, in this case, informative and should be treated as such.

Retaining zero trade flows in the sample requires using appropriate estimation techniques. Strategies (ii) and (iii) are incorrect if an OLS estimation method is used. First, the substitution of small values to prevent the omission of observations from the model is *ad hoc* and there is no guarantee that it reflects the underlying expected values, thus yielding inconsistent estimates. Second, the use of OLS estimation on levels is not supported by theoretically founded gravity equations that present a multiplicative form.

What estimator should be used once we have established the true zeros? The answer to this question depends partially on the reason we believe to be at the origin of the zero trade flows: zeros may also be the result of rounding errors, zeros can simply be missing observations that are wrongly recorded as zeros or zeros may be the result of firms' decision not to export.

Empirical literature on trade has adopted various approaches. One approach often used is to employ a Tobit estimator with left-censoring at zero on the log of trade plus a constant. However, the appropriateness of this approach to solving the zero trade issue has been questioned. The Tobit model reflects a situation where some observations are censored (unobservable) and recorded as zero. The model applies to situations where small values of trade are rounded to zero or actual zero trade might reflect "desired" negative trade. The censoring of trade flows below some positive value is a plausible assumption for some countries but it is hard to believe for other countries for which trade data are reported at a very high degree of accuracy. Therefore, from this perspective the use of a Tobit estimation can only be partially justified. With regard to the second hypothesis, Linders and de Groot (2006: p. 5) noted that "it is unclear which optimizing framework would justify negative desired trade, even if caused by randomly distributed factors not explicitly identified in the

model. As a consequence, the Tobit model is not the appropriate model to explain why some trade flows are missing.”

An alternative approach is to use the (Pseudo) Poisson maximum likelihood (ML) estimator. This method can be applied to the levels of trade, thus estimating directly the non-linear form of the gravity model and avoiding dropping zero trade. An influential paper by Santos Silva and Tenreyro (2006) highlights that, in the presence of heteroskedasticity (as is usual in trade data), the PPML is a robust approach. This approach has been used in a number of estimations of gravity equations, such as for example Westerlund and Wilhelmsson (2006).

In a cross section, the STATA commands to implement these techniques are:

```
gen lnexports1=ln(exports+1)
tobit ln(exports1) lndist cont lang ccol col landlock RTA exporter_* importer_*, ll(o) robust
```

Or

```
poisson exports lndist cont lang ccol col landlock RTA exporter_* importer_*, robust
```

In the case of panel data, the commands are *xttobit* and *xtpoisson*. In this case, the fixed effect option (fe) allows us to account for country-pair fixed effects.<sup>10</sup>

Most importantly, it is also possible — indeed, likely — that the probability of having positive (non-zero) trade between two countries is correlated with unobserved characteristics of that country pair. If this is the case, a selection model à la Heckman is called for. In this context, zero trade flows result from the firms’ decisions not to export to a certain market. The appropriate estimation procedure is therefore to model these decisions and correct the estimation on the volume of trade for this selection bias. As we will discuss further in subsection 3b, an important limitation in the use of the Heckman approach to solving sample selection bias is that we can only have confidence in the results if we identify a variable that explains firms’ decisions to export or not to a certain market but does not affect the volume of trade.

Before turning to a more in-depth discussion of the sample selection problem, it is worth stressing the importance of distinguishing whether zero reported trade between two countries in year  $t$  is really zero trade and not simply a reporting error. Unlike true zero trade, reporting errors should be treated either by leaving them out of the sample or by interpolating trade values before and after the missing observation (when they are sufficiently stable around a trend). The problem is that, typically, the researcher does not know what he or she is really looking at. Again, there is no perfect fix and it is a matter of judgment how zero-trade observations should be treated. In cross sections, it is virtually impossible to identify real zero trade from missing observations. In panels, a good rule of thumb is to plot the whole time series for the country pair in question. A zero-trade observation sandwiched between ones that are regularly positive should be regarded as suspect. Note that the number of reporting errors is inversely correlated with income per capita (for two reasons: because rich countries have better statistics and because their trade is also large and large numbers are less likely to go unreported). The problem also occurs more frequently when estimating gravity equations at the sectoral level (see Box 3.2) than it does at the aggregate level because it is more common to have no trade in one particular commodity than it is for the entirety of bilateral trade between two countries.

**Box 3.2 A cautionary note on gravity models with disaggregated data**

Applying the logic of the gravity equation to sectoral trade flows (trade in one particular good) is not entirely straightforward. In the monopolistic-competition model, larger countries produce more varieties of goods and that contributes to increasing their trade. That is, they do not necessarily trade more of each good but they trade more goods. Thus, the idea that trade flows between  $i$  and  $j$  in a certain sector  $k$  are increasing in  $i$ 's GDP is not necessarily warranted. Recent empirical research (e.g. Hummels and Klenow, 2005) suggests that as economies grow, trade expands both at the extensive margin (more products) and at the intensive one (more volume for each product). Thus, at the risk of finding an insignificant coefficient on exporter GDP, we are by and large justified in using the gravity framework to predict trade in one particular commodity.

When looking at sectoral trade flows, trade barriers are of particular importance. They also matter of course at the aggregate level, but aggregation of trade barriers into overall indices takes a lot of useful information out, which justifies their usual absence from aggregate gravity equations (trade barriers being bunched with country fixed effects or in the error term). When analyzing sectoral trade flows, the bad pretext of aggregation is no longer there, so trade barriers ought to be explicitly in the equation. Indeed, at the sectoral level the gravity equation becomes a good vehicle for analyzing how trade barriers affect trade flows. This is the focus of this case study, in which we will use the simultaneous presence of tariff and non-tariff barriers in the equation to derive a tariff equivalent of the latter on the basis of observed effects on trade flows.

By and large, database construction and estimation issues for sectoral trade flows are as in the previous case study, which used aggregate trade flows. It is worth keeping in mind, however, that GDPs are not always good proxies for demand and supply and that, when country fixed effects are included, they should be interacted with sectoral dummies. Two issues deserve special mention: zero trade and heterogeneity.

The issue of zero trade is of course likely to arise more frequently in sectoral trade flows than in aggregate ones. Again, how we should treat those is a matter of judgment. In some cases – say, bulky goods – frequent occurrence of no-trade country pairs will reflect prohibitive transport costs due to excessive distances or the smallness of the economies involved. A density mass of observations at zero is, in this case, informative and should be treated as such (e.g. using a Poisson or Tobit). In other cases – e.g. agricultural goods whose production requires particular local conditions, like bananas – no-trade country pairs may simply reflect the fact that neither of the countries is suitable for production of the good. For instance, there is no information in the fact that Norway and Sweden do not trade bananas. Such country pairs can be dropped altogether from the sample without information loss. Finally, zero trade flows may result from the self-selection of firms out of the export sector because of high fixed costs of export to certain destinations. In this case a model à la Heckman or – if firm-level information is available – a Tobit model with firm-specific censoring levels (as suggested in Crozet et al., 2009). Use the `cnr` (censored normal regression) command in STATA to allow for censoring values to change from observation to observation.

Finally, sectoral trade flows are likely to be more heterogeneous than aggregate ones – in which sectoral idiosyncrasies are averaged out – so outliers and heteroskedasticity should be handled with special care.

## b. Zero trade and heterogeneity

Trade theory in general assumes that firms are identical and that their behaviour can be characterized by a representative firm. These models can only explain zero trade flows as a measurement error, missing information or as the consequence of prohibitive trade costs, but these factors cannot explain the significant presence of zero trade flows in the data. Helpman, Melitz and Rubinstein (HMR hereafter, 2008) explain zero trade flows across countries in a model with heterogeneous firms, where firms differ in terms of their productivity and there are fixed costs of exporting. In this set up, variable trade costs reduce the amount that exporting firms export, while fixed entry costs reduce the probability that a firm has decided to export. Zero trade costs are associated with high bilateral fixed costs of trade. Another interesting feature of the model is that it can explain asymmetric trade flows between country pairs.

Building on the monopolistic-competition model of heterogeneous firms developed by Melitz (2003), HMR have specified a model where consistent estimates of the value of trade can be obtained following a two-stage procedure. In the first stage, a Probit equation is used to estimate the extent of firms' entry into an export market, which is an unobserved variable in the gravity equation. The first-stage Probit is estimated as:

$$\rho_{ij} = \Pr(T_{ij} = 1) = \Theta(\gamma_0 + \xi_j + \zeta_i - \gamma d_{ij} - \kappa \phi_{ij}) \quad (3.12)$$

where the probability of positive trade flows between  $i$  and  $j$ ,  $\rho$ , depends on the importer and exporter dummies ( $\xi$  and  $\zeta$ ) and bilateral trade costs, where  $d$  denotes variable trade costs and  $\phi$  denotes bilateral fixed costs of entry.

HMR's second stage equation is a gravity model of positive trade values where the results of the first stage are used to correct for the sample selection bias introduced by omitting zero trade flows (the standard Heckman correction term, the inverse of Mill's ratio) and to estimate the (unobserved) share of firms selecting into the export market. The gravity equation augmented by these terms is:

$$x_{ij} = \beta_0 + l_j + l_i - \gamma d_{ij} + \ln \left\{ \exp \left[ \delta (z_{ij} + \eta_{ij}) \right] - 1 \right\} + \beta_\eta \eta_{ij} + e_{ij} \quad (3.13)$$

where  $l_j$  and  $l_i$  denote the exporter and importer individual effects and the term in the curly brackets is the estimator for the share of firms that export to  $i$ ,  $z$  is the fitted variable for the latent variable from the first-stage Probit and  $\eta$  is the inverse Mill's ratio.

Since equation (3.13) is nonlinear in  $\delta$ , it is estimated using non-linear least squares.

Note that there are several estimation issues related to the use of HMR methodology. First, the use of the Probit with fixed effects in the first stage estimation may induce the so-called "incidental parameters problems", which lead to inconsistent estimation of all parameters of the model, especially in short panels. One possible solution is to use random effects (see Cameron and Trivedi, 2005, p. 786). Second, the estimation of the HMR model requires exclusion restrictions (i.e. the cost variables that enter into the first stage, but not into the second stage equation) to help identification, as regressors are allowed to have different effects on the extensive and the intensive

margin of trade. However, HMR suggest using regulation costs of firm entry or a variable denoting the degree of communality of religion; recent studies suggest that the HMR Probit model is wrongly specified (see Santos Silva and Tenreyro, 2009).

Third, the estimation of the second stage regression may have problematic results in a large sample because of the large number of exporter and importer dummies required. To solve the problem, it may be necessary to use other software.

Notwithstanding these limitations, we provide below the main commands to run the HMR model in STATA. Furthermore, an illustrative example of the HMR estimation method is provided in the application.

```
STATA commands
/* first stage, probit */
probit rho ldist contig colony comlang_off religion xi_* zeta*, robust
* Compute the inverse Mills ratio
predict z_hat, xb
predict pr, pr
gen pdf_z_hat = normalden(z_hat)
gen cdf_z_hat = normprob(z_hat)
gen eta_hat = pdf_z_hat / cdf_z_hat
/* Second stage, non-linear estimation*/
nl (limport = {constant} + {xb: ldist contig colony comlang_off xi1-xiN zeta1-zetaN} +
{etastar}*z_hat + ln(exp(exp({delta=1})*( z_hat + eta_hat )) - 1) ), vce(robust)
*notice the variable religion, the identifier, is not in the second stage
```

### c. Measuring overall trade costs and calculating the tariff equivalent of non-tariff barriers

Although the gravity equation is typically used to measure the impact of trade costs on bilateral trade flows, it can also be used in reverse to measure bilateral trade costs and to decompose trade costs into a tariff and non-tariff component (Head and Ries, 2001; Jacks et al., 2008; Novy, 2009). The idea is to solve a theoretical gravity equation for the trade costs term instead of trade flows and to express these costs as a function of the observable trade data. The advantage of this approach compared with the alternative approaches based either on price differences across border<sup>11</sup> or on direct measures of certain trade costs is the lighter data requirement. It is indeed hard to get reliable price data on comparable goods in different countries as well as ascertaining many trade cost components.

Algebraically, the expression for trade costs is readily obtained. The first step is to use the gravity equation (3.2) to find an expression for country *i*'s intra-national trade:

$$X_{ii} = \frac{Y_i Y_i}{Y} \left( \frac{t_{ii}}{\Pi_i P_i} \right)^{1-\sigma} \quad (3.14)$$

where  $t_{ii}$  represents intra-national trade costs such as domestic transportation costs. In particular, equation (3.14) implies that intra-national trade does not only depend on a country's economic size but also on multilateral resistances. In particular, the closer is an economy the higher the intra-national trade.

The second step is to multiply the gravity equation (3.2) for  $X_{ij}$  by the corresponding gravity equation for trade flows in the opposite direction  $X_{ji}$ ,  $X_{ji} = Y_j Y_i / Y (t_{ji} / \Pi_j P_i)^{1-\sigma}$ , replace (3.14) into this expression and rearrange for trade costs. The resulting expression for trade costs is:

$$\frac{t_{ij} t_{ji}}{t_{ii} t_{jj}} = \left( \frac{X_{ij} X_{jj}}{X_{ji} X_{ji}} \right)^{\frac{1}{\sigma-1}} \quad (3.15)$$

The tariff equivalent of bilateral trade costs relative to domestic trade costs can be expressed as the geometric average of trade barriers in both directions:

$$\tau = \left( \frac{t_{ij} t_{ji}}{t_{ii} t_{jj}} \right)^{\frac{1}{2}} - 1 \quad (3.16)$$

denoting the extent to which international trade is more costly than domestic trade, i.e. bilateral trade costs relative to domestic trade costs. Following this approach, overall trade costs are derived from the gravity equation without imposing a cost function. Furthermore, it is neither assumed that domestic trade costs are zero nor that they are the same across countries ( $t_{ii}$  may differ from  $t_{jj}$ ) nor that bilateral trade costs are symmetric ( $t_{ij}$  may differ from  $t_{ji}$ ).

Novy (2009) shows that similar trade costs measures can be obtained from a variety of models. The difference is in the sensitivity of the implied trade costs to trade flows. This depends on the degree of product differentiation in the Anderson and van Wincoop (2003) model, whereas it depends on the heterogeneity of countries' relative productivities in a Ricardian model and on the degree of firm heterogeneity in a heterogeneous firms model.

Using trade flows data, equation (3.15) can be used to estimate the overall trade costs, i.e. including both tariff and non-tariff barriers. Note, however, that the precise estimate for the *level* of trade cost depends on the parameter of the elasticity of substitution  $\sigma$  (or the parameter denoting the degree of productivity heterogeneity across firms or across countries), while *changes* over time do not. Since there is no consensus in the literature concerning the exact value of these parameters (in general, assumed to fall in the range from 5 to 10 – see Anderson and van Wincoop, 2004), it may be less controversial to look at *changes* of trade costs over time that – changes in elasticity apart – are not affected by the level of the elasticity.

The difficulty in calculating equation (3.15) is to get figures for intra-national trade. One approach is to estimate these figures as the difference between production and exports (see Wei, 2006 and Novy, 2009). The use of GDP instead of production data tends to overstate intra-national trade, and therefore trade costs, because a growing share of GDP is services – largely non-tradable.

Under the specific assumption that domestic trade costs are zero and bilateral trade costs are symmetric (as implied by taking the geometric average as measure of bilateral trade costs), it is also possible to decompose overall trade costs (as calculated from equation (3.15)) into their various cost components by assuming an arbitrary trade cost function, such as for example the log-linear

version of equation (3.6). For instance, it is possible to decompose overall trade costs into their tariff and non-tariff components simply by estimating:<sup>12</sup>

$$\ln \tau_{ij} = \delta_1 \ln(\text{distance}_{ij}) + \delta_2 \ln(1 + \text{tariff}_{ij}) + \delta_3 \text{NTB}_{ij} + \varepsilon_{ij} \quad (3.17)$$

where  $\text{NTB}_{ij}$  is a dummy that denotes the existence of an NTB. Head and Ries estimate the effect of non-tariff barriers (defined to comprise all barriers other than tariffs including transportation costs, home bias, TBTs, etc.) with year dummies. Jacks et al. (2008) estimate a similar equation with random effects as well as year dummies.

```
STATA commands
gen internal_tradeii=productionii-totalexportsi
gen lntotal_trade_costs = ln(exportsij/internal_tradeii * exportsji/internal_tradejj)
regress lntotal_trade_costs lndist lntariff lnNTB
```

In order to calculate the tariff equivalent of a quota, we only need to calculate the tariff that has the same impact on trade costs as a quota.

$$\text{tariff equivalent}^{13} = \exp(\delta_3/\delta_2) - 1 \quad (3.18)$$

Refer to application 2 to further explore this issue.

#### d. Endogeneity

A problem of endogeneity often arises in gravity models when estimating the impact of trade policies. The typical example is that regional trade agreements (RTAs) are unlikely to be purely exogenous: Countries are likely to form RTAs with partners with which they already trade a lot (following the “natural trading partners” hypothesis). If this is the case, the RTA dummy on the right-hand side of the gravity equation is correlated with the error term because unobserved characteristics of some pairs of countries explain why they trade a lot and at the same time make it more likely that they would form a RTA. Reverse causality apart, endogeneity issues may arise because of omitted variable bias. That is, it may be that RTAs are signed by countries that have other characteristics omitted in the regression (peaceful relationship, common legal origin, etc.) that facilitate trade.

There is not an easy fix to the problem of endogeneity of RTA. In a panel the use of (country-pair) fixed effects can help to overcome part of the endogeneity problem due to the omitted variable bias, although time-varying omitted variables remain a problem.

In general, one would like to use an instrumental variable (IV) approach. The usual problem with IV techniques is finding instruments that are correlated with the PTA dummy but not with trade. There is, unfortunately, no perfect solution to this problem. An instrumental-variable technique developed by Hausman and Taylor (1981) can be used; alternatively, one can use the Generalized Method of Moments (GMM) estimation, in particular system GMM where lagged levels are used as instruments for current differences and vice versa. GMM estimates are, however, typically sensitive to the number of lags used.

Alternatively, endogeneity may be addressed by trying to identify a natural experiment. For example, Frankel (2010) uses the case of the 14 CFA countries as a natural experiment to study the impact

of a currency union on trade. Using firm level data, one may want to remove large firms and study the impact of a RTA on the trade of small firms, as entry in an RTA is likely to be exogenous to small firms' trade. Another way would be to look at the impact of RTAs on the extensive margin of trade.

Recent analysis of the effects of FTA on trade has been using nonparametric (matching) econometric techniques (Baier and Bergstrand, 2006). Other studies have used Probit models to estimate the likelihood that an RTA is formed between two countries; these models use economic and political economy determinants of RTAs (e.g. Mansfield and Reinhardt, 2003; Baier and Bergstrand, 2004; Mansfield et al., 2008). However, these approaches mainly solve for selection bias rather than endogeneity.

#### 4. Data sources

Estimation of a gravity equation requires data on bilateral trade, GDPs, distances, tariffs and possibly other determinants of bilateral trade including contiguity (common border), common language, colonial ties, exchange rates and so on. There is a wealth of databases from which the researcher can draw on for these variables.

As discussed in Chapter 1, bilateral trade flows can be found in the IMF's DOTS, in COMTRADE, in BACI or in the World Bank's Trade, Production and Protection database by Nicita and Olarreaga.<sup>14</sup> In a gravity model, trade flows are typically expressed in current international prices (dollars) and import statistics are generally preferred to export statistics. Sources for tariff data include TRAINS, IDB and CTS.<sup>15</sup> Data on NTBs can be found in TRAINS and Kee, Nicita and Olarreaga.<sup>16</sup>

GDPs in current dollars, converted at current exchange rates, can be found in the IMF's International Financial Statistics (IFS) and in the World Bank's World Development Indicators (WDI; available online) together with a wealth of other indicators. Additional relevant data can also be found in the Penn World Tables (PWT),<sup>17</sup> which currently include time series such as:

- population
- real GDP per capita, in constant dollars and relative to the US at PPP, and growth rates
- exchange rates
- decompositions of national expenditure (consumption, investment and government expenditure, with price indices for each)<sup>18</sup>
- openness (in current and constant prices)
- ratio of GNP to GDP
- current savings.

The PWT in their original form are described in Summers and Heston (1991). The current version, PWT 6.3, covers 189 countries over the years 1950–2007. Not all series are available in PWT 6.3 so earlier versions may be used, but the user should be aware of changes in the base year (2005 in version 6.3, 2002 in version 6.2, 2000 in version 6.1, 1996 in version 6.0 and 1985 in version 5.6).

A complete gravity database is available on the website of Thierry Mayer.<sup>19</sup> A good source of macro data already in STATA is the MACRODAT for STATA website.<sup>20</sup> Some gravity covariates datasets

are available at Andrew Rose's and CEPII's websites.<sup>21</sup> These include bilateral distances — typically the “great-circle” distances between capitals, i.e. the shortest distances measured on the earth's surface irrespective of actual highways or sailing routes — common language, common border, whether either country is an island, whether either country is landlocked, etc. See Haveman's webpage.<sup>22</sup> Information on existing RTAs and the year of their entry into force as well as some of the contents of RTAs can be found at the WTO website.<sup>23</sup>

## C. Applications

### 1. Building a database and estimating a gravity model

Estimation of a gravity equation requires a substantial upfront investment in data collection and organization of the data. One reason is that the estimation of a gravity model typically involves a large database. This has an advantage and a drawback. The advantage is that with a large sample, estimation is typically precise and stable. The drawback is that large samples are cumbersome to work with and use up computing power.

The large size of the typical database of a gravity model is due to the basic principle that even if the researcher is interested only in the factors influencing a particular trading relationship — say, whether the creation of a certain free trade area has diverted trade from a certain country — the effect should be measured on the basis of a gravity equation estimated for *all* countries, not just the countries involved. In addition, gravity equations can be estimated for either cross sections or panels of countries. In the first case, the unit of observation is a pair of countries; so with  $n$  countries there are  $n(n-1)$  observations. In the second case the unit of observation is a pair of countries in a year, so there are  $Tn(n-1)$  observations with  $T$  being the number of time periods covered by the panel. Thus sample size in a gravity equation is typically very large (in a panel of 100 countries over 10 time periods, there are 100,000 observations).<sup>24</sup> However, whenever possible panels should be preferred.

Another difficulty related to building a database for a gravity model is that data from a variety of different data sources (see subsection B.4) have to be merged in a single database. Since data may be available in different formats or classifications, the researcher needs to invest some time in organizing this information. This section helps to address some of the problems that may emerge in this process.

As an example of the typical steps required to build a database for the estimation of a gravity model, we describe here the simple case of a standard gravity model estimated on data aggregated at the country level and augmented with a dummy denoting WTO membership (see Rose, 2004). For this purpose we extract raw data for bilateral trade for the period 1990–2005 from the UN COMTRADE, GDP data for the same time period from the World Bank World Development Indicators, the set of bilateral covariates (distance, common language, border and so on) from the CEPII website and get information on the GATT/WTO accession from the WTO website. The do files we will refer to in this subsection are provided in the folder “Chapter3\Applications\1\_Building a database and estimating a gravity model”.

For illustrative purposes we will distinguish nine steps:

### Step 1: Import data into STATA

While data from CEPII are provided in STATA format, data on GDP, trade flows and WTO accession are in .txt, .csv or .xls format (data can be found in the folder *Datasets/Original* or *Datasets/Stata*). Obviously, we will need to import the data in STATA to be able to manipulate them. Provided that all data are in STATA format, we can proceed with the data manipulation. Note that since data on GDP are provided for the Benelux region rather than Belgium and Luxembourg separately, we will need to adjust all covariate variables for which data are available for the two countries separately in a way that matches GDP data. There are different methodologies to match covariate data to GDP data: (1) to pick one of the two countries as representative of the region, (2) to take the average of the variable (e.g. distance) between the two countries. In the do file we will show the commands for this matching.

To import data in STATA use the “insheet” command.

```
insheet tradeflows.csv, clear
save tradeflows.dta
insheet joinwto.csv, clear
save joinwto.dta
```

### Step 2: Create all possible country-pairs–year combinations

Let’s first check whether the data on bilateral trade flows are correct and complete. It is always good first to check randomly that the data have been properly put in. For this you should randomly select some observations and go back to the original dataset to verify whether they are correct.

Then, you may want to get a complete database of bilateral trade including zero trade flows. The command *fillin* in STATA will create all possible country-pair–year combinations. You must end up with  $n \times n \times T$  observations, where  $n$  is the number of countries and  $T$  the time period. Then, if you accept the assumption that all non-reported information is zero (Helpman et al., 2007 adopt this approach), you may want to replace all missing observations with zeros.

```
use tradeflows.dta, clear
fillin importer exporter year
replace imports=0 if imports=.
```

### Step 3: Reshape and merge country-specific data with bilateral trade flows

In our database each observation is identified by three indicators: importer, exporter and the year. Trade data are in “long” format, i.e. information for each variable is displayed in the form of a vector.

Data on GDP extracted from WDI are instead in “wide” format, i.e. they are in the form of a matrix  $n \times T$ . Before merging GDP country-specific data into our database we need to transform the matrix into a vector data form. The command *reshape* in STATA allows this transformation (note in the reshape command the letters  $i, j$  are used to indicate the cross section and the time dimension of the observations). In particular, given a file where the GDP figures of countries A, B, C for various years, say 1990–1992, are reported in columns named as *gdpyear*. That is, given a file of the form:

```
(wide form)
i ..... variable_ij .....
country gdp1990 gdp1991 gdp1992
-----
A 5000 5500 6000
B 2000 2200 3300
C 3000 2000 1000
```

we can reshape it as:

```
(long form)
i j variable_ij
country year gdp
-----
A 1990 5000
A 1991 5500
A 1992 6000
B 1990 2000
B 1991 2200
B 1992 3300
C 1990 3000
C 1991 2000
C 1992 1000
```

by simply using the command

```
reshape long gdp, i(country) j(year)
```

Country-specific information (e.g. GDP data in long format) can be merged into the bilateral database with trade flows information over time. However, you need to specify whether the data refer to the exporting or the importing country before merging. A simple way to do this is to save the data on GDP twice: the first time you will refer to the variable country as the exporter and save the file as `gdp_exporter`, the second time you will refer to the country as the importer and save the file as `gdp_importer`. In STATA, simply use the commands:

```
use gdp.dta, clear
rename country exporter
rename gdp gdp_exporter
sort exporter year
save gdp_exporter.dta
use gdp.dta, clear
rename country importer
rename gdp gdp_importer
sort importer year
save gdp_importer.dta
```

Now you can merge the two GDP data files with trade flows. Recall that you need to sort data by the variable you intend to use to match observations in the two databases. For example, to merge the file with data for GDP for the exporting country use the STATA commands:

```
use tradeflows, clear
sort exporter year
merge exporter year using gdp_exporter /*gdp_exporter must be sorted by exporter year*/
save gravity
```

The same procedure can be used to merge the database with the information about a country's year of accession to the WTO.

#### *Step 4: Merge with pair-specific data*

Use the command *merge* in STATA to merge bilateral covariates from CEPII. As an alternative it would be possible to use *joinby*. The advantage of using *merge* is that STATA in this case automatically creates an additional variable called “merge\_” that allows you to check that all observations across databases match. Note that since the information does not vary over time, the importer and exporter identifiers are the only matching variables.

```
use gravity.dta, clear
sort exporter importer
merge exporter importer using cepii.dta /*cepii.dta must be sorted by exporter and importer*/
```

#### *Step 5: Generate new country-pair variables*

Bilateral variables can be generated using country-specific information. Suppose, for example, that like Rose (2004) we want to study the impact on trade of WTO accession. Provided that we have information on the year in which a country joins the WTO, we can easily generate a set of variables that denote whether both the exporter and the importer are WTO members (Bothin) or only one of the two countries is a WTO member (Onein).

```
/*Generate dummies for WTO membership status */
gen onein=0
gen bothin=0
replace onein=1 if (join_exporter<=year & join_importer>year) | (join_importer<=year & join_
exporter>year) /* the symbol | corresponds to the operator “or” */
replace bothin=1 if (join_exporter<=year & join_importer<=year)
```

#### *Step 6: Generate dummies*

As discussed above a simple way to obtain unbiased estimations of a gravity equation is to use country fixed effects. In a cross section (e.g. when data are only available for a certain year), it is possible to use country dummies on the exporter and importer side — often called “country fixed effects” — because the unit of observation in a gravity model is a pair of countries, not a country. Hence, while there are  $n^2$  observations in a cross section, there will be  $n$  country dummies on the exporter side and  $n$  on the importer side using a total of  $2n$  (clearly less than  $n^2$ ) degrees of freedom. Note, however, that using exporter and importer fixed effects in a cross section, you will not be able to estimate the coefficients on country-specific variables (e.g. GDP) due to perfect collinearity.

```
/* Country dummies */
tab exporter, gen(exporter_)
tab importer, gen(importer_)
```

In a panel, time effects (a set of dummy variables, one for each year) should be included in order to control for global economic effects (booms or slowdowns in the global economy). In addition, a set of time-varying fixed effects both for the exporter and the importer should be included to control for the time-varying multilateral resistance terms. Again, note that time-varying fixed effects are perfectly collinear with time-varying country-specific variables. Therefore, they render estimation of the impact of country-specific variables such as GDP impossible.

```
/*Time dummies*/
tab year, gen(year_)
```

```
/*Country-time dummies*/
tab gdp_exporter, gen(exporteryear_)
tab gdp_importer, gen(importeryear_)
```

There may be circumstances when estimates may be improved by using country-pair effects. Assume, for example, that there is a monopoly over shipping lines between two countries. This would reduce trade between those two but would not affect the trade of each of the two with third countries. It would therefore not be controlled for by country effects. Country-pair dummies can be easily generated in STATA:

```
/*Pair dummies*/
egen pairid = group(importer exporter)
tab pairid, gen(pair_)
```

Note that in a panel it is possible to model country-pair factors as random rather than fixed effects (see Brun et al., 2005 or Carrère, 2006).<sup>25</sup> This approach preserves the possibility of estimating separately the effect of bilateral factors such as distance, common borders etc. that would otherwise be confounded with the fixed effects. However, as with country effects, random-effect estimation bunches unobserved country-pair characteristics in the error term. If they happen to be correlated with some of the regressors (like GDPs), estimates are inconsistent. This can be tested for by using a Hausman test.

Table 3.1 shows a snapshot of the STATA editor with gravity database.

### *Step 7: Data transformation*

Typically, the estimated gravity equation takes a log-linear form. We therefore need to take the natural logarithm of the continuous variables in the equation (i.e. except dummies). Note that in so doing the zero trade flows will drop out of the sample.<sup>26</sup>

```
gen limports=ln(imports)
/* idem for gdp exporter, gdp importer and distance*/
```

Table 3.1 Excerpt from an illustrative gravity database

Importer	Exporter	Year	Imports	GDP_Exporter	GDP_Importer	Dist	Onein	Bothin	Nonein
IDN	BRU	1999	9.659	3.324e+09	1.409e+11	16932.21	0	1	0
IDN	BOL	1999	119.247	8.285e+09	1.409e+11	17453.36	0	1	0
IDN	BFA	1999	114304.1	6.878e+11	1.409e+11	18644.48	0	2	0
IDN	BRE	1999	.85	2.428e+09	1.409e+11	18349.78	0	1	0
IDN	BKN	1999	37654.51	4.600e+09	1.409e+11	15371.113	1	0	0
IDN	BTN	1999	0	1.967e+06	1.409e+11	4169.54	1	0	0
IDN	BWA	1999	0	3.821e+09	1.409e+11	9807.18	0	1	0
IDN	CAT	1999	3763.993	1.051e+09	1.409e+11	9847.057	0	1	0
IDN	CAN	1999	421146.6	4.618e+11	1.409e+11	15815.39	0	1	0
IDN	CHE	1999	111274	2.498e+11	1.409e+11	11212.49	0	1	0
IDN	CHL	1999	88932.25	7.700e+10	1.409e+11	15614.28	0	1	0
IDN	CHN	1999	1142141	1.608e+12	1.409e+11	5220.679	1	0	0
IDN	CTV	1999	40985.74	1.254e+10	1.409e+11	12373.43	0	1	0
IDN	CMR	1999	2789.479	1.049e+10	1.409e+11	10840.49	0	1	0
IDN	COG	1999	16.811	2.754e+09	1.409e+11	10134	0	1	0
IDN	COL	1999	1768.134	8.638e+10	1.409e+11	19772.34	0	1	0
IDN	COM	1999	31.135	2.229e+08	1.409e+11	6991.042	0	1	0
IDN	CPV	1999	46.421	9.934e+09	1.409e+11	14914.71	1	0	0
IDN	CRI	1999	142.145	1.588e+10	1.409e+11	18747.43	0	1	0
IDN	CUB	1999	137.164	.	1.409e+11	17993.41	1	0	0
IDN	CYM	1999	0	.	1.409e+11	18314.11	1	0	0
IDN	CYP	1999	69.655	5.788e+09	1.409e+11	8922.731	0	1	0
IDN	CZE	1999	10698.94	4.019e+10	1.409e+11	10705.16	0	1	0

*Note:* The variables are, in the order in which they appear on the table:

<i>importer</i>	<i>The exporter's 3-letter ISO code (here Indonesia)</i>
<i>exporter</i>	<i>The importer's 3-letter ISO code</i>
<i>year</i>	<i>Year</i>
<i>imports</i>	<i>Imports value (one way), in dollars</i>
<i>gdp_exporter</i>	<i>The exporter's GDP (from WDI or PWT) in current dollars</i>
<i>gdp_importer</i>	<i>The importer's GDP (from WDI or PWT) in current dollars</i>
<i>dist</i>	<i>Distance between the importer and exporter countries (from CEPII database)</i>
<i>onein</i>	<i>Only one of the two countries in the pair is a WTO member</i>
<i>bothin</i>	<i>Both countries in the pair are WTO members</i>
<i>nonein</i>	<i>None of the two countries in the pair are WTO members</i>

It is important to recall that if you need to average flows over a certain period, theoretical foundations suggest that when you are averaging, the log transformation should come first (this is a geometric mean).

```

/*period (5 year) averages */
gen period=1
replace period=2 if year<2000 & year>=1995
replace period=3 if year>=2000
gen limports=ln(imports)
collapse (mean) limports lgdp_exporter ldist, by(period) /* non-time varying covariates can also be added
to the variable list*/
save av_gravity

```

### Step 8: Identify the panel and run regressions

Panel data refer to the situation when information on bilateral trade flows is available over time. Once the individual and time dimensions of the panel have been identified, a number of easy commands in STATA allow you to generate lag variables or growth rates. The command *xtdes* allows you to describe the pattern of panel data, e.g. whether the panel is balanced or not.

```
use gravity.dta, clear
/* to identify the dimension of the panel*/
xtset pairid year
/*generate the first-lag variable of imports*/
gen Limports=L1.imports
/* generate the growth rate of import*/
gen Gimports=imports-Limports
```

Now the database is ready for you to run regressions. Look at the discussion above on estimation methods and the STATA commands *reg*, *tobit*, *ivreg*, *heckman*, *poisson*, *nl* along with their time series versions (e.g. *xtnl*, *xttobit*, *xtpoisson*). For example, the simplest gravity model

```
*for a cross section
xi: reg lnimports lndist other covariates i.exporter i.importer if year=2000, robust
```

```
* for a panel
xtreg lnimports lndist other covariates exporter_ * importer_ * year_ *, robust fe /* where the option fe
provides for country-pair fixed effects*/
```

### Step 9: Presenting and interpreting regression results

Professional presentations of regression results should always include the following information:

- dependent variable
- unit of observation (country pair, country pair/time)
- number of observations
- estimation method
- for each estimation method, a list of coefficient estimates in column with t-statistics (preferably to standard errors for ease of interpretation) in parentheses below, and variable names that the reader can comprehend
- indications of what sets of dummy variables were used (fixed effects, time effects, etc.) without typically reporting estimates on those
- R-squared and standard tests (depending on the case, over-identification, properties of residuals like homoskedasticity or absence of serial correlation, etc.).

A special STATA package called “outreg2” that makes it fast and easy to present results in the standard way (parameter estimates with t-stats in parentheses below, stars for levels of significance, and variable labels instead of names, which improves readability) can be freely downloaded from the web using the “findit outreg2” command in STATA.

As gravity estimates of the influence of distance and GDPs on trade have proved remarkably stable across studies, they provide checks to determine how reasonable the estimates are from a new study. Most of the variables are expressed in natural logarithms, so coefficients obtained from linear estimation can be read directly as elasticities. The elasticity of trade to distance, for instance, is usually between  $-0.7$  and  $-1.5$ , so a 10 per cent increase in distance between two countries cuts their trade, on average, by 7 to 15 per cent. Elasticities with respect to importing-country GDPs are also typically unitary, suggesting unitary income elasticities of imports at the aggregate level. Estimates departing significantly from these orders of magnitude would signal that something is probably wrong in either estimation or measurement.

Note, however, that while the coefficients for the natural logarithm of continuous variables (e.g. GDP, distance) are elasticities, the coefficients for the dummies (such as a dummy denoting whether two countries belong to the same trade agreement) are not. They need to be transformed as follows in order to be interpreted as elasticities: elasticity =  $\exp(a) - 1$  where  $a$  is the estimated coefficient of the dummy variable.<sup>27</sup> As stressed by Anderson and van Wincoop (2003) and Feenstra (2004), however, the multilateral resistance terms are essential in order to estimate the general equilibrium, for instance comparative static effects on bilateral trade of the existence of a regional trade agreement between two countries. Once estimated with a gravity model, one would need to retrieve estimates for the multilateral resistance terms  $\Pi_i$  and  $P_j$  of equation (3.2) with and without a regional trade agreement and derive the effect of a regional trade agreement on trade using the equation:

$$\text{elasticity} = e^a \left( \Pi_i^{1-\sigma} / \Pi_i^{1-\sigma} \right) \left( P_j^{1-\sigma} / P_j^{1-\sigma} \right) - 1 \quad (3.19)$$

where  $*$  denotes the estimate of the multilateral resistance term for the two countries without a regional trade agreement.

## 2. Measuring the effect of NTBs

As shown in subsection B.3, gravity models can be used to retrieve the tariff equivalent of non-tariff barriers. In this application we will study the case of the European Union (EU) bananas regime as an example of a special regime combining tariffs and quotas. While the theoretical arguments have been presented for a general case, in practice economic literature generally assumes symmetric trade costs, zero domestic trade costs and that trade costs are of the form specified in equation (3.6) for estimating tariff equivalents. This application will retain these assumptions. Data and do files can be found in the folder "Chapter3\Applications\2\_Measuring the effect of NTBs".

Let  $\tau_{ijt}$  and  $Q_{ijt}$  be respectively any tariff and quota imposed by  $j$  on  $i$  in the sector in question (here bananas) at time  $t$ , and other variables be as before. In its general formulation, a gravity equation estimated at the sectoral level looks like this:

$$\ln X_{ijt} = \beta_0 + \beta_1 \ln(1 + \tau_{ijt}) + \beta_2 \ln Q_{ijt} + \beta_3 \ln GDP_{it} + \beta_4 \ln GDP_{jt} + \beta_5 \ln dist_{ij} + \beta_6 I_j + \beta_7 I_i + \sum_{\ell=1}^T \beta_{T+\ell} I_{\ell} + u_{ijt} \quad (3.20)$$

Note that 1 has been added to the tariff because, the equation being in logs, zero tariffs would send the log to minus infinity whereas  $\ln(1) = 0$ .

Table 3.2 gives regression results for a gravity equation estimated for worldwide banana trade over 1989–2004. In particular, regression results are reported for the case in which exporter and importer exchange rates. The dummy for the Framework Agreement and ACP countries are included as control variables to account for these countries' preferential regime. Observe first that, as usual, row headings indicate the name of the explanatory variable. Thus, for example, the number  $-1.150$  that appears in column 1 and in the row market " $\ln(1 + \tau)$ , applied" is the estimated value for the coefficient  $\beta_1$  in the equation above and gives an approximation to the price elasticity of importing countries' demand for bananas, estimated "on average" for all years and countries.<sup>28</sup> With sufficiently many countries and no domestic production in the importing countries, it is also the elasticity of substitution.

The elasticity of banana trade flows relative to distance is close to unity, as in most gravity equations (however, the present exercise cannot be directly compared in this regard with standard gravity estimates as we are dealing with a single commodity with special transport arrangements). The elasticity with respect to the importing country's GDP can be taken as a rough approximation of the income elasticity of banana consumption (since there is no domestic production in most importing countries) and is less than unity (between 0.72 and 0.84 depending on the estimation method). This is probably a slight underestimate, since the share of bananas in household budgets tends to rise with income (bananas are a "luxury").

Exchange rates are significant and with the expected sign for exporter countries (banana exports go up when the exporting country's currency depreciates *vis-à-vis* the dollar) but not for importing countries. With the exception of the Framework Agreement dummy, special-regime variables are highly significant and with the expected sign.

We can now use these estimates to retrieve the tariff equivalent of the quota. Let us use hats over variables for estimated coefficients and predicted trade values. Labelling  $Z_{nt}^{ij}$  the explanatory variables other than the quota and bunching together the other coefficients from  $\beta_0$  to  $\beta_5$ , we have

$$\ln \hat{X}_{ijt} = \sum_{n \neq 2} \hat{\beta}_n Z_{ijnt} + \hat{\beta}_2 Q_{ijt} \quad (3.21)$$

Note that  $Q_{ijt}$  is equal to one if a quota applies and zero otherwise. Thus, the predicted difference in trade between a country pair *with* a quota and the same country pair *without* the quota would be

$$\begin{aligned} \ln \hat{X}_{ijt, quota} - \ln \hat{X}_{ijt, noquota} &= \sum_{n \neq 2} \hat{\beta}_n Z_{ijnt} + \hat{\beta}_2 (1) - \left[ \sum_{n \neq 2} \hat{\beta}_n Z_{ijnt} + \hat{\beta}_2 (0) \right] \\ &= \hat{\beta}_2 \end{aligned} \quad (3.22)$$

A similar calculation can be performed for the effect of a tariff at rate  $\tau_t^{ij}$  compared to no tariff at all:

$$\begin{aligned} \ln \hat{X}_{t, tariff}^{ij} - \ln \hat{X}_{t, no tariff}^{ij} &= \sum_{\ell \neq 4} \hat{\beta}_\ell Z_{\ell t}^{ij} + \hat{\beta}_4 (\ln(1 + \tau_t^{ij})) - \left[ \sum_{\ell \neq 5} \hat{\beta}_\ell Z_{\ell t}^{ij} + \hat{\beta}_4 (1) \right] \\ &= \hat{\beta}_4 \ln(1 + \tau_t^{ij}) \end{aligned} \quad (3.23)$$

**Table 3.2 Gravity estimates, banana market**

<i>Dep. var.: trade value</i>	<i>OLS</i>	<i>OLS robust</i>	<i>OLS robust</i>	<i>iterative</i>	<i>iterative</i>
1n(1+ $\tau$ ), applied	-1.150** -0.488	-1.150** -0.497		-1.261*** -0.469	
1n(1+ $\tau$ ), unconstrained			-1.195** -0.582		-1.136** -0.537
1n(1+ $\tau$ ), constrained			-1.065 -0.675		-1.486** -0.69
MFN quota dummy	-0.671*** -0.163	-0.671*** -0.165	-0.691*** -0.205	-0.515*** -0.157	-0.459** -0.2
Framework Agr. dummy	0.426 -0.29	0.426 -0.321	0.428 -0.322	0.395 -0.278	0.387 -0.279
ACP dummy	1.046*** -0.218	1.046*** -0.24	1.044*** -0.24	0.993*** -0.21	0.997*** -0.21
Ivory Coast * time trend	0.0871 -0.0652	0.0871 -0.0756	0.0877 -0.0754	0.157** -0.0627	0.156** -0.0628
Cameroon * time trend	0.211*** -0.0743	0.211*** -0.0787	0.212*** -0.0788	0.260*** -0.0714	0.258*** -0.0716
log distance	-1.119*** -0.0631	-1.119*** -0.0753	-1.119*** -0.0753	-1.269*** -0.0607	-1.271*** -0.0607
log importer's GDP	0.852*** -0.28	0.852*** -0.303	0.853*** -0.304	0.729*** -0.269	0.723*** -0.269
log exporter's GDP	0.178 -0.219	0.178 -0.222	0.177 -0.222	0.251 -0.21	0.252 -0.21
log importer's exch. rate	-0.0514 -0.0884	-0.0514 -0.0793	-0.0511 -0.0794	-0.0335 -0.0851	-0.0346 -0.0851
log exporter's exch. rate	0.0701** -0.032	0.0701** -0.0274	0.0703** -0.0274	0.0859*** -0.0308	0.0854*** -0.0308
Constant	-14.44* -8.063			-321.5** -125.8	-11.74 -7.754
Observations	6,983	6,983	6,983	6,969	6,983
R-squared	0.58	0.81	0.81	0.62	0.62
Cook-Weisberg chi-sq.	4.03				
<b>Implied tariff equiv.</b> <b>(€/ton)</b>	<b>346</b>	<b>346</b>	<b>343</b>	<b>221</b>	<b>158</b>

*Source:* Author calculations

*Notes:* Iterative estimates (fourth and fifth columns) were obtained using STATA's *rreg* procedure, which uses iteratively reweighted least squares with Huber and biweight functions, where the more extreme an outlier is, the less heavily it gets weighted in the regression calculations. Very extreme cases get dropped altogether. An alternative is *qreg* (quantile regression), whose most common form is median regression. Median regression, also called Least Absolute Value regression, minimizes the sum of the absolute value of the residuals rather than their squares, thus giving less weight to outliers. The Cook-Weisberg test statistic shows that the homoskedasticity assumption is rejected at the 10% level. The variable labelled "1n(1+ $\tau$ ), applied" uses the tariff applied on bananas by importing countries, irrespective of other measures they may have. The variable labelled "1n(1+ $\tau$ ), constrained" uses the tariff applied by the EU on dollar bananas post-1994; the variable labelled "1n(1+ $\tau$ ), unconstrained" uses the tariff applied in all other cases.<sup>29</sup>

A tariff equivalent of quota  $Q_t^j$  is a tariff that has the same effect on trade flows. This is equivalent to equating the left-hand sides of (3.22) and (3.23). But if their left-hand sides are equal, so are their right-hand sides; thus, the tariff equivalent  $\tilde{\tau}$  of quota  $Q_t^j$  satisfies

$$\hat{\beta}_1 \ln(1 + \tau_t^j) = \hat{\beta}_2 \quad (3.24)$$

or

$$\tilde{\tau} = \exp\left(\hat{\beta}_2 / \hat{\beta}_1\right) - 1 \quad (3.25)$$

This simple calculation can be programmed after the estimation of the gravity equation, yielding an *ad valorem* tariff equivalent to the EU's quota. In a final step, observed unit values can be used to translate the *ad valorem* equivalent into a specific form.

Tariff equivalents calculated in accordance with this method and converted into specific rates on the basis of a CIF unit value of €438/ton are reported at the bottom of Table 3.2. The last estimate (€158/ton) is obtained using as “ $\beta_1$ ” the coefficient on the tariff on QR-constrained markets. This choice has advantages and disadvantages. On the one hand, what is measured is the effect of in-quota tariffs which might be expected not to be binding (although the data suggests that they are binding). On the other hand, because the QR-constrained market is the EU's, the coefficient measures the elasticity of substitution on the EU market which, if the assumption of constant elasticity of substitution is not taken at face value, is better than using the elasticity of substitution applying to other markets. Note that the estimate of €158/ton does not include the €75/ton in-quota tariff, so it is equivalent to a price gap of  $158 + 75 = 233$  euros per ton. An interesting feature of the €158/ton estimate is that it is roughly in line with anecdotal estimates of the market value of import licences.

```
reg lnvalue lnApptariff quotaregime frameworkregime ACPregime CIVtime CMRtime Indistance lnmgdp
lnxgdp lnrate lnrate Y2-Y15 M2-M96 X2-X118
```

```
* Compute the quota's specific tariff equivalent, unit value= 438 euros/ton
gen t_advalorem = exp(_b[quotaregime] / _b[lnApptariff]) - 1
gen t_specific = t_advalorem * 438
```

Note that, following the approach described in this application, non-tariff barriers other than quotas such as norms can be converted into tariff equivalents using the same methodology. This is potentially important to measure the market-access restrictions implied by sanitary and phytosanitary measures in foodstuffs, for instance.<sup>30</sup>

## D. Exercises

### 1. Estimating the impact of a regional trade agreement

The aim of this exercise is to assess the impact on trade of the formation of a regional trade agreement. The exercise focuses on NAFTA and refers to the 1985–2004 period, but a similar exercise can be applied to other PTAs provided the sample period covers sufficient years before and after the agreement. The do file “AnalyzingBilateralTradeUsingGravity.do” including solutions can be found at “Chapter3\Exercises\1\_Estimating the impact of a Regional Trade Agreement”. (use STATA 10 for this exercise).

#### 1. Preliminaries

Import in STATA the Trade, Protection and Production data base constructed by the World Bank (Nicita and Olarreaga 2006) available in the folder the folder “Chapter3\Datasets” and merge it with trade data in “Chapter3\Datasets\BilateralTrade.dta” for the period 1985–2004. Then aggregate data at the country level. Note that this process may take time since you need to load a large database. For this reason you may also need to set memory at a high level (e.g. 800m). The do file to construct the data can be found at “Chapter3\Exercises\Preliminary\TPPGGravity.do”.

*Hints: insheet, forvalues, foreach, append, merge, collapse*

- a. Define a dummy variable equal to one for intra-NAFTA trade (i.e. between Canada, Mexico and the US since 1994, the year of entry into force of NAFTA), and another one for each NAFTA's country import from the rest of the world (i.e. build the dummies to measure trade creation and trade diversion).

*Hints: generate*

- b. Plot the temporal evolution of intra-NAFTA imports and of NAFTA's imports from the rest of the world. Comment.

*Hints: twoway tsline, xtline, graph save*

#### 2. Average trade creation and diversion

- a. Introduce the two above dummies in a gravity equation (fixed effects model with country-pair fixed effects and year dummies) estimated on all countries, not just the countries involved.

*Hints: tsset, gen, replace, tabulate, xtreg, outreg2*

- b. Present the results and interpret the coefficients associated with the dummies (i.e. quantify the trade creation/diversion).

*Hints: outreg2*

#### 3. Evolution of trade creation and diversion

- a. Interact the two NAFTA dummies (denoting intra and extra NAFTA country pairs) with year effects and introduce them into the gravity equation (with still a fixed effects model with country-pair fixed effects and year dummies).

*Hints: levelsof, foreach, gen, replace, xtreg, outreg2*

- b. Interpret the evolution of the coefficients in terms of trade creation and trade diversion.

#### 4. Export diversion

- a. Add one dummy capturing the exports of NAFTA towards the rest of the world and add this third RTA dummy in the gravity equation.

*Hints: gen, replace, xtreg, outreg2*

- b. Repeat Questions 1b, 2b, 3a and 3b using this new variable in addition to the others. Comment on all your results.

*Hints: collapse, gen, replace, twoway tsline, graph save, levelsof, foreach, tsset, xtreg, outreg2.*

## 2. Calculating tariff equivalent

The aim of this exercise is to use the gravity model to measure the tariff equivalent of non-tariff trade barriers. The exercise follows the approach developed by Jacks et al. (2008). The do files “i\_NTB.do” and “ii\_Tariff\_Equiv.do” including the solutions can be found in “Chapter3\Exercises\2\_Calculating tariff equivalent”.

### 1. Preliminaries

Import in STATA the Trade, Protection and Production data base constructed by the World Bank (Nicita and Olarreaga 2006) available in the folder “Chapter3\Datasets” and merge it with trade data in “Chapter3\Datasets\BilateralTrade.dta” and the standard gravity variables in “Chapter3\Datasets\GravityData.dta”. Then aggregate data at the country level. Note that this process may take time as you need to load a large database. For this reason you also may need to set memory at a high level (e.g. 800m). The do file to construct the data can be found at “Chapter3\Exercises\Preliminary\TPPGGravity.do”.

*Hints: insheet, forvalues, foreach, append, merge, collapse*

- a. Build the importer and partner country tariff variables:  $\text{tariff}_i$  and  $\text{tariff}_j$ . Then compute domestic consumption variables for the importer and the exporter by taking the difference between output and total exports.

*Hints: generate, joinby*

- b. Bilateralize tariffs by multiplying importer and exporter tariffs and then taking logs, i.e.  $t_{ij} = \ln(\text{tariffs}_i \cdot \text{tariffs}_j)$ . Calculate the tariff equivalent of total trade costs as in equation (3.16),  $\tau_{ij} = (X_{ij} X_{ji} / X_{ij} X_{ji})^{1/[2(\sigma-1)]} - 1$ , using an elasticity of substitution set to  $\sigma = 11$ .

### 2. Gravity estimation

- a. Generate a dummy variable equal to one for the existence of core non-tariff barriers implemented.
- b. Estimate the following gravity equation with country-pair fixed effects.

$$\tau_{ijt} = \beta_0 + \beta_1 \ln(\text{distance}_{ij}) + \beta_2 \ln(t_{ijt}) + \beta_3 \text{Quota}_{ijt} + \text{TimeDummies} + u_{ijt}$$

Then, compare the results when the country-pair effects are assumed to be random and when the country-pair fixed effects are replaced by exporter and importer dummies.

*Hints: reg, xtreg*

### 3. Tariff equivalent

- a. For each gravity estimation result, determine the tariff equivalent of the non-tariff barriers.  
*Hints: estimates store, estimate restore*
- b. Check for the sensitivity of the trade cost measure, by re-estimating the gravity equation and computing the tariff equivalent, assuming the elasticity of substitution is set to  $\sigma = 5$  or  $\sigma = 15$ . Comment.

## Endnotes

1. A clear and concise introduction to the gravity equation can be found in Head (2003). A thorough treatment for the advanced reader is in Chapter 5 of Feenstra (2004).
2. See Feenstra et al. (2001), Evenett and Keller (2002) and Feenstra (2004).
3. This is a model built along the lines of Melitz (2003), where firms face fixed and variable costs of exporting. Firms vary by productivity and only the more productive firms will find it profitable to export.
4. Dummies are variables that only assume the value zero or one. For example, a dummy denoting whether the importing country is an island takes the value one for all observations when the importing country is indeed an island and zero otherwise.
5. Alternative methodologies to estimate the gravity models without directly controlling for MRT rely on manipulations of the basic gravity equation aiming at getting rid of one or both MRTs. One methodology consists in normalizing bilateral trade flows with respect to a certain country-pair (Martin et al., 2008 and Romalis, 2008). Another method is the so-called "Tetrads method" (Head and Mayer's website provides the do file for estimations conducted with this methodology) that consists in taking ratio of ratios so as to remove both MRTs.
6. Recall that the unit of observation (the "individual") in a gravity equation is a pair of countries, not a single country. So when we speak of "country effects", those are not identical with "fixed effects" in the standard meaning, which refers to dummy variables marking each individual pair.
7. This can be done most easily in STATA using the "robust" option after the estimation command "regress". In cases where outliers create particular problems, alternative estimation methods, like Huber's, can be preferable to OLS. Outliers can be detected and dropped from the estimation. To detect outliers use the Hadi test (STATA command: hadimvo). Another problem associated with using country-pair observations is that the errors may be correlated across country-pairs (that is, country-pair observations are not independent). To address this problem, one should correct for cluster errors. In STATA, use the option "cluster" or the command "cgmreg" for the multi-way clustering.
8. Note that "time effects" should not be confused with a "time trend". The former are dummy variables, one per year, as explained in section 1. The latter is a variable that starts from 1 and goes up one unit each period: 1 for the first, 2 for the second, and so on. The former is more general because it does not impose the assumption of a linear time trend. For instance, if production is depressed in year  $t$  because of a hurricane, this temporary drop will be picked up by the variable  $I_t$ , which will have a negative coefficient. It won't be picked up, in contrast, by a time trend.
9. The latter in fact can be obtained as a linear combination of the set of fixed effects.
10. Note that the standard Poisson model is vulnerable to problems of overdispersion and excess zero flows. To overcome these problems, Brueger et al. (2009) suggest using modified Poisson fixed-effects estimations (negative binomial, zero-inflated). STATA commands to run these estimations are: "nb" for the negative binomial, and "zip" and "zinb" for the zero-inflated Poisson and negative binomial, respectively.
11. The motivation for using price gaps as a measure of trade costs is that in absence of such costs arbitrage will equalize prices.
12. See Head and Ries (2001) and Jacks et al. (2008).
13. For small changes this formula is equivalent to that calculated in Kee et al. (2009), where  $\text{tarriff equivalent} = (\exp(\delta\beta) - 1) / \delta^2$ .
14. See <http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/0,contentMDK:21085384~pagePK:64214825~piPK:64214943~theSitePK:469382,00.html> for the latter.
15. See Chapter 2.
16. Found at [http://siteresources.worldbank.org/INTRES/Resources/469232-1107449512766/OTRI\\_INDICES\\_2008.xlsx](http://siteresources.worldbank.org/INTRES/Resources/469232-1107449512766/OTRI_INDICES_2008.xlsx) as of April 2011.
17. PWT Mark 6.3 is freely available on the web at [http://pwt.econ.upenn.edu/php\\_site/pwt\\_index.php](http://pwt.econ.upenn.edu/php_site/pwt_index.php). It can also be found with a different data-extraction interface at the CHASS center of the University of Toronto at <http://datacentre2.chass.utoronto.ca/pwt/>. Country codes are not identical across databases but concordance tables can be found on Jon Haveman's page at <http://www.maclester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/Concordances/OthMap/country.txt> as of April 2011.

18. Note that as country price indices combine a PPP adjustment with an exchange rate, they can change because of either inflation without exchange rate adjustment or exchange-rate change without inflation. This can cause year-to-year jumps.
19. Found at <http://econ.sciences-po.fr/thierry-mayer/publications> as of April 2011.
20. Found at <http://www.graduateinstitute.ch/md4stata> as of April 2011.
21. Found at <http://www.cepii.fr/anglaisgraph/bdd/gravity.htm> as of April 2011.
22. Found at <http://www.maclester.edu/research/economics/page/haveman/trade.resources/tradedata.html> as of April 2011.
23. Found at <http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx> as of April 2011.
24. In practice, however, there are always many country/year pairs with missing data, either for trade or, more frequently, for other variables the researcher may be interested in (e.g. transportation infrastructure levels).
25. The commands to use in STATA in the case of a panel for fixed and random effect estimations are `xtreg ... , fe` and `xtreg ... , re`, respectively.
26. See discussion above on estimations with zero trade flows.
27. To derive this formula, consider that  $\ln X_{ij}(1)$  is the predicted value of trade when the dummy is equal to 1 (e.g. two countries are in a regional trade agreement, share a common language, a border, etc.) while  $\ln X_{ij}(0)$  is the value of trade when the dummy takes the value 0. It follows that the difference  $\ln X_{ij}(1) - \ln X_{ij}(0) = a$ , where  $a$  is the estimated coefficient for the dummy variable. It follows that  $X_{ij}(1)/X_{ij}(0) = \exp(a)$ , which in turn implies that the percentage change in trade value due to the dummy switching from 0 to 1 is:  $X_{ij}(1) - X_{ij}(0) / X_{ij}(0) = \exp(a) - 1$ .
28. It is not exactly the price elasticity of import demand because trade is measured in dollars, so what we are really measuring is  $d \ln(p^*q) / d \ln(1 + \tau)$  instead of  $d \ln(q) / d \ln(1 + \tau)$ . However, the price that is implicit in the value of trade flows,  $p^*$ , is the world price (which is why we put a star on it); if the tariffs affect a sufficiently small share of world trade, the world price can be considered as fixed and the approximation is acceptable.
29. For country-pairs with no QRs, the variable " $\ln(1 + \tau)$ , constrained" is zero, but then the variable " $\ln(1 + \tau)$ , unconstrained" is positive. They cannot both be zero.
30. For a survey of methods for the quantification of non-tariff barriers, see e.g. Maskus et al. (2001) or Beghin and Bureau (2001).

## References

- Anderson, J. E. and van Wincoop, E. (2003), "Gravity with gravitas: a solution to the border puzzle", *American Economic Review* 93: 170–92.
- Anderson, J. E. and van Wincoop, E. (2004), "Trade costs", *Journal of Economic Literature* 42: 691–751.
- Baier, S. L. and Bergstrand, J. H. (2004), "Economic determinants of free trade agreements", *Journal of International Economics* 64(1): 29–63.
- Baier, S. L. and Bergstrand, J. H. (2006), "Estimating the effects of free trade agreements on trade flows using matching econometrics", mimeo, published in *Journal of International Economics* (2009) 77(1): 63–76.
- Baier, S. L. and Bergstrand, J. H. (2007), "Do free trade agreements actually increase members' international trade?", *Journal of International Economics* 71(1): 72–95.
- Baier, S. L. and Bergstrand, J. H. (2009), "Bonus vetus OLS: a simple method for approximating international trade-cost effects using the gravity equation", *Journal of International Economics* 77(1): 77–85.
- Baldwin, R. and Taglioni, D. (2006), "Gravity for dummies and dummies for gravity equations", National Bureau of Economic Research Working Paper 12516, NBER.
- Beghin, J. and Bureau, J.-C. (2001), "Quantification of sanitary, phytosanitary, and technical barriers to trade for trade policy analysis", Iowa State University, Center for Agricultural and Rural Development Working Paper 01-WP-291.
- Bergstrand, J. H. (1985), "The gravity equation in international trade: some microeconomic foundations and empirical evidence", *The Review of Economics and Statistics* 67(3): 474–81.
- Bergstrand, J. H. (1989), "The generalized gravity equation, monopolistic competition and the factor-proportions theory in international trade", *The Review of Economics and Statistics* 71(1): 143–53.
- Brun, J.-F., Carrère, C., Guillaumont, P. and de Melo, J. (2005), "Has distance died? Evidence from a panel gravity model", *World Bank Economic Review* 19: 99–120.
- Cameron, A.C. and Trivedi, P. K. (2005), *Microeconometrics: Methods and Applications*, Cambridge University Press.
- Carrère, C. (2006), "Revisiting the effects of regional trade agreements on trade flows with proper specification of the gravity model", *European Economic Review* 50: 223–47.
- Chaney, T. (2008), "Distorted gravity: the intensive and extensive margins of international trade", *American Economic Review* 98: 1707–21.
- Crozet, M., Head, K. and Mayer, T. (2009), "Quality sorting and trade: firm-level evidence for French wine", Centre for Economic Policy Research Discussion Paper 7295, CEPR.
- Dixit, A. and Norman, V. (1980), *Theory of International Trade*, Cambridge University Press.
- Eaton, J. and Kortum, S. (2002), "Technology, geography and trade", *Econometrica* 70: 1741–79.
- Ethier, W. (1998), "Regionalism in a multilateral world", *Journal of Political Economy* 106: 1214–45.
- Evenett, S. and Keller, W. (2002), "On theories explaining the gravity equation", *Journal of Political Economy* 110: 281–316.
- Feenstra, R. (2004), *Advanced International Trade*, MIT Press.
- Feenstra, R., Markusen, J. and Rose, A. (2001), "Using the gravity equation to differentiate across alternative theories of trade", *Canadian Journal of Economics* 34: 430–47.
- Frankel, J. (2010), "The estimated effects of the Euro on trade: why are they below historical evidence on effects of monetary unions among smaller countries?", in Alesina, A. and Giavazzi, F. (eds.), *Europe and the Euro*, University of Chicago Press.
- Hausman, J. A. and Taylor, E. (1981), "Panel data and unobservable individual effects", *Econometrica* 49: 1377–98.

- Head, K. (2003), "Gravity for beginners", mimeo, University of British Columbia.
- Head, K. and Ries, J. (2001), "Increasing returns versus national product differentiation as an explanation for the pattern of US–Canada trade", *The American Economic Review* 91(4): 858–76.
- Helpman, E., Melitz, M. and Rubinstein, Y. (2008), "Trading partners and trade volumes", *Quarterly Journal of Economics* 123: 441–87.
- Hummels, D. and Klenow, P. J. (2005), "The variety and quality of a nation's exports", *American Economic Review* 95: 704–23.
- Jacks, D. S., Meissner, C. M. and Novy, D. (2008), "Trade costs, 1870–2000", *American Economic Review: Papers and Proceedings* 98(2): 529–34.
- Kee, H.L., Nicita, A. and Olarreaga, M. (2009), "Estimating trade restrictiveness indices", *The Economic Journal* 119: 172–199.
- Krugman, P. (1980), "Scale economies, product differentiation and the pattern of trade", *American Economic Review* 70: 950–9.
- Limao, N. (2006), "Preferential trade agreements as stumbling blocks for multilateral trade liberalization: evidence for the United States", *American Economic Review* 96: 896–914.
- Linders, G. M. and de Groot, H. L. (2006), "Estimation of the gravity equation in the presence of zero flows", Tinbergen Institute Discussion Paper 2006–072/3.
- Magee, C. (2003), "Endogenous preferential trade agreements: an empirical analysis", *Contributions to Economic Analysis and Policy* 2, Article 15.
- Maskus, K., Wilson, J. and Otsuki, T. (2001), "Quantifying the impact of technical barriers to trade: a framework for analysis", in Maskus, K. and Wilson, J. (eds.), *Quantifying the Impact of Technical Barriers to Trade: Can It Be Done?*, University of Michigan Press.
- Melitz, M. and Ottaviano, G. (2008), "Market size, trade and productivity", *Review of Economic Studies* 75: 295–316.
- Novy, D. (2009), "Gravity redux: measuring international trade costs with panel data", mimeo, University of Warwick.
- Rose, A. and van Wincoop, E. (2001), "National money as a barrier to international trade: the real case for currency union", *American Economic Review* 91(2): 386–90.
- Santos Silva, J. and Tenreyro, S. (2006), "The log of gravity", *The Review of Economics and Statistics* 88: 641–58.
- Santos Silva, J. and Tenreyro, S. (2009), "Trading partners and trading volumes: implementing the Helpman-Melitz-Rubinstein model empirically", Center of Economic Performance (CEP) Discussion Paper 935.
- Summers, R. and Heston, A. (1991), "The Penn World Table (Mark 5): an expanded set of international comparisons, 1950–1988", *Quarterly Journal of Economics* 101: 327–68.
- Tinbergen, J. (1962), *Shaping the World Economy*, Twentieth Century Fund.

## CHAPTER 4: Partial-equilibrium trade-policy simulation

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### TABLE OF CONTENTS

A. Overview and learning objectives	139
B. Analytical tools	141
1. Preliminary discussion	141
2. Empirical tools	146
C. Applications	162
1. SMART	162
2. GSIM	164
3. TRIST	166
4. ATPSM	171
D. Exercises	172
1. Bus market in Albania (SMART)	172
2. Japan's meat market (SMART)	173
3. Socks trade between the EU and China (GSIM)	174
4. Burundi's trade opening (TRIST)	175
Endnotes	176
References	177

## LIST OF FIGURES

Figure 4.1.	Tariff reduction in the small country case	141
Figure 4.2.	Tariff reduction in the large country case	142
Figure 4.3.	How tariff elimination increases welfare	144
Figure 4.4.	Trade creation and trade diversion in SMART	148
Figure 4.5.	Total welfare effects in GSIM	167

## LIST OF TABLES

Table 4.1.	Partial vs. general equilibrium models	140
Table 4.2.	SMART output "Revenue Impact Report" for the case of Albania, liberalization of HS 870210	149
Table 4.3.	Total welfare effects (changes) in case of a trade liberalization in HS 6115 between China and the European Union	154
Table 4.4.	Breakdown of effects if tariffs are reduced with country A but not with country B	157
Table 4.5.	Revenue implications of a COMESA common external tariff (in US\$ million)	158
Table 4.6.	GSIM table model solutions	166
Table 4.7.	Total welfare effects in GSIM	167
Table 4.8.	Detailed import data for TRIST	168
Table 4.9.	Detailed import data for TRIST	168
Table 4.10.	Default scenarios for ATPSM	172
Table 4.11.	Trade flows in HS 6115 for the three largest exporters (2009, in US\$ million)	174
Table 4.12.	Applied tariffs in HS 6115 between the three main exporters and ROW (year 2009)	174
Table 4.13.	Projected tariffs in HS 6115 between the three main exporters and ROW	175

## LIST OF BOXES

Box 4.1.	Example of Albania's unilateral tariff liberalization with the European Union	149
Box 4.2.	Example of a trade liberalization in HS 6115 between China and the European Union	154
Box 4.3.	Example of COMESA customs union	158

## A. Overview and learning objectives

Chapters 4, 5 and 6 introduce you to *ex-ante* analysis of trade policy changes. Analyzing a policy or policy reform using statistical methods such as those discussed in Chapter 3 requires the policy or reform to have been in place for a sufficient period of time for its effects to be observable in the data. However, if policymakers are interested in an *ex-ante* assessment of its likely effects, a different approach is needed. Another possible scenario is that the reform has been in place for a while, but that no appropriate counterfactual is available to benchmark its effect. In this case, a simulation approach is suitable even if data are available.

In the absence of data, the logic of *ex-ante* policy evaluation has to be different from the empirical logic of statistical assessments. There are two important differences. First, although proper econometric estimations must in general be backed by theory, this is even truer of simulations because the diagnostic tests available in statistics have no equivalent here. All you can do is to replicate the simulation over a range of parameter values in order to check the results' sensitivity; but beyond this relatively crude type of robustness check there is no alternative to simply trusting the model. Second, in a statistical assessment we want to control for as many outside influences as possible, which means estimating many parameters. In a simulation, by contrast, we want as few parameters as possible because parameter values often have to be guessed or borrowed from previous studies and because the more there are, the harder it will be to understand what drives the results. Often, this means imposing constant-elasticity forms for demand and supply functions.

The typical trade policy simulation procedure consists of four steps:

1. Choose a theoretical model that is appropriate to predict the effects of the policy under consideration.
2. Collect the corresponding trade (including import and export flows as well as tariffs) and production data for the specific sector(s) before the policy change.
3. Select values for the model's key parameters (elasticities).
4. Change the value of the policy variables of interest and recalculate the prices and trade volume for comparison with the baseline one.

One of the key choices facing the analyst is whether to use a partial-equilibrium (PE) or general-equilibrium (GE) model. The choice involves a trade-off: on the one hand, a GE approach takes into account inter-market linkages which a PE approach cannot; on the other hand, a GE model will typically be set up at an aggregate level, whereas a PE model can be as disaggregated as you wish. What is best – disaggregation or a proper treatment of inter-market linkages – depends on the nature of the policy experiment conducted and on the specific concerns of the policymaker.

There are other considerations to take into account when deciding whether to choose PE or GE analysis. PE analysis offers several advantages compared to GE models. First, a number of simple, ready-made models are available online that are relatively easy to use. The working of those models and their results are relatively straightforward to interpret, since only a relatively limited number of equations are used to calculate changes in demand and supply. Second, the data requirements are typically smaller, as only data from the sector in question is needed: mainly trade flows, trade policy data and elasticities. At the same time, these advantages may be seen as weaknesses in the PE models. First, PE models do not include constraints on production factors. Second, the results of PE

**Table 4.1** Partial vs. general equilibrium models

	PE	GE
Capturing economy wide linkages		X
Consistency with budget constraints		X
Capturing disaggregated effects	X	
Capturing complicated policy mechanisms	X	
Use of timely data	X	
Capturing short and med. term effects	X	
Capturing long term effects		X

*Source:* WITS Advanced Course Presentation (World Bank, 2008)

models can be very sensitive to the values used for the elasticities, for which the empirical literature is still limited. Table 4.1 provides an overview of the main characteristics of PE and GE models.

This chapter provides an introduction to PE analysis. The first part describes the key theoretical concepts behind PE while the second part gives an overview of four ready-made PE models, namely:

- SMART
- Global Simulation Analysis of Industry-Level Trade Policy (GSIM)
- Tariff Reform Impact Simulation Tool (TRIST)
- Agricultural Trade Policy Simulation Model (ATPSM).

The chapter first explains the theoretical assumptions behind the models (Part B) and then shows how the models can be implemented in practice (Part C). It provides a comparison of the main features of the four models and highlights the context in which each model applies best. Several *ex ante* PE simulation case studies that explore the implications and feasibility of trade reforms are presented. The first case study uses SMART to analyse the example of Albania liberalizing the tariff on buses from the EU. The second case study applies GSIM to the hypothetical example of China and the EU mutually opening their markets for socks. Finally, TRIST is used to assess how modifying the common external tariff of the Common Market for Eastern and Southern Africa (COMESA) would affect the revenues of Malawi, Zambia and Kenya.

In this chapter, you will learn:

1. the basic idea behind partial equilibrium models
2. the logic of several ready-made PE simulation models and the situations in which these models are best applied
3. what are the key elasticities and how to exploit simulation analysis to explore the sensitivity of results to assumptions about elasticity values
4. how to use the basic features of these PE simulation models, including generating simulation results.

After reading this chapter, you will have understood the choices facing a modeller: (i) the advantages and disadvantages of a disaggregated analysis and when it is useful; (ii) the choice of a functional form; (iii) an introduction to the different simulation models; (iv) the choice between these different simulation models.

## B. Analytical tools

### 1. Preliminary discussion

#### a. The basic set-up

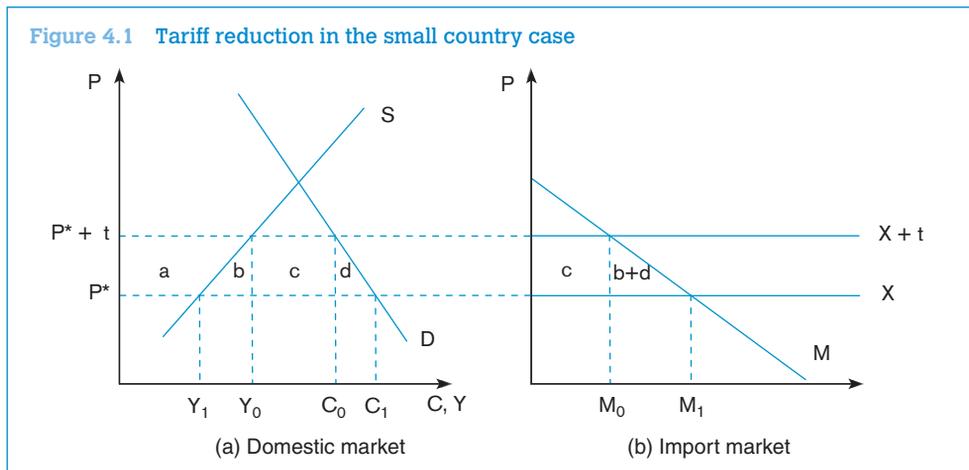
Assume that we would like to gauge *ex-ante* the impact of a change in trade policy on prices, trade flows, tariff revenues and welfare. We start with a graphical illustration of the simplest case, namely the effect of the elimination of a tariff  $t$  by a small country that faces fixed world prices,  $P^*$  (see Figure 4.1).

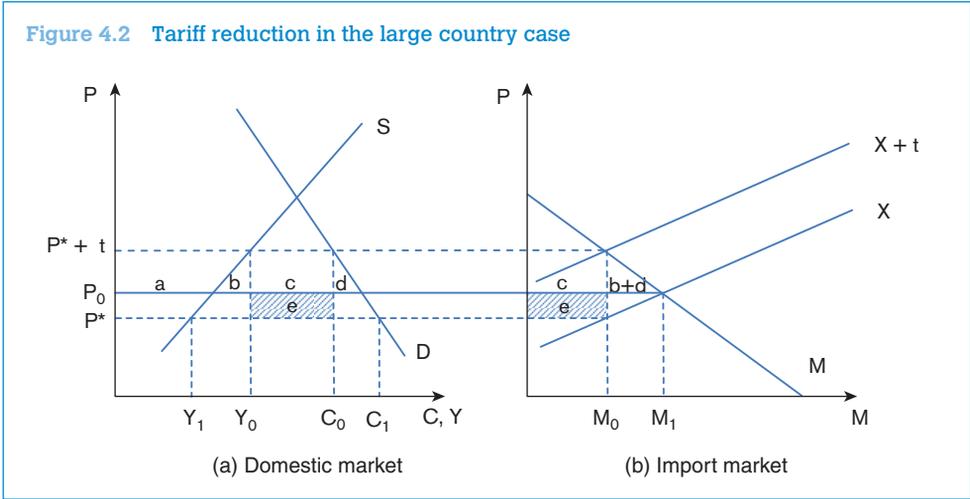
At world price  $P^* + t$ , domestic demand is given by  $C_0$ , domestic supply is  $Y_0$  and imports are  $M_0$ . The elimination of the tariff  $t$  decreases the domestic price by the full amount  $t$  and as a consequence increases demand to  $C_1$  and increases domestic supply to  $Y_1$ . Imports increase from  $M_0$  to  $M_1$ .

The change in domestic price leads to a consumer surplus gain ( $a+b+c+d$ ), as she/he is now able to purchase a larger amount of goods (i.e.  $C_1 - C_0$ ). The tariff elimination leads to a producer surplus loss ( $a$ ) and a loss in tariff revenue for the taxpayers ( $c$ ). The total gain of the tariff elimination is thus the area ( $b + d$ ) or the triangle under the import demand curve. As the height and base of the triangle depend on the tariff, the deadweight loss depends on the square of the tariff.

Overall, we observe that in the case of a small country an import tariff elimination lowers the domestic price by the full amount of the tariff  $t$ . It also increases imports and removes the tariff revenue,  $c$ . However, the elimination of a tariff always results in a net gain that depends on the square of the tariff.

In the case of a large country, we assume that the foreign supply curve  $X$  is upward sloping as depicted in panel (d) of Figure 4.2. With the tariff, the price equilibrium is at  $P_0 + t$ . Eliminating the tariff shifts the export supply to  $X$ , which results in a new domestic price  $P_0$ . As the supply curve is upward sloping, the decrease in the domestic price is less than the full amount of the tariff  $t$ . This also means that the foreign price in the presence of the tariff ( $P$ ) is lower than the free trade





price  $P_0$ , which translates into a terms of trade gain ( $e$ ) for the importing country. We recall that the terms of trade are usually defined by the price of a country's exports divided by price of its imports.

As in the case of a small country, eliminating a tariff leads to lower domestic prices, more imports and less domestic supply. However, all three effects are attenuated by the fact that the foreign supply curve is assumed to be upward sloping. The change in welfare looks now also slightly different, since there exist terms of trade gains. The area  $e$  measures these terms of trade losses by multiplying the drop in prices by the new import demand,  $M_1$ . The net gain triangle still corresponds to  $(b + d)$  and depends on the square of the tariff,  $t^2$ . The net welfare effect  $e - (b + d)$  is thus positive for sufficiently small tariffs and negative for large tariffs.

**b. Measuring net welfare gains (the Harberger triangle)**

Let us now turn to a theoretical analysis of the effect of an elimination of a tariff on trade flows, tariff revenue and welfare. Consider an economy whose representative individual has quasi-linear (QL) preferences over two goods: good zero, the numéraire, and good one (without subscript), the import-competing one. That is, the consumer's utility is:

$$U = C_0 + u(C) \tag{4.1}$$

where  $C_0$  and  $C$  are the quantities of numéraire and good one consumed, respectively, and  $u(\cdot)$  is an increasing, concave sub-utility function. Two useful properties of QL preferences are that:

- The indirect utility function is the sum of income  $I$  and consumer surplus  $u(C) - PC$ , where  $P = P^*$ .  $(1+t)$  is the domestic price with  $t$  being the tariff rate (it can be shown that the consumer derives no consumer surplus from good zero).
- The marginal utility of income is always one, so at the consumer's optimum  $u' = P$ .

Income is the sum of profits  $\pi$  and tariff revenue  $tM$ . Thus, once the representative individual's optimal choices are taken into account, welfare as a function of the tariff is

$$\begin{aligned} W(t) &= I + u(C) - PC \\ &= \pi + tM + u(C) - PC \end{aligned} \quad (4.2)$$

and the derivative of this expression with respect to the tariff is

$$\begin{aligned} W' &= u' C' - (C + PC') + \pi' + M + tM' \\ &= (u' - P)C' - C + Y + M + tM' \\ &= Y + M - C + tM' \\ &= tM' \end{aligned} \quad (4.3)$$

In going from the first to the second line of (4.3) we used Hotelling's lemma, according to which the price derivative of the profit function is output (that is,  $\pi' = Y$ ); in going from the second to the third line we used the second property of QL preferences (namely that the marginal utility of income is one). Finally, in going from the third to the last line note that by definition, for the import-competing good, consumption  $C$  is the sum of domestic output  $Y$  and imports  $M$ .

Now let us take a second-order Taylor approximation of (4.3) around  $t = 0$ :

$$W(t) \cong W(0) + tW'(t) + \frac{1}{2}t^2W''(t) \quad (4.4)$$

so, noting that at  $t = 0$   $W''(t) = 0$  and that  $W''(t) = M'$  (this can be directly derived from simply noting that  $W'' = M' + tM'' = M'$  if  $t = 0$ ),

$$\Delta W \cong W(t) - W(0) \cong \frac{1}{2}t^2M' \quad (4.5)$$

As  $tM' = dM$  (that is, the change in imports from a position of zero tariff is the tariff times the price derivative of import demand) the welfare change is  $t\Delta M/2$ , i.e. the area of a right-angle triangle whose height and base are respectively the tariff and import changes — the familiar “Harberger triangle”.

Because functional forms in simulation models are often of the constant-elasticity type, it is useful to cast expression (4.5) in terms of the elasticity of import demand. To do this, write  $M'$  as  $dM/dP$ , where as before  $P = P^*(1+t)$  is the domestic price ( $P^*$  being the world price) and write

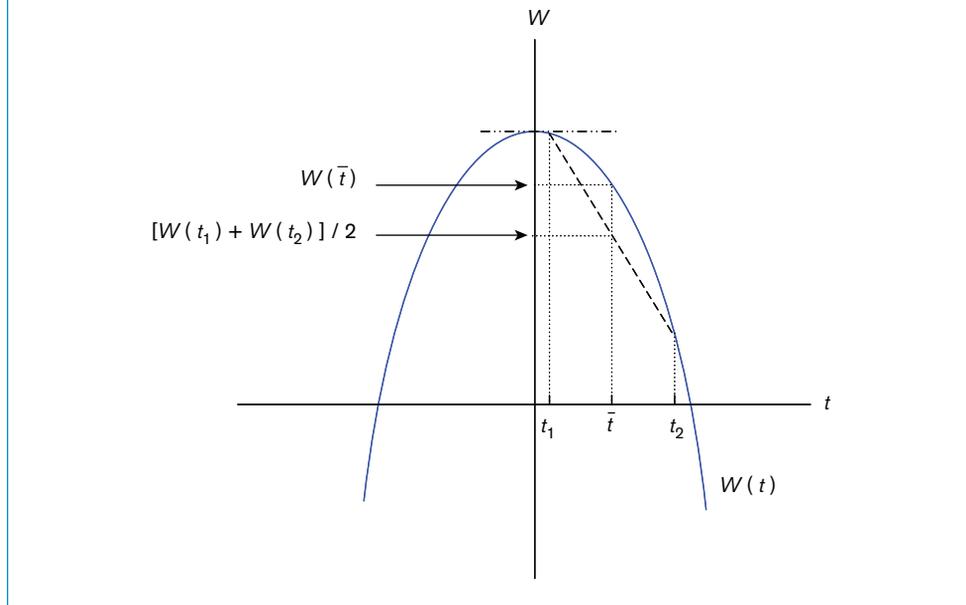
$$M' = \frac{M}{P} \left( \frac{P}{M} \frac{dM}{dP} \right) = \frac{M}{P} \varepsilon \quad (4.6)$$

where the price elasticity of import demand  $\varepsilon$  is in algebraic form (i.e. negative); so, finally,

$$\Delta W = \frac{1}{2} \frac{M}{P} \varepsilon t^2 \leq 0 \quad (4.7)$$

In this formula, the net welfare gain  $\Delta W$  generated by elimination of a tariff  $t$  depends only on the own-price elasticity of demand and the tariff itself. Where did we slip in the assumption needed to get rid of cross-price elasticities? Looking back at the utility function, obviously with only two goods we could have only one cross-price elasticity. However, even that one has been eliminated, because the utility function is strongly (i.e. additively) separable. We could easily generalize it to

Figure 4.3 How tariff elimination increases welfare



$= X_0 + u(X_1) + \dots + u(X_n)$ ; as long as it remains additive, no cross-price elasticity will appear in (4.7). But we need to remember that this is only an assumption on preferences and not a feature of the data.

Because welfare shrinks with the *square* of the tariff in (4.7), with several goods, tariff variance in itself reduces welfare. To see why, consider a two-good economy with the following policy options:

- a low tariff  $t_1$  on good one and a high tariff  $t_2$  on good two
- a uniform tariff  $\bar{t} = (t_1 + t_2) / 2$  on both.

Average welfare generated in the two markets is shown in Figure 4.3 as a parabolic function of tariffs, with a maximum at  $t_1 = t_2 = 0$ .

Under a uniform tariff, welfare is  $W(\bar{t})$ ; under a pair of differentiated tariffs, it is the average of  $W(t_1)$  and  $W(t_2)$ . It is obvious that the former is higher than the latter because the arc is above the chord; this is a straightforward application of a mathematical principle known as Jensen's inequality. We will discuss its practical implications later on in this chapter.

### C. Product differentiation

As we will see in the next section, most simulation models use the "Armington assumption" whereby varieties of goods are differentiated by country of origin (Armington, 1969). Why this assumption? Schott (2004) reports evidence that at a highly disaggregated level the price of goods imported

into the US is correlated with the exporting country's level of income. This suggests that rich countries export higher-quality or higher-technology varieties than poor ones do. However, the rationale for the Armington assumption is less clear-cut when varieties are imported from countries at similar income levels. There is in fact a more technical reason for avoiding the assumption of homogeneity across national varieties.

The first problem relates to prices and specialization. In a Heckscher-Ohlin model with just as many goods as factors, all countries are fully diversified, the outputs of all goods are jointly determined by full-employment conditions (one per factor of production) and factor prices are determined by zero-profit conditions (one per good). In this setting, a tariff change will trigger factor-price adjustments as predicted by the Stolper-Samuelson theorem.

With more goods than factors — the typical case in simulation exercises — things are less smooth and two situations can arise:

1. If the vector of good prices happens to be such that our country of interest is fully diversified, its sectoral output levels are, in general, indeterminate because there are not enough full-employment conditions to determine all output levels.
2. If the vector of prices is different from the particular value that ensures diversification, then each country produces just as many goods as it has factors; countries are then in different “diversification cones”.

Thus, instead of merely pinning down factor *prices*, good prices now determine the *number* of goods produced. This complicates the analysis. To see why, consider an initial situation where  $n$  goods are produced. Under the assumption of perfect competition and constant unit costs, all industries make zero profits. Suppose now that tariffs are reduced on some of those goods. Their domestic prices then drop below the break-even point and because of constant unit costs reducing output does not help (as it would with an upward-sloping supply curve). Domestic industries will therefore disappear altogether. This is both unrealistic and awkward to deal with mathematically.

Several fixes are possible. For one, in a fully specified model such as in the GE models examined in the next chapter, where supply curves are derived from underlying technologies, we can impose upward-sloping supply curves so that price changes induce smooth quantity adjustments. The alternative and standard fix for our problem is to assume that domestic varieties are not perfect substitutes for each other; this is what we called earlier the Armington assumption. We now have a two-dimensional definition of products: “goods”, say bananas, and “varieties”, say bananas from St Lucia, from Costa Rica or from Cameroon. This has several advantages. First, it solves our problem with the number of goods; a tariff change will now induce smooth substitution between domestic varieties with the number of goods remaining constant. Second, it makes it possible to accommodate two-way trade: Japan exports the Japanese variety of steel and imports the US variety because they are not perfect substitutes in the eyes of buyers.

However, the Armington assumption creates a new difficulty. Suppose that, as discussed in the overview of this chapter, we impose constant-elasticity forms to all our demand functions so we have only elasticities to worry about. However, we have to recall that the advantage of PE is to “go disaggregate”, so let us have 5,000 goods (at the HS-6 level) and, say, 50 countries from which we

import. With one differentiated variety per country, we have potentially 250,000 own- and cross-price elasticities to guess! This is, of course, way too many. Own-price elasticity estimates are available at the HS-6 level from Kee et al. (2006), but cross-price estimates are yet to be found, and even if they existed, you would not want to interpret a model with 250,000 elasticities.

So an additional simplifying ingredient must be thrown in, namely what is called “two-stage budgeting”. Simulation exercises typically assume a form for individual utility functions that ensures strong separability between goods, so cross-price elasticities between goods (not national varieties) are all zero, along with CES (constant elasticity of substitution) for national varieties.

All these assumptions can be relaxed as per the modeller’s needs at the cost of added complication. It is common to assume a similar framework on the supply side, where export markets are imperfect substitutes for each other. The equivalent of the CES function is a CET (constant elasticity of transformation), and changes in producer prices induce smooth substitution across export markets rather than complete withdrawal.

## 2. Empirical tools

### a. SMART

This section describes the analytical set-up of the SMART model, following Jammes and Olarreaga (2005). The core assumption of this PE model is the Armington assumption, i.e. the imports from different countries are imperfect substitutes. When it comes to export supply elasticities, SMART can either be solved with perfectly elastic export supplies, i.e. world prices of each variety are given, or by assuming upward-sloping export supply curves.

#### *Case 1: Perfectly elastic export supply*

Let us start by assuming that agents in a representative country (whose index we omit) have a quasi-linear utility function of the form

$$U(c_0, c_1, \dots, c_n) = c_0 + \sum_{i=1}^n u(c_k^i) \quad (4.8)$$

where  $c_0$  stands for consumption of a composite good used as numéraire and  $c_k^i$  for consumption of good  $k$  imported from country  $i$ . The function  $u(\cdot)$  is increasing, concave and identical in all countries. The fact that the utility function is additive ensures that we do not have substitution effects between goods  $k$ , as explained above.

Consider a representative good, an importer and two exporters. Let us use subscript  $k$  for the good and superscript  $i$  and  $l$  for the exporters, whereas importer indices are omitted (all indices are dispensed of when not needed). Let  $P$  be the good’s domestic price in the importing country,  $P^*$  its world price and  $M$  the quantity imported. All variables should carry three indices (for the importer and exporter and for the good).

Let  $\tilde{M}_k^i = M_k^i / M_k^l$  be the ratio of a representative country’s imports of good  $k$  from exporters  $i$  and  $l$  respectively, and  $\tilde{P}_k^i = P_k^i / P_k^l$  the ratio of their landed (duty-paid) prices. The elasticity of

substitution  $\sigma$  between the two origins for good  $k$ , assumed to be the same across all origins, for all countries and for all goods, is

$$\sigma = \frac{\tilde{P}_k^j}{\tilde{M}_k^j} \frac{d\tilde{M}_k^j}{d\tilde{P}_k^j} \quad (4.9)$$

Without indices, the elasticity of import demand (in algebraic value, i.e. negative) is

$$\varepsilon = \frac{P}{M} \frac{dM}{dP} \quad (4.10)$$

where  $p$  is the landed price of a representative good in a representative importer country, equal to

$$P = P^*(1+t) \quad (4.11)$$

and  $t$  is the applied tariff, i.e. the MFN tariff reduced by the preference margin:

$$t = t^{MFN}(1-\delta) \quad (4.12)$$

SMART assumes that all countries face fixed world prices (also labelled as small country case). As a consequence, in all the derivations of this section  $P^*$  is fixed and the change in the domestic price is simply the direct effect of tariff changes (as seen in the graphical analysis above).

Trade creation is calculated in SMART as the direct increase in imports attributable to a tariff reduction. That is, using (4.10),

$$\begin{aligned} TC &\equiv PdM = \varepsilon MdP \\ &= \varepsilon MP^* dt \\ &= \varepsilon MP^* \frac{dt}{(1+t)} \end{aligned} \quad (4.13)$$

Total trade creation from a set of tariff reductions  $\Delta t_k^1, \dots, \Delta t_k^n$  applied on good  $k$  to partners  $i = 1, \dots, n$  is then

$$TC_k = \sum_{i=1}^n TC_k^i = \sum_{i=1}^n \varepsilon_k M_k^i P_k^* \frac{\Delta t_k^i}{1+t_k^i} \quad (4.14)$$

where the elasticity of import demand for good  $k$  is assumed to be the same for all source countries  $i = 1, \dots, n$ .

A preferential tariff reduction granted by  $j$  to partner country  $i$  will induce substitution of imports away from other countries. This trade diversion is calculated in SMART using the elasticity of substitution. With a little bit of algebra, it can be checked that

$$\frac{d\tilde{P}_k^j}{\tilde{P}_k^j} = \frac{dt_k^i}{1+t_k^i} \quad (4.15)$$

Moreover, by the definition of  $\tilde{m}_k^j$ ,

$$d\tilde{M}_k^i = \frac{M_k^i dM_k^i - M_k^i dM_k^l}{(M_k^i)^2} = \frac{1}{M_k^i} (dM_k^i - \tilde{M}_k^i dM_k^l) \quad (4.16)$$

The “diversion” component of the change in trade flows is the increase in imports from the preferred sources ( $i$ ) that displace imports from MFN sources ( $l$ ). That is, set

$$dM_k^l = -dM_k^i \quad (4.17)$$

where  $l$  is an aggregate of all MFN partners. Then it can be rewritten as

$$d\tilde{M}_k^i = \frac{1 + \tilde{M}_k^i}{M_k^i} dM_k^i \quad (4.18)$$

Substituting for  $d\tilde{M}_k^i$  using (4.19) gives (after several simple transformations):

$$dM_k^i = \left( \frac{M_k^i M_k^l}{M_k^i + M_k^l} \right) \sigma \frac{dt_k^i}{t_k^i} \quad (4.19)$$

This is the basic expression for measuring trade diversion in SMART. Observe that it is increasing in  $\sigma$  (the elasticity of substitution), which is itself unbounded. As the amount of trade diverted cannot be larger than the initial value of imports from  $l$ , we need to introduce a constraint to that effect. We write trade diversion TD as

$$\text{TD} = \begin{cases} \left( \frac{M_k^i M_k^l}{M_k^i + M_k^l} \right) \sigma \frac{dt_k^i}{t_k^i} & \text{if } -dM_k^l \leq M_k^l \\ M_k^l & \text{otherwise} \end{cases} \quad (4.20)$$

where  $M_k^l$  is the initial level of MFN imports.<sup>1</sup>

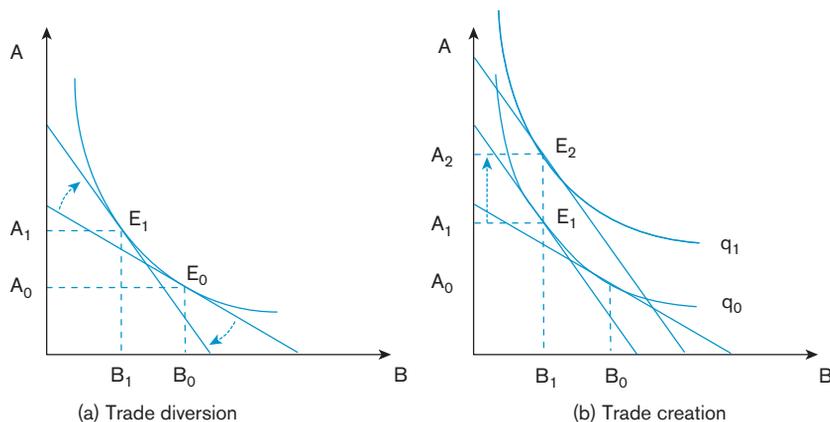
SMART is typically used to analyse the effect of a tariff change that provides a more favourable treatment for one trading partner. For example, granting country  $A$  a lower tariff compared to country  $B$  changes relative prices of the two goods. Consumption of the good from country  $A$  will increase (from  $A_0$  to  $A_1$ ), whereas imports from  $B$  will decrease from  $B_0$  to  $B_1$ . This effect is called trade diversion (as calculated in SMART; see Figure 4.4(a)).

Trade creation happens when the lower price of the variety coming from  $A$  enables consumers to reach a higher composite quantity curve  $q_1$ . Keeping the expenditures constant, consumers are now able to import more of the variety coming from  $A$  ( $A_1$  to  $A_2$ ). (See Figure 4.4(b)).

In SMART, exporter  $A$  will enjoy both a positive diversion effect (from  $A_0$  to  $A_1$ ) and a positive creation effect (from  $A_1$  to  $A_2$ ), whereas exporter  $B$  will suffer from a negative diversion effect (from  $B_0$  to  $B_1$ ), and yet no trade creation effect.

SMART also calculates the effect of trade policy changes on tariff revenue, consumer surplus and welfare. The change in tariff revenue is simply calculated by the difference between the old tariff revenue (initial *ad valorem* tariff multiplied by initial import value) and the new tariff revenue (new *ad valorem* tariff multiplied by new import value).

Figure 4.4 Trade creation and trade diversion in SMART



Source: WITS Online Help on SMART

#### Box 4.1 Example of Albania's unilateral tariff liberalization with the European Union

Let us now turn to a small example in order to illustrate the functioning of SMART in the case of a small country. In the year 2007, Albania sourced buses (HS 870210) from 19 trading partners, of which 11 were European Union countries. The total imports under HS 870210 amounted to US\$ 8.6 million. Albania levied tariffs from all sources, including the EU. Using SMART, the user can simulate the effect of a full trade liberalization towards the EU but not the rest of the world. SMART yields the results that all 11 EU countries would be able to increase their exports to Albania. Germany, for example, the biggest exporter, would see its exports increase by almost US\$ 1 million. Non-EU countries, by contrast, would see their shares shrink. The United States, in particular, would see their exports decrease by about US\$ 0.3 million.

When it comes to changes in revenues, SMART generates a so-called "Revenue Impact Report". In the case of our example, the tariff liberalization would obviously increase imports but at the same time lower tariff revenue (see Table 4.2). SMART calculates the new tariff revenue, the change in tariff revenue and the consumer surplus. As we have seen above graphically and analytically, the trade opening would result in lower tariff revenues but at the same time a higher consumer surplus.

Table 4.2 SMART output "Revenue Impact Report" for the case of Albania, liberalization of HS 870210

Imports Before in US\$ 1,000	Import Change	Tariff Revenue in US\$ 1,000	Tariff New Revenue in US\$ 1,000	Tariff Change in Revenue in US\$ 1,000	Consumer Surplus in US\$ 1,000
8599.096	1714.038	1289.86	346.363	-943.502	157.335

*Case 2: Upward-sloping demand curves*

Until now, we have discussed the case where export supplies are elastic. This is a reasonable assumption for cases such as Albania, a small country with little influence on world market prices. We will now turn to the case of upward-sloping demand curves, i.e. the case where world prices are endogenous.

Few countries can claim to be large enough to affect world price. However, the “large country” assumption can be useful in other contexts as well. Consider the effect of Brazil’s elimination of intra-MERCOSUR tariffs on its imports of, say, milk from Uruguay. The small-country assumption means that Uruguay is assumed in practice to be able to supply the entire Brazilian market at unchanged prices. This is unlikely to be true. So in many preferential-liberalization contexts, assuming a finite elasticity of supply – and hence a variable “world”, or more exactly foreign, price – is more realistic.

However, this raises an additional issue. Take the Uruguay–Brazil example again. If Brazil’s preferential liberalization *vis à vis* Uruguay makes it possible for Uruguayan producers to obtain a higher price on the Brazilian than on other markets, then all of Uruguay’s production should now be diverted to Brazil, which means that Uruguay’s export supply to Brazil should *jump* to the total value of Uruguay’s production, a big-bang outcome that is not amenable to calculus. There is no obvious fix to this problem; you are to assume symmetric structures on the import and export side, with a finite elasticity of transformation between geographical markets playing the same role on the export side as Armington’s elasticity of substitution on the import side. On this, see Francois and Hall (1993), Hoekman et al. (2004) or Jammes and Olarreaga (2005).

We can again derive the term that measures the extent of trade creation. For each good, we now have three unknowns to determine instead of two:  $dX$ ,  $dP$  and  $dP^*$ , all in terms of the tariff change  $dt$ . In order to have a solution we need three equations: the definition of the elasticity of supply,

$$\mu = \frac{P}{X} \frac{dX}{dP}, \tag{4.21}$$

the equation linking the world price, the tariff, and the domestic price, given by (4.11), and the definition of the elasticity of demand, given by (4.10). We will close this simple system of equations by noting that home imports equal foreign exports.

Differentiating again (4.11), but now without holding  $p^*$  constant and substituting from (4.19), gives

$$\begin{aligned} dX &= \frac{\epsilon X}{P} dP \\ dP &= P^* dt + (1+t)dP^* \\ dP^* &= \frac{P^*}{\mu X} dX \end{aligned} \tag{4.22}$$

or, after substitution and replacing  $X$  by  $M$ ,

$$TC \equiv \Delta X = \left( \frac{\mu \epsilon}{\mu - \epsilon} \right) M \frac{\Delta t}{1+t} \tag{4.23}$$

Recall that  $\varepsilon$  is in algebraic value and is thus normally negative, so trade creation is *positive* when the tariff goes *down*. (The large-country formula for trade diversion is more tedious to derive but follows the same logic. Please refer to Jammes and Olarreaga, 2005 for details.)

The easiest way to use SMART is to access it through the World Integrated Trade Solution (WITS) Portal (see Chapter 1). In the main menu under “Tariff and Trade Simulations” you are able to access SMART and to estimate the effect of tariff changes on trade flows, tariff revenues and consumer welfare.

## b. Global Simulation Analysis of Industry-Level Trade Policy (GSIM)

GSIM was developed as an extension and improvement of SMART by Francois and Hall (2003). It shares the same insight that a relatively simple yet flexible PE framework for detailed analysis of trade policy was needed. One simplifying assumption of SMART was that everything is treated in terms of bilateral relationships and world markets are ignored. The key difference between the two tools is therefore that in SMART the market clearing conditions only apply to the import markets, whereas in GSIM the global market is cleared. In the simplest case, we look at a trade policy change between two countries, e.g. a tariff cut, and also include in the analysis of the outcome the impact on the rest of the world. Taking into account global markets enhances the complexity of the model and requires greater computational power, which is, however, easily available today.

Let us illustrate the notion of market clearing using a concrete example. Let us assume a tariff reduction in a particular sector between two countries, assumed to be the EU and the United States, with no changes with respect to the rest of the world. GSIM enables us to calculate the changes in world prices and the welfare impact of the three parties involved (EU, the United States and the rest of the world). The tariff reduction would lead to a new market clearing price. In our example, the bilateral tariff cut would lead to an increase in prices for exporters in the EU and the United States and thus gains in producer surplus for the latter. For producers outside the two, the preferential liberalization would bring down demand for third-country exports and their prices would fall. The result is a loss in producer surplus. The net effects, including the combination of producer surplus, consumer surplus and tariff revenue changes, involve gains for the EU and the United States and losses for the rest of the world.

As in SMART, one of the key assumptions of GSIM is that imports are imperfect substitutes for each other. The elasticity of substitution is assumed to be equal and constant across products from different sources.

Following the formulation of Jammes and Olarreaga (2005), the theoretical model on which GSIM is built up can be summarized as follows.

Within each importing country  $m$ , imports ( $M_{mki}$ ) of the product category  $k$  from country  $i$  are a function of their prices and the total expenditure on the category:

$$M_{m,k,i} = f(P_{m,k,i}; P_{m,k,\neq i}; Y_{m,k}) \quad (4.24)$$

where  $Y_{m,k}$  is the total import expenditure of country  $m$  on product  $k$  and  $P_{m,k,i}$  is the domestic price in country  $m$  of product  $k$  exported by  $i$ .  $P_{m,k,i}$  includes the tariff, therefore

$$P_{m,k,i} \equiv (1 + t_{m,k,i}) P_{k,i}^* \equiv T_{m,k,i} P_{k,i}^* \quad (4.25)$$

where  $t_{m,k,i}$  is the respective tariff imposed by country  $m$  on its imports of good  $k$  from  $i$ .  $P_{k,i}^*$  stands for the world price of product  $k$  exported by  $i$ .

In order to obtain the own price demand elasticity and the cross-price elasticity, we differentiate (4.24) applying the Slutsky decomposition of partial demand and taking advantage of the zero homogeneity property of Hicksian demand:

$$\begin{aligned} \varepsilon_{m,k,i} &= \theta_{m,k,i} (\varepsilon_{m,k} + \sigma_k) \\ \varepsilon_{m,k,\neq i} &= \theta_{m,k,\neq i} \varepsilon_{m,k} - (1 - \theta_{m,k,\neq i}) \sigma_{m,k} \end{aligned} \quad (4.26)$$

$\varepsilon_{m,k,i}$  is the own price demand elasticity in country  $m$  for product  $k$  exported from different countries. The import demand function is the product of  $\theta_{m,k,i}$ , which is the expenditure share of product  $k$  exported by country  $i$  in total imports of product  $k$  by country  $m$  and the sum of  $\varepsilon_{m,k} < 0$  (the composite import demand function for product  $k$  in country  $m$ ) and  $\sigma_{m,k} > 0$  (the elasticity of substitution in country  $m$  for product  $k$  exported from different countries).  $\varepsilon_{m,k,\neq i}$  is the cross-price elasticity of the import demand function in country  $m$  for product  $k$  exported from  $i$  when the price of product  $k$  exported from other countries  $\neq i$  changes.

Before establishing the market equilibrium, we need to define the export supply function as a function of world prices:

$$X_{k,i} = g(P_{k,i}^*) \quad (4.27)$$

Differentiating the export supply function and rearranging in percentage terms gives us the export supply elasticity:

$$e_{k,i} = \frac{\hat{X}_{k,i}}{\hat{P}_{k,i}^*} > 0 \quad (4.28)$$

As we have now defined demand and supply, we are able to estimate the impact of a trade reform on world prices. We use matrix notation in order to obtain a quick analytical solution. First, denote  $\mathbf{E}_{m,k}$  as a diagonal  $x$  by  $x$  matrix of elasticities in country  $m$  for product  $k$ . The elements in the diagonal are equal to  $\varepsilon_{m,k,i} / e_{k,i}$  and the elements off the diagonal are given by  $\varepsilon_{m,k,\neq i} / e_{k,i}$ .

We note  $\mathbf{P}_k^*$  as a vector of percentage changes in world prices of product  $k$ .  $\mathbf{T}_{m,k}$  is a vector recording the tariff changes imposed by country  $m$  on import of  $k$  from different countries. We further denote  $\mathbf{E}_k = \sum_m \mathbf{E}_{m,k}$  and  $\mathbf{B}_k = \sum_m \mathbf{E}_{m,k} \mathbf{T}_{m,k}$ . Assuming market clearing conditions and solving for the changes in the world prices yields:

$$\mathbf{P}_k^* = (\mathbf{I} - \mathbf{E}_k)^{-1} \mathbf{B}_k \quad (4.29)$$

Equation (4.29) allows us to calculate the percentage change in world prices. Once we obtain this information, it is relatively simple to calculate the changes in import and export flows, tariff revenue and welfare (consumer and producer surplus).

The percentage change in imports is obtained by using (4.26) and the definition of import demand elasticity (i.e. the ratio of percentage quantity changes over percentage price changes).

The linear approximation of the changes in tariff revenue is given by:

$$TR_{m,k,i} = t_{m,k,i} M_{m,k,i} P_{m,k,i}^* (\hat{t}_{m,k,i} + \hat{P}_{m,k,i}^* (1 + \varepsilon_{m,k,i})) \quad (4.30)$$

where  $\hat{t}_{m,k,i}$  is the percentage change in the tariff levied by  $m$  on good  $k$  exported from  $i$  and  $\hat{P}_{m,k,i}^*$

is the percentage change in the world price of good  $k$  exported from  $i$ .

The price and quantity effects can also be used to estimate the producer and consumer surplus. A linear approximation of the exporter producer surplus is given by:

$$\Delta PS_{k,i} = P_{k,i}^* X_{k,i} \hat{P}_{k,i}^* \left( 1 + \frac{e_{k,i} \hat{P}_{k,i}^*}{2} \right) \quad (4.31)$$

For the consumer surplus the linear approximation can be estimated as:

$$\Delta CS_{m,k} = \sum_i M_{m,k,i} P_{m,k,i}^* T_{m,k,i} \left( \frac{1}{2} \varepsilon_{m,k} [\hat{P}_{m,k}^*]^2 \text{sign}(\hat{P}_{m,k}^* - \hat{P}_{m,k}) \right) \quad (4.32)$$

where  $P_{m,k} = \sum_i \theta_{m,k,i} \hat{P}_{k,i}^* + \hat{t}_{k,i}$ .

The consumer surplus is measured with respect to the composite import demand curve, with  $P_{m,k}$  representing the price for composite imports and  $M_{m,k,i} P_{m,k,i}^* T_{m,k,i}$  representing initial expenditure at internal prices. Finally, the welfare changes can be calculated as the sum of producer surplus, consumer surplus and import tariff revenues.

In summary, GSIM is an analytical tool for global simulations, i.e. tariff reforms by one or more countries at a time. As in SMART, it assumes imperfect substitution among imported sources. GSIM solves by clearing world markets for the price of each source taking into account substitution across all sources. GSIM can hence be considered as an extension of SMART by adding a multiple market simulation and a solution for world prices.

The developers of GSIM, Francois and Hall, have made available two simple Excel spread sheets to estimate the model.<sup>2</sup> The simplest version is the 4x4 case, meaning three importing and exporting countries as well as all other countries lumped together as the rest of the world. The more complex version is a 25x25 case. The data requirements in the 4x4 case are the trade flows between the four entities, the tariffs before and after a trade policy change as well as the relevant demand, supply and substitution elasticities. In contrast, in SMART you only need information on the trade flows and tariffs of one particular country (for the elasticities default values are set).

**Box 4.2 Example of a trade liberalization in HS 6115 between China and the European Union**

We would like to take a concrete example to show how the 4x4 Excel sheet implements the model. Let us take the global market for the product group HS (2002) 6115: Panty hose, tights, stockings, socks and other hosiery, knitted or crocheted. In this product group the three biggest exporters are, in the following order, China, Turkey and the European Union (considering only extra-EU trade and not intra-EU trade).

Taking the year 2009 as the baseline for trade flows and tariffs, let us assume a bilateral trade liberalization for this product group between the EU and China. Hence the tariffs between the two fall from around 15 per cent and 9 per cent to zero on both sides, whereas the tariffs towards Turkey and the ROW are maintained.

Using the Excel solver we obtain the new prices that clear all markets. These new prices then yield the new changes in trade values and quantities and finally the welfare effects (see Table 4.3). In our case we observe that European consumers and Chinese producers would be the big winners of a mutual trade opening. The total welfare effect would be strongly positive for both economies. The gains would come at the cost of Turkey and the rest of the world. Suffering from a terms-of-trade deterioration, their producers as well as consumers would lose out.

**Table 4.3 Total welfare effects (changes) in case of a trade liberalization in HS 6115 between China and the European Union**

		<i>A</i>	<i>B</i>	<i>C</i>	<i>D = A + B</i>
		<i>Producer surplus</i>	<i>Consumer surplus</i>	<i>Tariff revenue</i>	<i>Net welfare effect</i>
Country	EU	6.9	98.8	-79.7	26.0
	CHINA	65.4	0.7	-0.5	65.5
	TURKEY	-8.8	-0.1	0.0	-8.9
	ROW	-32.1	-58.6	-3.3	-93.9

### c. Tariff Reform Impact Simulation Tool (TRIST)

The Tariff Reform Impact Simulation Tool (TRIST) was developed by experts at the World Bank (Brenton et al., 2009). The development of TRIST was motivated by the observation that more and more countries ask for World Bank support to estimate the adjustment costs of trade policy reforms such as free trade agreements, customs unions or unilateral tariff cuts. The most immediate concern, especially for low-income countries, is typically the impact on tariff revenue, as the latter often represents an important source of government revenue. Compared to other PE tools, TRIST therefore takes a more careful look at actual revenues collected from trade, including all taxes levied on trade and not just tariffs. In case suitable data are available, TRIST also allows estimating the impact of changes in trade policy on output, employment and possibly household income. The latter information also proved to be key for policy makers when trying to garner support for trade

reforms. Since TRIST is a PE model, it can obviously not be used to project the aggregate impact of trade reforms on domestic production and employment but rather to identify sectors that are likely to be hardest hit.

TRIST has the stated objective to overcome two limitations of existing PE models. First, the models presented above assume that the statutory tariffs are indeed being levied on all recorded trade flows. However, it is common for import regimes to grant tariff exemptions for various reasons, such as for consumption by government agencies or on intermediated products to provide incentives for domestic and foreign investment. Brenton et al. (2009) estimate that low-income countries would be able to substantially increase their tariff revenue if they removed all tariff exemptions. Ignoring the tariff exemptions therefore leads to a substantial overestimation of the impact of tariff reform on trade flows and revenues.

The second objective of TRIST is to incorporate the interplay between tariffs and other forms of taxes collected at the border. Many countries levy excise taxes, VAT or sales tax that often generate more revenue than customs duties. In principle, these taxes are applied to both domestic and foreign goods; however, in practice the domestic tax base is usually very small in developing countries. It is unclear *ex ante* whether lowering tariffs will lead to lower or higher VAT and excise tax revenues. Increasing imports could provide more tax revenues. Conversely, as these taxes are usually levied on the value of imports including the tariff, it could also result in a fall of revenues.

Again, TRIST is based on the assumption of imperfect substitution between imports from different sources (Armington, 1969). As in the simplest version of SMART, TRIST assumes that export supplies are perfectly elastic, i.e. changes in tariffs leave world prices unaffected. The model presumes that tariffs are collected as a percentage of the CIF import value, the excise tax as a percentage of CIF import value plus the tariff, and finally the VAT as a percentage of CIF import value plus the tariff plus the excise tax.

In order to calculate the percentage change in the price of good  $k$  from exporter  $i$  due to a change in tariff (and leaving the VAT and excise rate unchanged), TRIST uses the following formula:

$$\frac{\Delta P_i}{P_i^{old}} = \frac{\left[ \frac{P_i^{new}}{P_{wld}} \right] - \left[ \frac{P_i^{old}}{P_{wld}} \right]}{\left[ \frac{P_i^{old}}{P_{wld}} \right]} = \frac{(1+t_i^{new})(1+ext_i)(1+vat_i) - (1+t_i^{old})(1+ext_i)(1+vat_i)}{(1+t_i^{old})(1+ext_i)(1+vat_i)} = \frac{t_i^{new} - t_i^{old}}{(1+t_i^{old})} \quad (4.33)$$

The superscripts “new” and “old” denote the prices and tariffs before and after the policy reform.

The import response to this price change is modelled in three consecutive steps. The substitution effect between different exporters due to changes in tariffs *vis à vis* different exporters is modelled first. Next comes the substitution effect between imports and domestic goods as the relative price between the two changes. Finally, the demand effect as a response to the overall change in the price of a product is modelled last.

In the first stage, TRIST calculates how a given expenditure for imports of a certain good is reallocated across different exporters following a trade policy change. The extent to which a given change in relative prices translates into a change in relative imports hinges on the exporter substitution elasticity (user-defined).

$$M_i^{ES} = \left[ \frac{\Delta P_i}{P_i^{old}} \gamma_i^{ES} + 1 \right] M_i^{old} \frac{\sum_{j=1, \dots, n} M_j^{old}}{\sum_{j=1, \dots, n} \left( \left[ \frac{\Delta P_j}{P_j^{old}} \gamma_j^{ES} + 1 \right] M_j^{old} \right)} \quad (4.34)$$

where  $M_i^{ES}$  stands for the imported quantity from  $i$  after exporter substitution,  $M_i^{old}$  is the imported quantity from  $i$  before reform and  $\gamma_i^{ES}$  is the exporter substitution elasticity for imports from country  $i$ .

In the second step, TRIST estimates how the total expenditure on the good is reallocated between domestic and imported products due to the change in relative prices. The change in allocation is defined by the elasticity of substitution between domestic and foreign goods,  $\lambda^{DS}$ . The change in imports is then distributed across individual suppliers according to their share of overall imports. The total domestic consumption remains constant at this stage, since any change in imports is offset by an opposite change in domestic output.

$$M_i^{DS} = \left[ \frac{\Delta \bar{P}_{imp}}{\bar{P}_{imp}^{old}} \lambda^{DS} + 1 \right] M_i^{old} \quad (4.35)$$

$$M_i^{DS} = M_i^{ES} + [M^{DS} - M^{ES}] \left[ \frac{M_i^{old}}{\sum_{j=1, \dots, n} M_j^{old}} \right] \quad (4.36)$$

where  $M^{old}$  is the total imported quantity before the tariff reform,  $M^{DS}$  is the total imported quantity after substitution with domestic input and  $M_i^{DS}$  is the imported quantity from country  $i$  after substitution between imports and domestic output. The price change of total imports is given by:

$$\frac{\Delta \bar{P}}{\bar{P}^{old}} = \sum_{i=1, \dots, n} \left[ \frac{M_i^{old}}{\sum_{j=1, \dots, n} M_j^{old}} \frac{\Delta P_i}{P_i^{old}} \right] \quad (4.37)$$

In the third and final step, TRIST simulates how the demand effect leads to a change in domestic consumption, i.e. the change of the relative price of the good to which the trade reform applies results in a change in domestic consumption of the good.

$$Q_{TD}^{new} = \left[ \frac{\Delta \tilde{P}}{\tilde{P}^{old}} \mu^D + 1 \right] Q_{TD}^{old} \quad (4.38)$$

$$M^{new} = M^{DS} + [Q_{TD}^{new} - Q_{TD}^{old}] \left[ \frac{M^{old}}{M^{old} + D^{old}} \right]. \quad (4.39)$$

$$m_i^{new} = m_i^{DS} + [M^{new} - M^{old}] \left[ \frac{m_i^{old}}{\sum_{j=1, \dots, n} m_j^{old}} \right] \quad (4.40)$$

**Table 4.4** Breakdown of effects if tariffs are reduced with country A but not with country B

	<i>Imports from A</i>	<i>Imports from B</i>	<i>Domestic Prod.</i>
Exporter substitution effect	↑	↓	—
Domestic substitution effect	↑	↑	↓
Demand effect	↑	↑	↑
Total effect	↑	In theory ambiguous, depends on elasticities	In theory ambiguous, depends on elasticities

where  $Q_{TD}^{old}$  is the initial total demand for product  $k$ ,  $Q_{TD}^{new}$  is the total demand after the change in the overall price of product  $k$ ,  $D^{old}$  is the initial quantity of demand for domestic output,  $M^{new}$  is the final demand for import of product  $k$ ,  $M_i^{new}$  stands for the quantity imported from supplier  $i$  after all three effects and  $\mu^D$  is the demand elasticity for product  $k$ .

The change in price of total domestic consumption is defined as:

$$\frac{\Delta P}{\bar{P}^{old}} = \left[ \frac{M^{old}}{M^{old} + D^{old}} \frac{\Delta \bar{P}}{\bar{P}^{old}} \right] \quad (4.41)$$

TRIST is again set up in Excel and is free to use.<sup>3</sup> It is based on two spread sheets that can be downloaded from the internet. The first one is the Data Aggregation Tool which organizes and formats the data to be imported into the second, the Simulation Tool. The Data Aggregation Tool allows users to create all necessary country and product groups in order to simulate various trade policy scenarios. In the Simulation Tool the user is able actually to define the various policy scenarios and can modify the parameters underlying the calculations.

As TRIST is built upon the idea of carefully examining trade transactions, the model requires detailed and complete data on import flows. For each import transaction the data should include the type of product (typically at the HS eight-digit level), the country of origin, the customs procedure code (CPC) that defines the customs regime under which the good enters, the actual import value, the statutory tariff and the applied tariff along with the value of VAT, excise and other taxes. This data is typically available from customs authorities that have implemented computerized customs systems, such as Asycuda and TradeNet.

The description of the three calculation steps above showed that elasticities played a key role in the model. Detailed estimates of elasticities are not readily available and therefore TRIST includes sensible default values for all three elasticities. The sensitivity of the results can be easily assessed by using different values for the elasticities. The users can also use import demand elasticities estimated by Kee et al. (2004), which are however not available for all product groups at the HS six-digit level.

Before entering the data, TRIST recommends preparing the data appropriately in three steps. First, clean the data by deleting trade flows that do not enter the home market in free circulation. Second, check for possible data entry errors and consistency in the raw data. Finally, manipulate the data into the format required for TRIST, basically with one row for each product imported (identified by the HS code) and one column for each trading partner. The exact procedure for entering the data is described in more detail in section D and also in a manual that can be downloaded for free.<sup>4</sup>

**Box 4.3 Example of COMESA customs union**

Let us now turn to a concrete example, the COMESA customs union (Brenton et al., 2009).<sup>5</sup> TRIST has been used in a considerable number of cases, including in Africa, to analyse the impact of regional trade initiatives. COMESA members were eager to know the possible impact, especially on revenues, of joining the customs union. This policy scenario assumes that all remaining non-zero intra-COMESA tariffs would be set at zero and that a common external tariff is applied to all other trading partners.

Table 4.5 shows the anticipated effects of the implementation of a customs union on three countries, namely Malawi, Zambia and Kenya. As expected, imports in all three countries would increase and tariff revenues would fall. Higher imports would also drive up the revenue by excise tax and VAT, but at the same time lower tariffs would lower the tax base for excise taxes and VAT. In total, all three countries would experience a small trade revenue loss, which is highest in the case of Kenya at 6.3 per cent.

**Table 4.5 Revenue implications of a COMESA common external tariff (in US\$ million)**

Country	Malawi	Zambia	Kenya
Old imports	1416.0	3930.9	9909.1
New imports	1416.6	3949.5	9947.9
% change	0.0	0.5	0.4
Old tariff revenue	75.9	245.8	436.4
New tariff revenue	72.2	203.0	330.3
% change	-4.8	-17.4	-24.3
Old excise revenue	78.8	98.5	517.6
New excise revenue	78.4	98.0	517.6
% change	-0.4	-0.5	0.0
Old VAT revenue	117.0	684.7	798.4
New VAT revenue	115.9	680.1	794.2
% change	-1.0	-0.7	-0.5
Old total revenue	271.8	1029.0	1752.4
New total revenue	266.5	981.2	1642.1
% change	-1.9	-4.6	-6.3
Old collected tariff rate	5.4	6.3	4.4
New collected tariff rate	5.1	5.1	3.3

Source: Brenton et al. (2009) with author modifications

**d. Agricultural Trade Policy Simulation Model (ATPSM)**

As the name indicates, the Agricultural Trade Policy Simulation Model (ATPSM) has been developed to analyse specifically agricultural trade policy issues. The model was mainly developed by UNCTAD in the 1990s in order to estimate the implications for developing countries of agricultural trade liberalization in the Uruguay Round. Compared with the PE models described above, ATPSM

focuses more on standard agricultural policies such as quotas or subsidies as long as the latter are quantifiable.

In the model, domestic prices are assumed to be a function of world market prices and national tariffs, subsidies, quotas and other support measures. For aggregate commodity groups such as beverages or cereals, countries are typically importers and exporters at the same time. To take into account this feature, ATPSM calculates composite tariffs that then determines the domestic consumption and production price.

A domestic market tariff ( $t_d$ ) is calculated as the weighted average of export tariffs ( $t_x$ ) and import tariffs ( $t_m$ ) using the imports ( $M$ ) and exports ( $X$ ) as weights:

$$t_d = \frac{Xt_x + Mt_m}{M + X} \quad (4.42)$$

ATPSM then computes a consumption (domestic market) tariff as the weighted average of the import tariff ( $t_m$ ) and the domestic market tariff ( $t_d$ ), with weights for imports and domestic supply,  $S_d$ , divided by total demand,  $D$ :

$$t_c = \frac{Mt_m + S_d t_d}{D} \quad (4.43)$$

In a similar way, a supply (domestic market) tariff is calculated as the weighted average of the export tariff ( $t_x$ ) and the domestic market tariff ( $t_d$ ), with weights for exports, domestic supply plus the domestic support tariff ( $t_p$ ).

$$t_s = \frac{Xt_x + S_d t_d}{S + t_p} \quad (4.44)$$

These calculations are done for the baseline scenario and the scenario for a trade policy change.

Four equations define the standard equation system for all countries:

$$\hat{D}_{j,i} = \mu_{j,j,i} \left[ \hat{P}_{w_j} + (1 + \hat{t}_{c_j,i}) \right] + \sum_{\substack{k=1 \\ j \neq k}}^K \mu_{j,k,i} \left[ \hat{P}_{w_k} + (1 + \hat{t}_{c_k,i}) \right] \quad (4.45)$$

$$\hat{S}_{j,i} = \varepsilon_{j,j,i} \left[ \hat{P}_{w_j} + (1 + \hat{t}_{p_j,i}) \right] + \sum_{\substack{k=1 \\ j \neq k}}^K \varepsilon_{j,k,i} \left[ \hat{P}_{w_k} + (1 + \hat{t}_{p_k,i}) \right] \quad (4.46)$$

$$\Delta X_{j,i} = \gamma_{j,i} \Delta S_{j,i} \quad (4.47)$$

$$\Delta M_{j,i} = D_{j,i} \hat{D}_{j,i} - S_{j,i} \hat{S}_{j,i} + \Delta X_{j,i} \quad (4.48)$$

where  $\hat{\phantom{x}}$  denotes a relative change and  $\Delta$  an absolute change. The demand elasticity is denoted  $\mu$  and the supply elasticity  $\varepsilon$ .  $P_w$  stands for the world prices. Furthermore,  $\gamma$  is the ratio of exports to production,  $i$  is the country index and  $j$  and  $k$  are the commodities indices.

Equation (4.47) implies that the change in exports goes hand in hand with a change in production. In other words, the proportion of exports to production is always maintained. Equation (4.48) clears the market so that imports plus production equals domestic consumption and exports. This market clearing solution differs from the models above, as we no longer assume Armington elasticities.

Using several mathematical manipulations, one is able to derive the change in world prices that can then be inserted into (4.45–4.48) in order to obtain the volume response,  $\Delta X$ ,  $\Delta M$ ,  $\Delta S$  and  $\Delta D$ . Using the volume response, the trade revenue and welfare effect (sum of changes in producer surplus, consumer surplus and net government revenue) can be estimated (for details please refer to the ATPSM Manual, pp. 17–22).

### *Quotas*

One of the particularities of ATPSM is that it can estimate the economic consequences of import quota changes. The import quotas are assumed to be binding. Changing the import quotas will change the quota rents and tariff revenues but not the level of imports.

The WTO Agreement on Agriculture introduced a new system of tariffication by which low tariffs would be applied within the import quota (“within-quota tariff”) and higher tariffs above (“out-of-quota tariff”). This system generates quota rents, which can make an important contribution to welfare and are therefore included in the model.

Quota rents are the import quotas times the difference between the domestic prices and world prices plus the within-quota tariff. Or expressed differently, whenever the quota is filled then imported goods enter the domestic market at two different tariff levels, at the within-quota tariff and the out-of-quota tariff. As the domestic price is identical for all products, it then equals the world price plus the out-of-quota tariff. As a consequence, those foreign producers who only pay within-quota tariffs earn quota rents. This usually only happens in cases where quotas are unfilled. However, the ATPSM assumes that the out-of-quota tariffs always determine the domestic market price, even if the quota is unfilled. Changes in tariff quotas can thus have different consequences. For example, a reduction in within-quota tariffs will increase quota rents and decrease tariff revenue, or a reduction in out-of-quota tariffs will decrease quota rents and out-of-quota revenue.

Each WTO member notifies its global quotas without, however, specifying bilateral quotas. ATPSM therefore uses bilateral trade flows to estimate the bilateral quota distribution. ATPSM gives the user the option to choose whether the rents should be allocated to the supplier or the importing country government. Similar to quotas, ATPSM also offers the option of taking into account export subsidies and export quotas.

### *Analyzing economic effects of trade policy proposals*

The basic idea in estimating the economic effects is that trade policy modifications trigger price changes that will alter supply, demand, exports and imports. ATPSM computes the market clearing world price where the global sum of net import changes is zero. For example, when a country unilaterally cuts a tariff on a certain commodity, the domestic demand will increase and the domestic supply will fall. As a consequence, world prices will increase.

The trade revenue change is calculated as the difference between the change in export and import values. For a country that cuts tariffs unilaterally, the volume, value and price of imports increase, while the export volume decreases. The direction of the change of export price and value is indeterminate.

Welfare in ATPSM is measured as producer surplus, consumer surplus and net government revenue. Producer surplus is calculated as the aggregate difference between price and marginal costs plus any quota rent received on exports. The consumer surplus is computed as the aggregate difference between marginal valuation and price. Finally, government revenue is determined by revenues from import tariffs, including both within-quota and out-of-quota tariffs, and expenditure on export subsidies and domestic support.

In the case of a unilateral tariff cut, the producer surplus shrinks while the consumer surplus increases. The direction of change of the net government revenue is indeterminate for two reasons. First, the tariff cut leads to more imports, which might result in a higher or lower tariff revenue overall. Second, the lowering of the tariff implies a reduction in the quota rents. Overall, the net effect of a unilateral tariff cut on a specific commodity is usually positive, unless the country is large enough to make world prices raise. As we have seen in SMART, in the case of upward-sloping demand curves an optimal tariff level exists.

In the rest of the world, the increased world price results in an increase in producer surplus and a fall in consumer surplus. The change in government revenue is indeterminate and depends on demand elasticity. Those countries that are net exports of the commodity gain in welfare while those that are net importers lose. The net effect is a global increase in welfare.

When a country unilaterally reduces its export subsidies on a commodity, the effects on the domestic economy are similar. Domestic prices fall as producers no longer receive supports for exporting the commodity. The increase in domestic demand (consumer surplus increases) and the reduction of supply (producer surplus shrinks) will lead to an increase in the world price. Now, however, government expenditure will be unambiguously lower. The net effect is an increase in aggregate welfare of the country, unless the country is able to influence world prices.

ATPSM has been translated into a software that can be downloaded for free from the UNCTAD website. Since the focus of ATPSM is on agriculture, the software covers all agricultural commodities. The software holds several predefined aggregated agricultural commodity groups, such as beverages (cocoa, tea, coffee) or cereals (wheat, rice, barley, maize and sorghum). However, the user is also able to change the composition of these groups.

The software is able to analyse various trade policy changes, in particular those particularly prevalent in agricultural trade, such as changes in import quotas or export subsidies. The software produces five economic estimates, namely:

- trade volume changes in production consumption, imports and exports
- trade value changes in production consumption, imports and exports
- welfare changes (producer surplus, consumer surplus and net government revenue)
- price changes (world market, wholesale and farm prices)
- changes in tariff quota rents.

In ATPSM, tariff cuts are expressed as a percentage of the initial tariff. Export subsidies and extra farm support are measured as *ad valorem* tariff equivalents and thus the cuts are also translated into percentage reductions of *ad valorem* equivalents. The model is able to simulate trade policy changes by individual countries, by a group of country or globally.

## C. Applications

This section provides a short manual for each of the four PE models. For each PE model, one can download for free very detailed descriptions of how to implement the models. The purpose of this section is therefore to provide a first introduction to potential users in order to enable them to run simple simulations.

Prior to the discussion below, remember that the first question the *ex ante* analyst is faced with is a simple one: what are the options to be compared? Sometimes the “client” — government agency, politician or other — has a clear idea of what the alternatives are but sometimes she/he does not. In that case the analyst must reduce the range of possibilities to a small set of scenarios. There is a trade-off involved in the choice of those scenarios: on the one hand, they should be realistic and thus should not involve extreme values of policy variables; on the other hand, they should be sufficiently differentiated to highlight the consequences of choices. Where the optimum lies is a matter for the analyst’s judgment, keeping in mind that as computing is free, the more scenarios that are explored in the early stages of the analysis the better.

### 1. SMART

SMART is accessible through the World Integrated Trade Solution (WITS) website. Access to this data consultation and extraction software is free and only requires user registration.<sup>6</sup>

#### a. The start

Once you have logged into WITS, the first page holds an upper bar with the following options: Quick Search, Advanced Query, Tariff and Trade Simulations, Results, Utilities, and Support Materials. Choose “Tariff and Trade Simulations” and then click on “SMART”.

A new page will be opened which allows you to give a name to your query or open an existing query. If you are using the program for the first time, enter a name for the new query, e.g. “test”, and a description, e.g. “To test SMART”. Please note that for the query name, spaces and special characters are not permitted. Once you have defined both the query name and the query description, click on the button “Proceed”.

Another new page will open which will allow you to define the year, products, scenario, elasticities and the type of tariff change (applied to applied MFN rate or to bound rate). First, select “Year” and choose the baseline year. The baseline year is the year against which you would like to benchmark a trade policy change.

Next, select the products that you would like to include in your analysis by clicking “Select”. This will prompt another window which enables you to make a detailed choice of the product(s) you would

like to include in the analysis. Remember from above that PE models are particularly suitable to estimate trade effects for a specific sector. First, select the nomenclature. You can choose from among 14 different nomenclatures, and depending on the nomenclature specify a product group or a product up to the six-digit level. You can select the product by clicking on the specific product. WITS also offers the possibility of choosing from among product groups predefined by COMESA or by the WTO or to define your own product groups. Once the products have been selected, please click the “Proceed” button which brings you back to the previous page.

### b. Defining a scenario

The next step consists in selecting a scenario. Click on “Modify” on the right of the scenario box which will open a new window. The new window holds two boxes entitled “Available Scenarios” and “Selected Scenarios”. As a first step, click on “Add/Modify” at the bottom of the box “Available Scenarios”. This will open yet another window called “Modify Scenario”.

You will now be asked as a first step to give a name and description of the scenario, for example “Test” as the scenario name and “Zero tariffs for imports from New Zealand”. As a second step, you need to identify the partners and the products to which the trade policy change applies. For the partner, click on “Select” and a new window will open. You are now able to select individual countries from a country list or use predefined country groups. A simple click on the country name is enough and the country selected appears in a box on the right side of the screen. Once all countries have been selected, click on the “Proceed” button to return to the previous page.

After selecting the country to which the new trade policy should apply, you have to identify the product that will be covered by the new policy. By clicking “Select”, a new window opens that looks almost identical to the window for product selection that came before. Again, select the nomenclature and then the product. You can again choose from among 14 nomenclatures and products up to six digits of detail. Obviously, you need to make sure that those products covered by the new trade policy include those that have been selected previously for the trade policy analysis.

Finally, you will be asked to define the tariff change. You can select either “New Rate”, “Maximum Rate”, “Linear Cut” or “Swiss Formula”. A switch to duty-free market access would, for example, mean that the new rate is zero. A “Maximum Rate” implies that an upper limit for the new tariff level can be chosen. The option “Linear Cut” would imply a linear reduction of all tariffs. Finally, a specific coefficient for the Swiss Formula can be entered. Once the formula has been chosen, please click on the “Proceed” button, which brings you back to the window entitled “Select a Scenario”. You can now choose the newly defined scenario, as it will appear under “Selected Scenarios”. Again, click the “Proceed” button and the window closes.

### c. The elasticities

You should now be back to the screen where you can choose the year, the products, the scenario and the elasticity. The next step is now to define the substitution and supply elasticity (the import demand elasticity is defined by the system). The default of the substitution elasticity is 1.5 but can be modified. The default of the supply elasticity is 99 in order to simulate a perfectly elastic supply response. As described above, you can also imagine upward-sloping supply curves which would

mean a much lower value for the supply elasticity, e.g. on the order of 2. As the last step, you need to decide whether the tariff changes should be applied to the applied MFN rate or to the bound rate. In order to finish the request, click on the “Save & Submit” button.

#### d. Download and view results

After the submission of the simulation, a new window pops up. This window has two tabs: one is called “View and Request Download” and the second “Download Data”. The first tab holds in one row the following information:

- ID of the request and the query/simulation name
- options to view, download or delete the request
- the log (query definition and execution statistics)
- the status, the source and the date.

Clicking on the view icon opens up a new window that allows you to access the following tables:

- detailed data
- exporter view report
- market view report
- revenue impact report
- trade creation effect report
- trade welfare effect report.

Viewing these tables gives a first impression of the estimation results. The tables can be downloaded by requesting the download (click on the download icon). WITS will then start downloading to your computer.

In order to download the entire estimation results, click on the “Download Data” tab. A very similar table is presented with the following columns:

- ID and query/simulation name
- options to save or delete the request
- information on the status, source, date, file size and the total number of rows.

Clicking on the “save” icon gives you the option to save all the above-mentioned tables as a single zip file. Downloading the zip file is the last step in using WITS for a SMART simulation.

## 2. GSIM

### a. The start

The Excel spread sheets use the Excel solver to find a solution for the new world prices after trade policy changes, assuming market clearing conditions. On the basis of the new equilibrium price values, other changes in the system are calculated subsequently, including the changes in trade quantities and values, in producer and consumer surplus as well as in tariff revenues.

### b. The 4×4 case

The simple 4×4 case is constructed to simulate the effect of a trade policy change between three countries as well as the rest of the world. For example, one could imagine a unilateral, bilateral or trilateral trade liberalization. The Excel file provided by Francois and Hall (2003) uses the example of a reciprocal tariff cut between the United States and the European Union to illustrate the functioning of the model.

The simplest way to simulate trade policy changes in GSIM is to use one of the two Excel files that can be downloaded from the website.<sup>7</sup> The file GSIM4x4.xls offers the possibility to simulate a trade policy change that affects trade between four countries. The file holds four worksheets that are called "Introduction", "The Model", "Trade Values" and "Welfare". The worksheets "The Model", "Trade Values" and "Welfare" are already filled with data from a hypothetical example of trade between the United States, Japan, the European Union and the Rest of the World (ROW). Users can learn about the functioning of GSIM by going through this example and then replacing the existing numbers with their own numbers.

### c. The input

The first worksheet, called "Introduction", only describes GSIM quickly and requests the user to install the Excel solver. The Excel solver is a tool to solve equation systems with constraints. Remember that the condition in GSIM was to have markets cleared. The Excel solver can be easily installed (see Help in Excel) and should be available for free.

The second worksheet, "The Model", is the key worksheet to work with. It holds four input tables that the user is required to fill in. The first input table requires trade data at world prices between the respective four trading partners: the United States, Japan, the European Union and ROW. The user needs to collect these bilateral trade data from sources introduced in the first chapters of this handbook, such as UN COMTRADE or WITS. The data reflects bilateral trade flows for which economists usually prefer to use recorded imports rather than exports.

The next input table in "The Model" worksheet is needed in order to enter the initial import tariffs between the four trading partners. The Excel sheet requires you to enter the tariffs as 1 + per cent of tariff. For example, a 10 per cent tariff should be entered as 1.1. Obviously, you are able to enter the applied or bound tariff rates depending on the purpose of the simulation. Also note that the tariffs are supposed to be bilateral and therefore a preferential rate applies in some cases.

The third input table reflects the trade change scenario and therefore holds all projected tariff rates. Thus in this table you can enter different liberalization scenarios. Again, you will need to decide whether the tariff changes will be implemented on the applied or the bound rates.

The last input table asks for parameters for the three elasticities in the model, namely import demand, export supply and substitution elasticity. The elasticities can obviously be different between countries. As for the import demand elasticity, most models use a value between 1 and 1.5 (Kee et al., 2006). The export supply elasticity depends on whether one country is large enough to influence world prices. In case the country is small, the export supply elasticity can be assumed to go to infinity (a value of 99 can then be entered). Finally, the substitution elasticity is usually assumed to be between 1 and 5.

#### d. The output

Once the input table is filled, the Excel solver has to be used to solve the excess demand conditions. In the table called “Model Solutions”, you will need to highlight all four fields in the column “Excess Demand” with the cursor. Once highlighted, you will need to click on “Solver” (add-in option under the “Data” tab). A small new window opens entitled “Solve Parameters”. You simply need to click “Solve” and Excel should be able to find a solution to the optimization problem. A window will then appear called “Solver Results” and ask you whether to keep the solver solution or to restore the original values. Please choose “Keep Solver Solution” and Excel will then adjust the values in the table “Market Clearing Conditions” accordingly. This concludes the entries required of you. Excel automatically generates all other tables using the results produced by the Excel solver.

The results produced by the Excel file consist of several tables and graphs. First, the worksheet “Model Solutions” shows the changes in prices, supply and demand as depicted above. Below these solutions another box called “Other Results” is presented with the following 4x4 tables:

- trade values and quantities as per cent change
- trade at new world prices at new values
- trade at world price as change in values
- proportional change in internal prices.

Finally, the worksheet has a short table on tariff revenue and consumer surplus as well as one on total welfare effect (see below). You can thus identify the changes in producer and consumer surplus as well as the changes in tariff revenue and finally the net welfare effect.

The next worksheet, “Trade Value”, duplicates the results from the worksheet “The Model” on trade at world prices as change in values in a table and in a graph. The last worksheet, “Welfare”, uses the table on welfare from “The Model” worksheet and also produces a graph by country (see below).

### 3. TRIST

TRIST is also based on Excel. It is, however, more complex to handle than SMART or GSIM. As explained above, a very detailed description of how to use TRIST can be downloaded from the World Bank’s website. Here we would like to give you a general idea of what you will be required to do without going into too much detail.

**Table 4.6** GSIM table model solutions

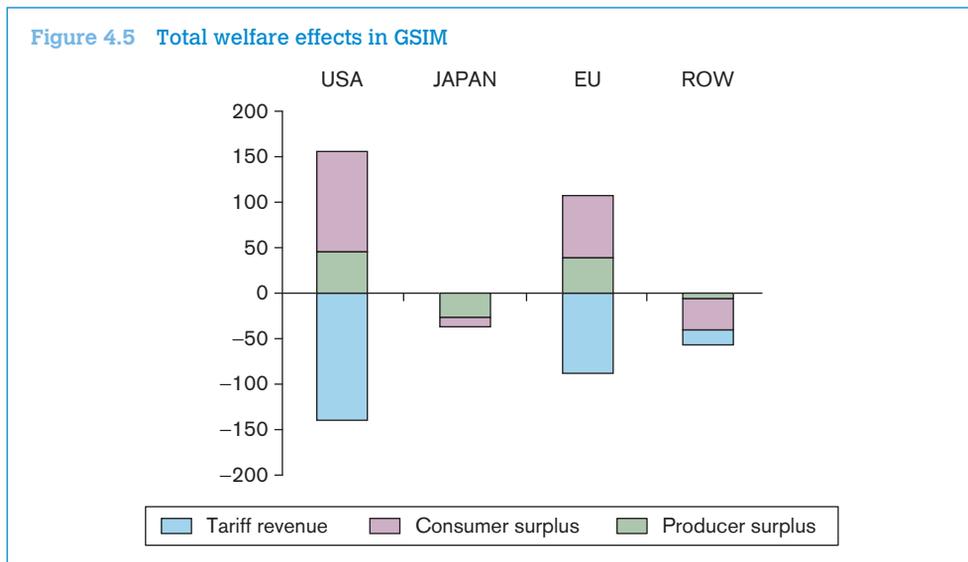
MARKET CLEARING CONDITIONS						
Relative price changes						
		Benchmark prices	New prices	Change in supply	Change in demand	Excess demand
Origin	United States	0.0000	0.0792	0.1188	0.1188	0.0000
	Japan	0.0000	-0.0316	-0.0474	-0.0474	0.0000
	EU	0.0000	0.0480	0.0721	0.0721	0.0000
	ROW	0.0000	-0.0184	-0.0276	-0.0276	0.0000

Source: Francois and Hall (2009), GSIM4x4.xls file

**Table 4.7 Total welfare effects in GSIM**

		Total welfare effects			
		A	B	C	D=A+B
Country		Producer surplus	Consumer surplus	Tariff revenue	Net welfare effect
		United States	46.1	110.6	-138.5
	Japan	-26.2	-8.9	0.6	-34.5
	EU	39.8	68.6	-93.8	14.5
	ROW	-5.1	-32.9	-2.9	-40.8

Source: Francois and Hall (2009), GSIM4x4.xls file



### a. The start

The first step in TRIST is to obtain very detailed trade data (typically at the eight-digit level), which includes the following entries:

- HS code
- country of origin
- Customs Procedure Code (CPC)
- import value
- tariff paid and exempted
- excise tax paid and exempted
- VAT paid and exempted
- other taxes paid and exempted.

In the best case, you might have a table available that looks like the Table 4.8.

**Table 4.8 Detailed import data for TRIST**

<i>National tariff code</i>	<i>Country of origin</i>	<i>CPC</i>	<i>Import value</i>	<i>Tariff paid</i>	<i>Tariff exempted</i>
01051110	USA	40000	100	10	0
39252000	BRA	400GM	500	100	0
42021210	DEU	40000	1200	0	120
11029000	ZMB	40000	400	40	0
...	...	...	...	...	...

<i>Excise tax paid</i>	<i>Excise tax exempted</i>	<i>VAT paid</i>	<i>VAT exempted</i>	<i>Other taxes paid</i>	<i>Other taxes exempted</i>
0	0	15	0	0	0
0	0	75	0	0	0
0	0	0	180	0	0
80	0	60	0	0	0
...	...	...	...	...	...

**Table 4.9 Detailed import data for TRIST**

	<i>Albania</i>	<i>American Samoa</i>	<i>Angola</i>	<i>...</i>
01011000	120		320	
01019000		310		
01021000		340		
...				

Obviously, the HS code identifies the type of product. The Customs Procedure Code (CPC) determines the customs regime under which a good enters the country. These codes are necessary in order to know which imports have to be removed from the dataset during the data cleaning procedure (for example, the CPC code 400GM could refer to government imports and could thus be dropped).

It is important to have information on all taxes applied at the border and exemptions granted for these taxes. If information on exemptions is not available, it can be calculated as: Exemptions = [tariff rate] \* [import value] – [tariff paid]. For tax, excise and VAT revenue, you can construct:

- applied tariff rate: [tariff revenue] / [imports]
- statutory tariff rate: [tariff revenue + tariff exemptions] / [imports]
- applied excise rate: typically, [excise revenue] / [imports + tariff revenue]
- applied VAT rate: typically, [VAT revenue] / [imports + tariff revenue + excise revenue].

Finally, the data have to be formatted in order to fit into TRIST. TRIST accepts data with the structure as outlined in Table 4.9.

The table should have one row for each product imported, identified by the HS code. If trade has been zero, the cell should stay blank. It is crucial that the codes (and their order) are exactly the same in all five tables. One column is also needed for each trading partner. Again, it is important that trading partners (and their order) are exactly the same in all tables.

You have to generate five separate tables with this structure and cover the following variables:

1. imports
2. statutory revenue (= collected tariff revenue + exemptions)
3. customs revenue
4. excise revenue
5. VAT revenue.

### b. Importing data into TRIST

Once the data have been cleaned and brought into the appropriate format, we can import them into TRIST using the TRIST data aggregation tool. First open the file TRIST\_Data\_Aggregation2RC.xls. It will first ask you to specify the country, currency, year and HS version. Then you are able to open the TRIST-Data Management Menu.

The next window that appears asks you to define the taxes collected at the border. You can choose the name of each tax and the tax base definition from a drop-down menu. Then press "OK". Back in the main menu, click on "Import Data". Next, import the previously cleaned data, i.e. the data sets on imports, statutory tariff revenue, collected tariff revenue, trade tax 1 revenue and trade tax 2 revenue. Once you have finished importing data, press "Close" and in the data import assistant press "Finish". This completes the data import process.

Help		DATASET INFORMATION	
Country:	Burundi		
Currency:	Burundi Franc (F Bu)		
Year:	2007		
HS Version:	HS2002 (HS2)	Open Data Management Menu	
TAXES: NAMES AND DEFINITIONS			
Tax	Name	Definition	Flag Product Group
Tax 1	Excise tax	Imports + Collected Tariff Rev. (CTR)	
Tax 2	VAT	Imports + CTR + Tax1 (T1)	
Other Taxes	No		
TRIST - Status of data imports			
	Step 3 (Imports data)		Completed
	Step 4 (Statutory tariff revenue data)		Completed
	Step 5 (Collected tariff revenue data)		Completed
	Step 6 (Excise tax)		Completed
	Step 7 (VAT)		Completed
	Step 8 (Other Taxes)		Optional
	Optional Step: EPA Exclusion list		Completed
TRIST - Data Aggregation and Filtering			
	User Defined Country Groups		6
	User Selected Tariff Lines		All

Source: TRIST

### c. Using the TRIST simulation tool

Once the data are imported, the user can open the actual simulation tool (TRIST Simulation 3.01.xls). In this tool the so-called “Control Panel” is key. It allows you to upload data from the aggregation tool, to customize TRIST and to define the policy scenarios.

The screenshot shows the TRIST Simulation Control Panel interface. It is titled "TRIST Simulation Control Panel" and has a "Country / Year" field. The interface is divided into several sections:

- 1. INPUT DATA:** Includes fields for "Number of Tariff Lines" and "Number of Country Groups".
- 2. TARIFF CHANGE SCENARIO:** Includes a "Group of Countries" dropdown menu (set to "Rest of the World"), a "Selected Scenario" dropdown menu (set to "No tariff change"), and a "Description" field (set to "Tariff levels unchanged for all products").
- 3. ELASTICITIES:** Includes three input fields for "Elasticity for exports", "Elasticity for domestic substitution", and "Elasticity for demand effect", with values 1.1, 1, and 0.2 respectively.
- 4. DOMESTIC PRODUCTION:** Includes a "Include data on production status?" dropdown menu (set to "no").
- 5. TARIFF CHANGE SCENARIO:** Includes a table for defining scenarios for Tariff 1, Tariff 2, and Tariff 3, all currently set to "No tariff change".

Source: TRIST

The first step is to upload the data, by choosing “Import Trade and Revenue Data” in the “Control Panel” and by selecting the previously saved data aggregation tool from the respective folder. Closing the control panel brings you back to the worksheet. To the right of the country groups you should see “No tariff change” under the heading “Selected Scenario”. This implies that the current scenario is to leave all tariffs as they are.

In order to define tariff reform scenarios go to the “Control Panel” and choose “Manage Tariff Reform Scenarios”. There, first choose the product group you would like to apply a separate tariff scenario to by choosing it from the “Affected Products” drop-down menu. Then, choose a type of tariff change to be applied as well as the corresponding parameter, e.g. “Fixed value” with parameter “0” implies that all tariffs are set to zero, or “Linear cut” with parameter “10” implies that all tariffs are cut by 10 per cent. Next, the user has to choose the “Tariff base” to which the change is to be applied. Finally, the user clicks on “Add Definition to the Scenario” and saves the scenario.

Below the reform scenarios, you can see the elasticities for the trade model, which can be customized in the “Control Panel”. By clicking again on the “Control Panel” we have now the options to manage the simulation results and to export the post simulation data. This step concludes the simulation exercise with TRIST. The main results are then summarized in the worksheet “Results” and presented in a table as below:

<b>RESULTS</b>	
<b>Impact on imports:</b>	
Imports pre	344,342,907,214
Imports post	344,342,907,214
Change in imports	0
% change in imports	0.0%
<b>Impact on revenue:</b>	
Tariff revenue pre	41,511,784,348
Tariff revenue post	41,511,784,348
Change in tariff revenue	0
% change in tariff revenue	0.0%
<b>Total Tax Revenues on Imports</b>	
Total revenue pre	106,463,453,437
Total revenue post	106,463,453,437
Change in Total revenue	0
% change in Total revenue	0.0%
<b>Total Tax Revenues on Imports and Domestic Production</b>	
Total tax revenue pre	106,463,453,437
Total tax revenue post	106,463,453,437
Change in total tax revenue	0
% change in total tax revenue	0.0%
<b>Collected Tariff rate:</b>	
Collected applied tariff rate pre	12.1%
Collected applied tariff rate post	12.1%
% change in collected applied tariff rate	0.0%
For more details see worksheet 'Detailed Results'	

Source: TRIST

## 4. ATPSM

ATPSM (version 3.1) can be downloaded for free from the UNCTAD website and installed automatically.<sup>8</sup> Once the program is installed, the user has the choice between six icons at the top of the page, namely "Title", "Scenario", "Country Groups", "Commodity Groups", "Results" and "Help". The software is rather intuitive, combined with the fact that ATPSM is specific to the agricultural sector, so this chapter does not provide a detailed description of how to use it. Instead we would like to sketch out an application of ATPSM.

ATPSM has been used to estimate the gains from a further multilateral liberalization of agricultural trade. One can imagine several scenarios for estimating the potential effects of such reforms on developed and developing countries. ATPSM offers the possibility of calculating the impact so as to include all main agricultural commodities and cover basically all world trade (176 countries including all larger economies). The rate cuts can be undertaken according to three types of measures: out-of-quota tariffs, export subsidies and domestic support. ATPSM contains the default scenarios as set out in Table 4.10.

**Table 4.10** Default scenarios for ATPSM

Country code	Commodity code	Parameters				Applied or bound rate
		Rate cut (%)				
		Out-of-quota tariff	Export subsidy	Domestic support		
Developed countries	All commodities	36	21	20	Bound	
Developing countries	All commodities	24	14	13	Bound	

This implies a 36 per cent reduction in out-of-quota tariff, a 21 per cent reduction in export subsidies and a 20 per cent reduction in domestic support in developed countries. Two-thirds of these cuts apply to developing countries.

ATPSM then estimates the impact on prices and produces five categories of economic estimates for each country:

1. volume changes in production consumption, imports and exports
2. trade value changes (changes in export, import and net trade revenue)
3. welfare changes (changes in producer surplus, consumer surpluses and net government revenue)
4. price changes (world market, wholesale (consumer) and farm prices)
5. changes in tariff quota rents (forgone and receivable).

The results of the estimation can be accessed under the icon "Results" and are discussed in detail in the paper by Vanzetti and Graham (2002). From an empirical perspective, the major drawback of the ATPSM is the relatively out-dated price, tariff and trade data. The latest version of ATPSM from 2006 uses volume data based on the average of the years 1999 to 2001, most recent price data from 2001 and applied tariff data from 2000 or 2001. Given the fact that many agricultural commodities have undergone substantial changes in prices, production, trade volume and patterns over recent years, the estimation results would probably look very different when using the most current data as baseline.

## D. Exercises

### 1. Bus market in Albania (SMART)

Albania is a small country in the Balkans with about three million inhabitants and a nominal GDP per capita of around US\$ 4,000. Albania is not yet a member of the European Union (EU), but the Albanian government submitted its application for membership in 2009. Albania acceded to the WTO in 2000 and has substantially liberalized its trade since then.

Albania is a net importer of manufactured goods (accounting for almost two-thirds of total merchandise imports) and the main imported goods are machinery and transport equipment, particularly automotive

products and certain non-electrical machinery. In 2009 the average applied MFN tariff for non-agricultural products was 4.2 per cent. The highest applied tariff was 15 per cent.

In 2006 Albania signed the Stabilization and Association Agreement with the EU that included a commitment to liberalize trade further between the EU and Albania. In this exercise, we would like to simulate the effect of such a liberalization towards the EU for one particular product group, namely HS 870210.

Taking the year 2007, we suppose that Albania is considering a full tariff elimination towards the EU for trade of products falling under HS 870210. Using SMART in WITS, you are supposed to generate the following tables:

- exporter view report
- market view report
- revenue impact report
- trade creation effect report
- trade welfare effect report.

## 2. Japan's meat market (SMART)

Let us assume a scenario in which Japan would fully open up its market of frozen meat from bovine animals (0202: HS 2002) for one particular country, e.g. New Zealand, while maintaining the same tariffs for all other trading partners. In 2009, Japan was the third biggest importer worldwide of frozen meat from bovine animals with imports totalling US\$ 840 million. New Zealand, on the other hand, even though it is a relatively small economy, was the third largest exporter worldwide, accounting for around 10 per cent of the world market in 2009 (UN COMTRADE, 2011).

Obviously, one would expect that Japan's decision to lower tariffs to zero on this product group would result in a substantial jump in exports of frozen meat from New Zealand to Japan. Part of this increase would come at the expense of other major meat exporters such as Australia.

In SMART, the export supply elasticity is set at infinite by default (using the value 99) making the country a price-taker. In our example, it would certainly be more realistic to assume that Japan's market opening would affect world prices and thus the export supply elasticity needs to be changed to a finite elasticity. Changing to a finite elasticity will transform part of the trade creation (quantity effect) into price effect.

For this exercise, we would like you to take the imports of Japan in the product group 0202 (HS 2002) for 2009 as the baseline. Now, assume that Japan opens its frozen meat market fully to New Zealand while keeping the same tariff for the other trading partners. Using the values of 99, 10 and 5 for the export supply elasticities, calculate the resulting:

- import shares
- revenue effects
- trade creation effects.

### 3. Socks trade between the EU and China (GSIM)

The objective of this exercise is to learn how to use the 4x4 Excel sheet of the GSIM model. Take the global market for the product group HS (2002) 6115: Panty hose, tights, stockings, socks and other hosiery, knitted or crocheted. In this product group, the three biggest exporters are, in the following order, China, Turkey and the European Union (considering only extra-EU trade and not intra-EU trade). As a first step, fill in all the trade flows between the three economies as well as between each of them and the rest of the world (ROW) for the year 2009. (The data can be downloaded from the UN COMTRADE website or through the WITS portal. Please measure the trade flows as imports.)

**Table 4.11 Trade flows in HS 6115 for the three largest exporters (2009, in US\$ million)**

		<i>Destination</i>				<i>Totals</i>
		<i>EU</i>	<i>CHINA</i>	<i>TURKEY</i>	<i>ROW</i>	
<i>Origin</i>	EU					
	CHINA					
	TURKEY					
	ROW					
	Totals					

The second data input requirements are the initial import tariffs and the envisaged ones. The model allows using applied or bound tariff rates. In our case, please use the applied tariff rates. Using WITS, download the data for 2009 and fill in the table.

**Table 4.12 Applied tariffs in HS 6115 between the three main exporters and ROW (year 2009)**

		<i>Initial import tariffs</i>			
		<i>Destination</i>			
		<i>EU</i>	<i>CHINA</i>	<i>TURKEY</i>	<i>ROW</i>
<i>Origin</i>	EU				
	CHINA				
	TURKEY				
	ROW				

We would like to simulate a scenario of a possible bilateral trade liberalization for this product group between the EU and China. The tariffs between the two would therefore be reduced to zero on both sides.

**Table 4.13** Projected tariffs in HS 6115 between the three main exporters and ROW

		Final import tariffs			
		Destination			
		EU	CHINA	TURKEY	ROW
Origin	EU				
	CHINA				
	TURKEY				
	ROW				

The final input requirements are the elasticities, namely for import demand, export supply and substitution. Since it is rather difficult to obtain estimates of these elasticities, we will use the same values provided as default in the 4x4 Excel sheet.

Please now use the function of the Excel solver to obtain the new prices that clear all markets. Look at the changes in trade values and quantities. The table on welfare effects should look similar to the one presented in section B of this chapter.

#### 4. Burundi's trade opening (TRIST)

Burundi is a land-locked least developed country in Central Africa. Burundi's exports are mainly destined for Europe and the United Arab Emirates and are composed of agricultural products. Burundi imports mainly from Europe and other Central African countries. Burundi is a member of various regional trade agreements, namely the Economic Community of Central African States (ECCAS), the Common Market for Eastern and Southern Africa (COMESA), the Economic Community for Great Lakes Countries (CEPGL) and the East African Community (EAC). Recently Burundi initiated an interim Economic Partnership Agreement with the EU, replacing the trade chapter of the expired Cotonou Agreement.

In this exercise, you will be asked to reproduce the simulation results generated by the World Bank for Burundi. The World Bank has made the data on Burundi freely available on their website.<sup>9</sup> We would like you to go through the same steps as described above, importing the data into the TRIST simulation tool. Using the simulation tool, simulate three liberalization scenarios:

- full trade liberalization with COMESA
- full trade liberalization with EAC
- full trade liberalization with the European Union, except for the EPA exclusion list (as defined in the data aggregation file for Burundi).

## Endnotes

1. SMART actually introduces the upper bound in a slightly different way but the spirit is the same.
2. In an earlier version of WITS, GSIM was offered as an option for simulations. In the future, the online-based version of WITS will offer again this functionality.
3. Background material and the two Excel files can be downloaded from the World Bank website: <http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/TRADE/0,,contentMDK:21537281~pagePK:210058~piPK:210062~theSitePK:239071,00.html>. The main file named TRIST\_Data\_Aggregation2RC.xls is password protected, which means that the content of the cells cannot be altered. To unprotect any worksheet, one needs to click on "tools", "protection", "unprotect sheet" and enter the password "TRIST".
4. The World Bank website offers a manual that shows in great detail how to enter the data. The manual can be downloaded from [http://siteresources.worldbank.org/INTRANETTRADE/Resources/239054-1196261607599/4442906-1253911939559/TRIST\\_Manual.pdf](http://siteresources.worldbank.org/INTRANETTRADE/Resources/239054-1196261607599/4442906-1253911939559/TRIST_Manual.pdf).
5. We basically summarize the results presented in Brenton et al. (2009).
6. Access to some specific databases can be fee-charging or limited depending on the status of the user.
7. <http://www.i4ide.org/people/~francois/Models/index.htm>
8. <http://r0.unctad.org/ditc/tab/atpsm.shtm>
9. <http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/TRADE/0,,contentMDK:22328199~pagePK:210058~piPK:210062~theSitePK:239071~isCURL:Y,00.html>

## References

- Armington, P. (1969), "A theory of demand for products distinguished by place of origin", IMF Staff Paper 16, Washington D.C.: International Monetary Fund, 159–78.
- Brenton, P., Saborowski, C., Staritz, C. and von Uexkull, E. (2009), "Assessing the adjustment implications of trade policy changes using TRIST (Tariff Reform Impact Simulation Tool)", Policy Research Working Paper 5045, Washington D.C.: The World Bank.
- Brooke, A., Kendrick, D. and Meeraus, A. (1988), *General Algebraic Modelling System: A User's Guide*, Redwood City: The Scientific Press.
- Francois, J. and Hall, K. (1997), "Partial equilibrium modelling", in Francois, J. and Reinert, K. (eds.), *Applied Methods for Trade Policy Analysis: A Handbook*, Cambridge, UK: Cambridge University Press.
- Francois, J. and Reinert, K. (eds.) (1997), *Applied Methods for Trade Policy Analysis*, Cambridge, UK: Cambridge University Press.
- Jammes, O. and Olarreaga, M. (2005), *Explaining SMART and GSIM*, Washington D.C.: The World Bank. Available at: [http://wits.worldbank.org/witsweb/download/docs/explaining\\_smart\\_and\\_gsim.pdf](http://wits.worldbank.org/witsweb/download/docs/explaining_smart_and_gsim.pdf). Accessed on 16 November 2011.
- Kee, H. L., Nicita, A. and Olarreaga, M. (2005), "Import demand elasticities and trade distortions", Policy Research Working Paper 3452, Washington D.C.: The World Bank, published in *The Review of Economics and Statistics* (2008) 90(4): 666–82.
- Laird, S. (1997), "Quantifying commercial policies", in Francois, J. and Reinert, K. (eds.), *Applied Methods for Trade Policy Analysis: A Handbook*, Cambridge, UK: Cambridge University Press.
- Nicita, A. and Olarreaga, M. (2006), "Trade, production and protection 1976–2004", *World Bank Economic Review* 21(1): 165–71.
- Roningen, V. O. (1997), "Multi-market, multi-region partial equilibrium modeling", in Francois, J. and Reinert, K. (eds.), *Applied Methods for Trade Policy Analysis: A Handbook*, Cambridge, UK: Cambridge University Press.
- Schott, P. (2004), "Across-product versus within-product specialization in international trade", *Quarterly Journal of Economics* 119: 647–78.
- United Nations Conference on Trade and Development (UNCTAD) (2003), *Major Developments and Recent Trends in International Banana Marketing Structures*, Geneva: UNCTAD. Available at: [http://www.unctad.org/en/docs/ditccom20031&c1\\_en.pdf](http://www.unctad.org/en/docs/ditccom20031&c1_en.pdf). Accessed on 16 November, 2011.
- Vanzetti, D. and Graham, B. (2002), "Simulating agricultural policy reform with ATPSM", paper presented at the European Trade Study Group Fourth Annual Conference, Kiel, 13–15 September.
- Vanzetti, D., Fernandez, S. and Chau, V. (2004), "Banana split: how EU policies divide global producers", United Nations Conference on Trade and Development (UNCTAD) Policy Issues in International Trade and Commodities Study Series No. 31, Geneva: UNCTAD.
- World Bank (2008), "WITS advanced course presentation tools for market access analysis".



## CHAPTER 5: General equilibrium<sup>1</sup>

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### TABLE OF CONTENTS

A. Overview and learning objectives	181
B. Analytical tools	181
1. The foundations of computable general equilibrium analysis	182
2. Implementation	185
C. Application	200
Policy simulations and their appraisal: assessing the impact of the Uruguay Round	200
Endnotes	204
References	205

## LIST OF FIGURES

Figure 5.1.	The circular flow of commodities in an open economy	185
Figure 5.2.	Steps towards a policy experiment with CGE models	186

## LIST OF TABLES

Table 5.1.	A Social Accounting Matrix for a standard trade model	198
Table 5.2.	CGE studies of the Uruguay Round	202

## A. Overview and learning objectives

While Chapter 4 looked at partial equilibrium models, this chapter focuses on the second family of simulation models, the so-called general equilibrium (GE) models. GE models will be preferred to partial equilibrium models when the scope of the experiment is large and when inter-market linkages (impact on factor rewards), budget constraints and real exchange rate effects are expected to be particularly important.

This chapter, however, fundamentally differs from the other chapters in this guide. We do not aim here at providing the tools and the techniques to actually run an economically meaningful GE model. We believe that the complexities of this technique cannot possibly be mastered in a single chapter of a guidebook. For this reason the chapter does not have a section with exercises.

The aim of this chapter is to provide the reader with an understanding of how GE models work, what they can and cannot do, and what is required to run a GE simulation. This knowledge is essential to choose the most appropriate methodology of analysis to address a question. Therefore, this chapter, although not a practical guide to GE analysis, is a necessary complement to the other chapters.

## B. Analytical tools

Economic analysis may be partial equilibrium or general equilibrium in nature. A general equilibrium analysis explicitly accounts for all the links between the sectors of an economy – households, firms, governments and countries. It imposes a set of constraints on these sectors so that expenditures do not exceed income, and income, in turn, is determined by what the factors of production earn. These constraints establish a direct link between what the factors of production earn and what households can spend. A partial equilibrium model usually focuses only on one part or sector of the economy, assuming that the impact of that sector on the rest of the economy, and vice versa, is either non-existent or small. Partial equilibrium has many advantages, but when it comes to extensive policy changes, economy-wide repercussions are likely to be important. For example, changes in the tariff structure are often pervasive. In many cases, moving to a common external tariff implies a drastic reduction in protection, which would call for a real depreciation of the national currency to restore external balance. These scenarios could also imply substantial changes in factor markets, requiring adjustment in factor rewards. Clearly, if these effects operate at the country level, they apply with greater force when multilateral trade agreements are implemented. Because GE analysis takes into account the interaction across markets, it overcomes these shortcomings. In particular, by taking into account budget constraints, GE analysis gets rid of “free lunches”. For example, in the case of a reduction in protection, a GE model will evaluate the extent of real depreciation necessary to maintain external balance. However, there are circumstances when the benefits of a general equilibrium model are offset by the high level of aggregation required to be able to use comparable and consistent data and by the difficulties in specifying parameters and functional forms in the model.

The purpose of the class of GE simulations in which we are interested is to determine the effects of a change in trade policy on the endogenous variables of the model – prices, production, consumption, exports, imports and welfare. The simulation represents what the economy would look like if the policy change or shock had occurred. The difference in the values of the endogenous

variables in the baseline and the simulation represents the effect of the policy change. So the model should be able to foretell the effect on trade and production patterns if the trade policy was changed. Furthermore, based on the change in welfare, the policy-maker would be able to judge whether the country benefited from the change in policy or not.

It is important to keep in mind that GE policy experiments should only be seen as comparing second-best situations. The reason why is that parameter estimates computed in order to calibrate the model to SAM's data, for instance (see sections 3.2 and 3.3 below), do capture rigidities and market distortions that are likely to be present in most economic markets. However, by assuming that those rigidities and market distortions are invariant in the experiment under consideration, GE policy experiments would be able to generate clear-cut quantitative results contrary to theoretical and analytical models. In the latter, outcomes would depend on parameter values and could thus only be assessed in an ad hoc manner. This could be seen as a good argument to rely on GE assessments while investigating the impact of a specific policy reform.

During the development of the field, computing equilibrium was often a problem and one often referred to GE simulation analysis as "Computable General Equilibrium" (CGE) modelling. The name has survived although computational aspects are no longer an issue. This means that with increasing data availability, the avenues open to GE simulations are almost infinite. Hence this is only an introduction to the subject.

Having suggested the limitless options for GE simulations, we should point out the major criticism raised concerning this approach. As will become clear in the discussion on calibration, the approach here is to fit the chosen behavioural specification to the data, which means that the flow data (here reflected in the constructed SAM) represent equilibrium. In short, the model is never confronted with the data (even if, as mentioned above, one can experiment with different models, sometimes referred to as different "closure" rules). There is thus no formal hypothesis testing even though, with today's computing power, one could carry out a Monte Carlo analysis.

In addition, building a GE model for policy analysis is a time-consuming task. First, you must assemble the dataset. This is not that easy even if you can rely on simple functional forms. You also have to start with a balanced dataset, i.e. a balanced Social Accounting Matrix (SAM). Usually this requires some work and, when data come from different sources, you have to do the balancing yourself. Second, you must specify the model. Here the difficulty is that the slightest mistake results in a leakage (i.e. income is not equal to expenditure for one agent) and the model will not solve. Again, finding the source of the mistake can be quite time-consuming.

Overall, the good news about GE analysis is that it is rigorous and is an effective tool for testing the implications of alternative model specifications. The less-good news is that, if you wish to learn about GE modelling, there is no alternative to getting your hands "dirty" and building a model yourself. This is why we will proceed with a description of the full set of equations for a simple "toy" model.

## 1. The foundations of computable general equilibrium analysis

A GE analysis is able to account for all the linkages between the sectors of an economy. These could be inter-linkages between industries, both backward and forward, or they could be linkages between household expenditures and incomes. A GE model imposes income/expenditure and resource

constraints, thus ensuring that households are keeping to their budget lines and that the total amount of primary factors employed in production does not exceed a country's factor endowments.

### a. Linkages in the economy

The *ceteris paribus* assumption of partial equilibrium models can be restrictive, particularly if the analysis involves more than one market and if account is to be taken of income effects along with the substitutability and complementarity of products as well as shifts in the factors of production among sectors. A general equilibrium model captures the fact that markets are linked and that events that take place in one market have effects on other markets that need to be taken into account, since they can feed back into the original market.

These linkages work through a number of channels. One channel is the consumer. A reduction of the tariff on wheat, for example, will increase the quantity of wheat demanded by consumers and simultaneously reduce demand for products that are substitutes for wheat (such as rice), increasing demand for products that are complementary to it (such as butter). Changes in relative prices will also affect the composition of demand through their income effects. Another channel is producers. A fall in the tariff on wheat will reduce the returns from wheat farming, leading to a decrease in the quantity of wheat supplied by domestic producers. This will release factors of production – land, capital and labour – employed in the wheat sector to other sectors (such as rice) whose production may expand. Since the quantity of wheat demanded increases while the quantity supplied decreases, the change can only be accommodated by rising imports.

All these changes set up ripple effects throughout the rest of the economy. Resources released from the wheat sector are now available for use by other sectors in the economy. They will flow to sectors such as the rice sector and maybe to the export sector as well. There will therefore be changes in the patterns of production, consumption and trade that go well beyond the wheat sector, although the most significant change may still occur in that sector. For trade economists, the gains from reducing tariffs on wheat come from freeing up resources so that they can be employed in sectors where their contribution to the economy is greater. The only reason why the resources in question were employed in the wheat sector in the first place was because trade protection allowed producers there to pay more for the additional resources.

By way of contrast, a typical partial equilibrium analysis would only stop at the wheat market. It would capture the increase in the quantity of wheat demanded, the reduction in domestic production and the increase in wheat imports. But it would fail to capture what occurs in the markets for wheat complements and substitutes and would especially fail to capture the link between consumer income and expenditures on these other goods. A partial equilibrium analysis would not take into account how other sectors (e.g. exportables) might expand using the resources released from the wheat sector.

A general equilibrium approach is ideal for analyzing the effects of multilateral trade liberalization or regional integration in its broader sense. This is because multiple countries and markets are involved, and tariffs would be changing in all of those countries and markets.

### b. Circular flow

Some of these economic linkages are captured by the circular flow picture of the economy's operation. There are two important institutions involved in the circular flow: households that are

consumers as well as being the owners of factors of production such as land, labour and capital; and firms. Households sell the services of factors of production to firms, so there is a flow of these factor services from households to firms. In exchange, firms sell goods and other services to households. Hence there is a reverse flow of products and other services going from firms to households. Many GE models also explicitly represent the government, but the latter's role in the circular flow is often passive, i.e. collecting taxes and disbursing these revenues to firms and households as subsidies and lump-sum transfers subject to rules of budgetary balance specified by the analyst.

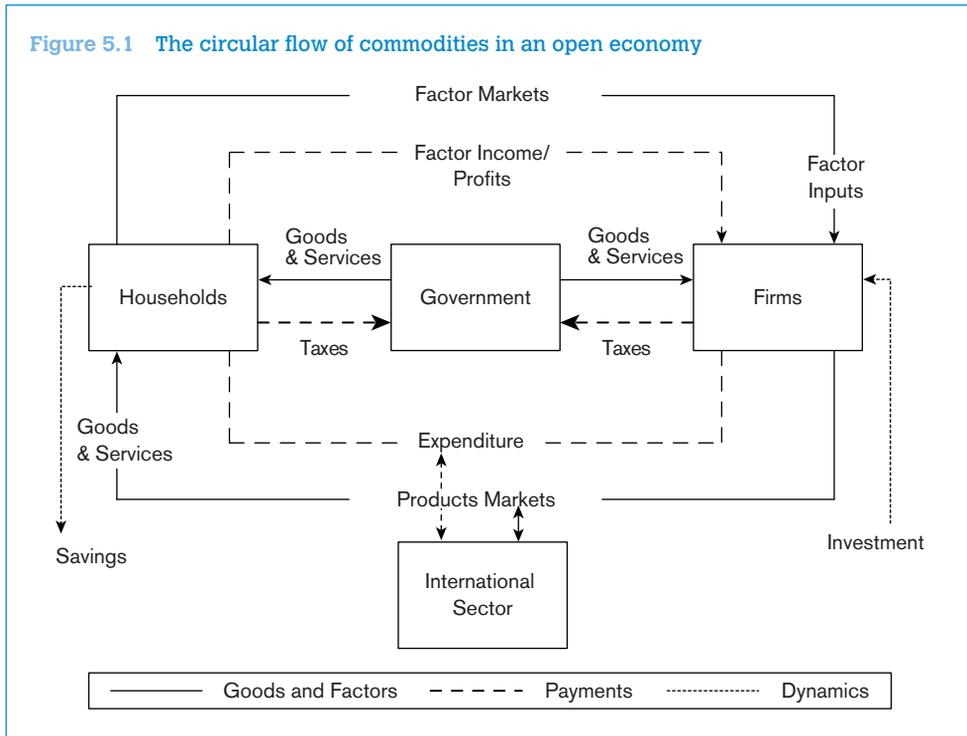
The circular flow could also be described in terms of payments and receipts instead of goods and services. Payments in the form of rent, wages, interest and profit are paid by firms to households, which receive the payments as income. There is thus a flow of payments from firms to households. Note that this means that firms do not retain profits (if any) and that these are redistributed to their rightful owners – households. Households in turn spend money on the goods and services produced by firms, which receive these as revenues; so there is a reverse flow of payments going from households to firms.

In a closed economic system, the value of these flows should be equivalent. This is reflected in accounting identities. Total expenditures on goods and services must equal the total income received by owners of the factors of production. If households save part of their income, this forgone consumption must be equal to investment, which allows an economy to increase its productive potential over time.

In dynamic models where the time path or sequence of equilibriums that the economy tracks is important, investment determines how fast the economy grows. In dynamic models, the distinction between stocks and flow has to be made. Savings by a household at any point in time is a flow. The household's wealth, however, is a stock and is formed out of the sum of all previous savings by the household. An analogous relationship holds between the economy's investments and its capital stock. Investments at any given time are a flow; capital stock is the accumulation of all past investments made by the economy. Hence, changes to the economy over time occur through the effect that these changes in flows have on stock variables.

Figure 5.1 describes the flow of goods and services/expenditures and receipts in an open economy with three sectors – households, firms and the international sector – plus government. Each economic transaction that involves an exchange of goods or services must be matched by a corresponding flow of expenditures and receipt of payment. For example, the transaction involving households purchasing goods produced by firms is depicted as both a flow of goods (plain line) and a flow of payments (dashed line). The flow of goods moves from firms to households; the flow of payments moves in the opposite direction from households to firms.

The link between the domestic economy and the international sector is captured in the four sets of arrows that lead to and out of the international sector. The international sector is a source of additional goods and services, i.e. imports, to the domestic economy. This is matched by a payment flow from domestic residents to foreigners. But some of the goods and services produced in the domestic economy also go to the international sector as exports. This flow outward of goods and services is matched by an inward flow of payments to domestic producers. If no capital flows are allowed between the domestic economy and the rest of the world, the value of exports must equal the value of imports.



### c. Optimizing behaviour in general equilibrium analysis

In general equilibrium analysis based on the Walrasian theory of general equilibrium, the underlying assumption is that of optimizing or “rational” behaviour by economic agents. This assumption is also maintained in partial equilibrium models but is more apparent and explicit in general equilibrium models. Thus households maximize utility subject to income constraints and firms maximize profits. This assumption is responsible for generating downward-sloping demand curves and upward-sloping supply curves. Optimizing behaviour by economic agents also lays the foundation for analyzing the welfare effects of different equilibriums and the policy measures that produce those outcomes.

The indicator for assessing the efficiency of an economic system is consumer welfare. This is because the material resources of any economy are there to satisfy human needs. The role of firms or producers is to transform these resources as efficiently as possible into those goods and services that households desire. In other words, the role of firms and the role of the assumption of profit maximization are to ensure that society produces all that it is capable of producing (i.e. it is on its production possibility frontier and not within). As we explained in the circular flow subsection above, households are the ultimate owners of all factors of production and they receive all factor payments as income – wages, interest and rent as well as profits.

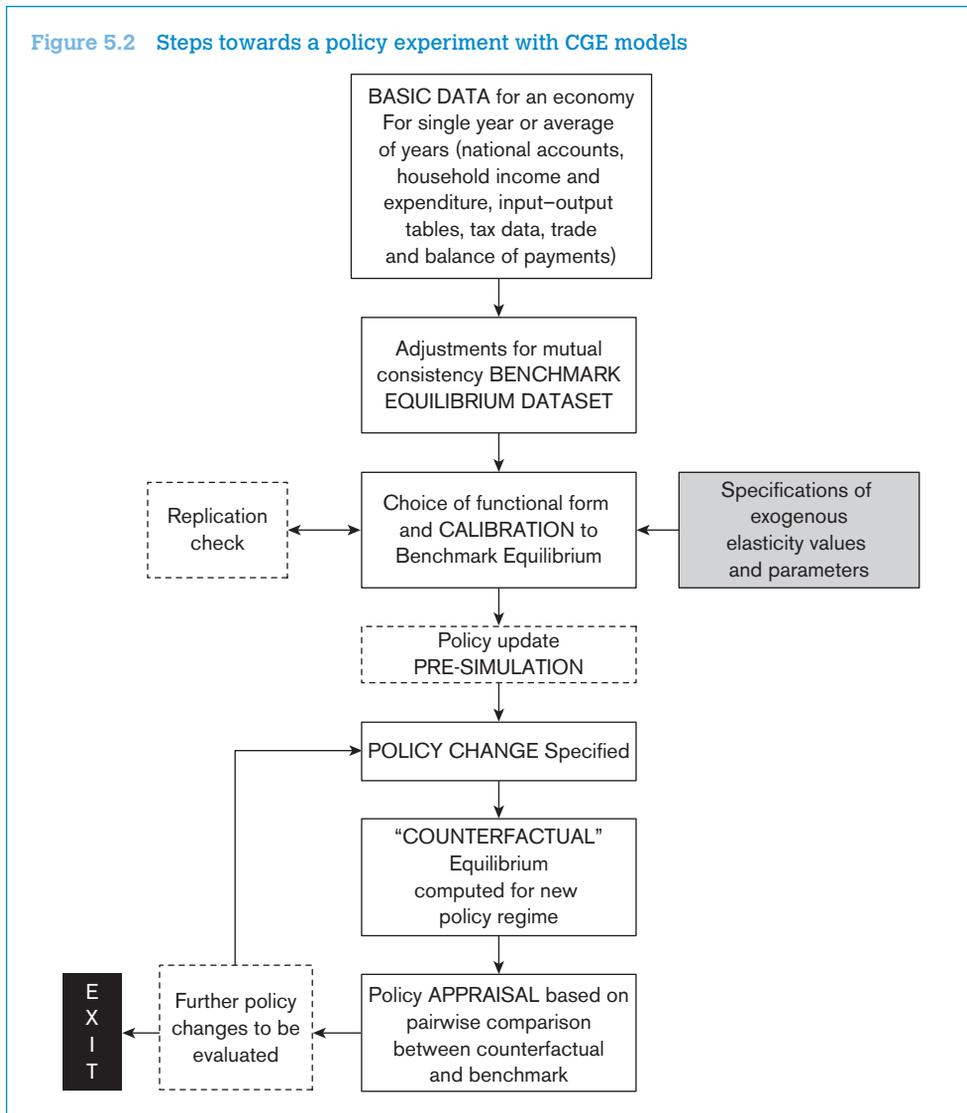
## 2. Implementation

Implementing some kinds of CGE analysis is not necessarily a very easy task if it has to be done from scratch. Shoven and Whalley (1984) noted that: “Modellers must know general-equilibrium

theory so that their models have a sound theoretical basis; they need to be able to program (or at least to communicate with programmers); they must understand the policy issues on which they work; they have to know about data sources and all their associated problems; and they have to be conversant with relevant literature, especially that on elasticities.” Although implementation is much more “user-friendly” today than it was two decades ago, the quality of an analysis still relies on the Shoven and Whalley competencies list.

Figure 5.2 contains the typical steps to follow in order to implement a CGE analysis of a particular policy reform.<sup>2</sup> The steps leading to defining the policy experiment to be assessed are presented in detail in the next three sub-sections, although not necessarily in the order appearing in the figure. The last steps dealing explicitly with the policy reform to be simulated and the analysis and

**Figure 5.2 Steps towards a policy experiment with CGE models**



appraisal of the relative results are the core of section 4. The case of the impact of the Uruguay Round is used to illustrate possible issues in such an exercise.

### a. Applied general equilibrium models of trade

From a theoretical point of view, there are two major traditions in CGE modelling. The neoclassical tradition generally assumes full employment of labour and capital; sectoral adjustments are driven by relative prices. CGE models from the structuralist tradition generally assume quantity adjustments of output and cost-driven prices. We present some of the main differences of the two approaches in Box 1.1.

The neoclassical tradition, however, remains the dominant one. Tractability and high consistency with SAMs' accounting mechanisms justify such a situation to a large extent. In what follows, the core tradition is neoclassical. However, we also present various structuralist peripheral extensions and components.

#### i. Structure

##### Market structure

The large majority of CGE models assume that product and factor markets are perfectly competitive. This means that households and firms make their decisions regarding the purchase and sales of products and factors of production by taking the prices of these goods and factors as given, i.e. outside their control. Neither a single household nor firm is able to affect prices by its behaviour. Perfect competition also means that in equilibrium firms do not make economic profits.

In some recent CGE models monopolistic competition is allowed, usually in the manufacturing sector. The idea is that some products are differentiated into different models or types, as for example cars (sedan, coupé, SUV), and that consumers prefer this differentiation. Within the relevant range of output, production of each of these differentiated goods is subject to increasing returns to scale. Although existing firms have market power (their output decision affects price), entry by new firms, which is equivalent to introducing a new product, ensures that in equilibrium no economic profits are made.

Although the assumption of product differentiation and monopolistic competition makes a CGE model more complex, it allows the model to capture the very large role that intra-industry trade plays in the trade of developed countries. Older models of international trade, such as that of Heckscher-Ohlin that assume homogeneous products, would be unable to explain the importance of intra-industry trade. CGE models based on the hypotheses of constant return to scale and homogeneous goods explain intra-industry trade by assuming that goods differ by country of origin. This is known as the Armington assumption. The advantage of product differentiation models is that the degree of product differentiation is determined within the model rather than exogenously by the value of the Armington coefficients. In a CGE model with product differentiation, policy changes affect an economy also through the impact on the number of varieties available to consumers. Since consumers love variety, the larger the range of products available in the market, the greater their well-being.

##### Production and firm behaviour

The production side of a CGE model is represented by a set of goods (outputs), the inputs that are required to produce them and the technology of production. In most CGE models the production technology is

divided into two levels – an intermediate and a final level. In the intermediate level, goods are used as inputs to produce a composite intermediate good; primary factors (land, labour and capital) are also used to produce a new item called value added. The final level involves using both the value added and the composite intermediate good to produce the (final) output. See Figure 5.2 for an example of this technology. The intermediate level is characterized by no substitution possibilities among the intermediate inputs and the primary factor of production. However, substitution is possible among primary factors and among intermediate goods. The final stage, which in essence creates the final product, also allows for substitutability between value added and the composite intermediate goods. This two-level structure affords a far better description of production in modern economies than the traditional production function involving just primary factors since most goods are made up of many finished components and parts sourced from other suppliers. The important parameters that describe this technology are the fixed coefficients of the intermediate input stage and the elasticities of substitution.

Control over the production sector of the economy is exercised by profit-maximizing firms. Using prices of goods and the factors of production as market signals, they make their decisions about how much of each good to produce. They purchase primary factors from households and intermediate goods from other firms and use these to produce the goods which, in turn, are sold back to households. Revenues received from sales of products are used to pay the owners of the primary factors of production in the form of rent, wages and interest and to pay suppliers of intermediate inputs. But because markets are perfectly competitive, economic profits are driven to zero.

## Households

Households are the consumers as well as the owners of factors of production. As owners of land, labour and capital, they receive rent, wages and interest paid out by firms. This income is then spent on goods and services that households consume. Some of the income may be paid as taxes to government directly (e.g. income tax) or indirectly (e.g. tariffs on goods, sales tax, etc.) and some of it may be saved. Consumption yields utility to households.

The utility maximization problem is often posed in terms of a representative household. With the objective of maximizing utility, it must decide how much of its income to allocate to the goods and services that are available in the market. All of its endowments of land and capital are made available to firms (a full employment assumption) at the going market price for these factor services. Posing the optimization problem in this way, however, presumes that all households in the economy are identical and thus sidesteps interpersonal welfare comparisons (the issue of inter-country comparison of welfare is pursued in a later discussion below). However, issues involving the distribution of income can still be analyzed since changes in factor prices will reveal how distribution is affected, i.e. whether labour gains against property owners, etc. Moreover, where impacts on individual households are important, as in the case of the impact of a policy change on poverty, CGE analysis can be complemented by country-specific case studies to establish the potential effect on different household groups or different regions within a country (see Hertel and Winters, 2005).

## Government

In CGE models, governments function to collect taxes and tariffs, disburse subsidies and purchase goods and services. These activities are not necessarily assumed to satisfy some optimization goal,

unlike the case of consumers and firms. Even if some budgetary restrictions could be imposed to assess some fiscal transfer schemes for instance, the role of the government remains essentially passive. However, changes to these fiscal policy instruments provide the exogenous shocks that lead to adjustments to the rest of the economy which the CGE model seeks to capture. It is then possible to conduct a welfare analysis of these policy changes and to rank the available policy choices.

## International trade

In a CGE model with international trade, the model will include links with other countries, which will also have their own sets of consumers, producers and governments. The introduction of a foreign sector requires treatment of one key issue – substitutability between imports and domestic products.

Almost all CGE models assume that the foreign and domestic products are not perfect substitutes so that products in international trade are differentiated by their country of origin (the Armington assumption). This means that wheat grown in the United States is different from wheat grown in Australia. Thus even with open trade between both countries, world prices for US wheat and Australian wheat need not be equalized and each country can simultaneously export its own wheat and import the wheat of its trade partner.

The differentiation by country of origin has implications for both consumer and firm choices. For example, in the case of the firm some of the intermediate goods that it purchases will be imported. The choice between domestic and imported intermediate inputs depends on the prices of the goods and the Armington elasticity, which is a measure of the substitutability between domestic and imported products. Furthermore, the imported product is also a composite good made up of imports coming from individual trade partners. For consumers, preferences are now defined for goods that are a composite of domestic and imported goods. Again, how much of domestic production or imports is purchased depends on the relative prices and the Armington elasticity.

On the export side, the country sells a differentiated product in the world market. One consequence of product differentiation by country of origin is the omnipresence of terms of trade changes. Terms of trade refers to the ratio of a country's export and import prices. Each country is the unique supplier of its differentiated product. This means the prices of its export goods depends on the amount demanded in the world market. A country can only export more if its export price were to fall, enticing foreigners to buy more of its goods. Thus, because of the Armington assumption changes in trade policy tend to produce significant terms of trade changes in CGE models. The possibility of terms of trade changes has important implications for gains from trade liberalization.

In CGE models with Armington's national product differentiation, trade expands purely at the intensive margin: each exporter increases the size of its exports but there is no change in the set of exporters nor in the set of destination countries. We know the importance of the extensive margin for international trade, which has been illustrated in previous chapters of this book. The extensive margin is a crucial force behind trade expansion following liberalization. Then the absence of the extensive margin in Armington-type CGE models results in the well-known "stuck on zero trade" problem.<sup>3</sup> The Armington specification has the effect of locking in pre-existing trade patterns and prevents the models from generating large changes in trade in sectors with little or no trade. Under this specification, if a country's imports from another country of a given product are zero

initially, they will always be zero even after significant reductions in trade barriers. If imports are non-zero but small, they will remain small even if there are large changes in prices. This “stuck on zero trade” problem makes CGE models especially inappropriate for the least developed countries, which usually have limited trade with the rest of the world.<sup>4</sup>

## *ii. Equilibrium*

Solving a CGE model involves searching for the set of prices that produces market equilibrium. In equilibrium, demand for goods equals their supply. The demand for factors of production equals the available endowments. Consumers have chosen the utility-maximizing basket of goods, given their incomes, while firms have chosen production levels that maximize their profits.

This means that equilibrium in the circular economic flow of Figure 5.1 results in the conservation of both product and value in the context of Walrasian general equilibrium. Conservation of product, which holds even when the economy is not in equilibrium, establishes that the quantity of a factor with which households are endowed or of a commodity that is produced by firms must be completely absorbed by the firms or households (respectively) in the rest of the economy. In other words conservation of product ensures that the flows of goods and factors must be absorbed by production and consumption activities in the economy. This is an expression of the principle of no free disposability and corresponds to the condition of market clearance. Conservation of value reflects budgetary balance, implying that for each activity in the economy the value of expenditures must be balanced by the value of incomes and that each unit of expenditure has to purchase some amount of some type of commodity. In other words, neither product nor value can appear out of nowhere. Nor can product or value disappear. Conservation of value is obtained with constant returns to scale in production and perfectly or monopolistically competitive markets. This implies that in equilibrium producers make zero profit. Lastly, the returns to households' endowments of primary factors that are associated with the value of factor rentals to producers accrue to households as income that the households exhaust on goods purchases. When households' factor endowments are fully employed so that no amount of any factor is left idle (e.g. there is no unemployment) and households spend their whole income on goods (some amount of which are for the purpose of saving), the principle of balanced-budget accounting known as income balance is satisfied.

The three conditions of market clearance, zero profit and income balance are sufficient to solve simultaneously for the set of prices and the allocation of goods and factors that support general equilibrium. The three conditions define Walrasian general equilibrium in terms of the allocation of goods and factors itself and not necessarily reaching this allocation through the process of exchange. This allocation is made up of the components of the circular flow corresponding to the solid lines in Figure 5.1. General equilibrium can therefore be modelled in terms of barter trade in goods and factors without the need to keep track of the compensating financial transfers explicitly. This explains why CGE models typically do not explicitly represent money as a good. However, the quantities of different goods need to be made comparable by expressing their values in some common unit of account. As a consequence, flows are expressed in terms of a numéraire good whose price is taken as fixed. This explains why CGE models only solve for relative prices.

Different settings of the exogenous variables such as tariff levels will produce different market equilibriums. For the policy-maker, it is important to be able to evaluate these different possible

outcomes. A CGE model provides the policy-maker with the required measure in the form of consumer welfare. Each setting of the trade measure is associated with a particular equilibrium and a corresponding value for consumer welfare. The policy-maker should prefer that policy setting which produces equilibrium where the consumer's welfare is highest.

### *iii. Model closure*

Differences in the process of adjustment of an economy to a policy shock will necessarily generate differences in the properties of the post-reform equilibrium. The way an economy adjusts to a policy shock will vary with the closure adopted by the CGE modeller, her choice being determined by her personal theoretical preferences and, in her view, the empirically most plausible adjustment processes.

For instance, different model closures are often used to represent various assumptions about the labour market, especially to allow for unemployment. If you assume that the labour market is perfectly flexible (neoclassical tradition) and that there is full employment, then you will adopt a closure that makes the wage rate endogenous with employment being exogenously determined by the labour endowment of the economy. In contrast, if you reckon that the labour market is characterized by involuntary unemployment, then the appropriate (structuralist tradition) closure rule would make employment endogenous and require that the wage rate be fixed exogenously, which could be at some level above the equilibrium level.

The choice of the "model closure", however, cannot be exclusively "ideological". It has to be determined also by the specific nature of the problem and by the variable the modeller intends to shock. Consider, for example, the case of a good produced in a small economy and on which the government levies an import tariff. In this case the domestic price of the good is set by the world market price plus the import tariff, while imports are determined by the model's equations of domestic demand and supply. Given the price, it is possible to calculate the quantity demanded and domestic supply, with imports being derived as the difference between demand and supply. In this set up, prices are exogenously fixed by the analyst while quantities are endogenously determined by the model. The modeller can simulate the impact of a tariff cut simply by solving the equations for the demand and supply for the new price (that is, the world price plus the new tariff rate).

Alternatively, it may be the case that the market for a certain product is protected by a quota and the modeller is interested in simulating the impact of changes in the volume of the quota on the economy. In this situation, given the world price and the quota, the market equilibrium condition "demand equal supply plus imports" (the latter given by the value of the quota) will determine the domestic price prevailing in the market. At that price the demand and supply will generate precisely the level of imports determined by the quota. In this set up, the quantity of imports is exogenous to the model, fixed by the specific country policy, while prices are endogenously determined by the model.

It is interesting to note that under certainty the economic impact of a tariff or a quota is equivalent. It is equivalent to setting a tariff at a level that yields a certain level of imports or setting a quota at the level that generates the same domestic price. It is for this reason that economists sometimes work with the tariff equivalent of a quota. In this case, the impact of changes in the quotas is simulated through variations in their tariff equivalents. The choice between working with quotas directly and working with

their tariff equivalents is one of model closure. In the former case the quantity of imports is exogenous and the domestic price is endogenous. In the latter case, the opposite will be true.

Mathematically, the need for “model closure” springs from the requirement that the number of endogenous variables in a model should be equal to the number of independent equations so that the model can be solved. Hence if a model has  $n$  independent equations and  $m$  variables, where  $m > n$ , then one way of interpreting closure is that it involves choosing which  $n$  variables are to be made endogenous from among the  $m$  total variables. The remaining  $m-n$  variables will have to be kept exogenous. In other words, choosing a closure is equivalent to choosing the set of equilibrium conditions versus the set of identities. The numéraire has to be identified amongst the set of the prices of equilibrium components. However, and this is true in all circumstances, factor prices cannot be used as the numéraire. This is due to the fact that the supply–demand equalities in factor markets do not appear in the aggregate identity (total excess demand in value is zero) that leads to Walras’ Law. The latter implies that one equilibrium condition becomes redundant when all others hold. One equilibrium condition can then be dropped and the underlying price becomes the numéraire. The numéraire can only be selected from the prices of composite goods, nominal saving or investment and foreign exchanges (in an open economy framework). For instance, in most neoclassical CGE models the numéraire is the price of nominal saving or investment. This means that the saving–investment equilibrium conditions have been dropped from the aggregate identity, setting total excess demand at zero and expressing all prices relative to the price of nominal savings or investment, i.e. the interest rate.

#### *iv. Welfare*

Various indicators of welfare have been used in the context of CGE models of trade. The measures most widely employed are Hicksian compensating and equivalent variations associated with the equilibrium comparison. The compensating variation (CV) takes the new equilibrium incomes and prices, calculating how much income must be taken away or added in order to maintain households at their pre-change utility level. The equivalent variation (EV) takes the old equilibrium incomes and prices and computes the change required to achieve utility levels reached in the new equilibrium. Welfare improvements correspond to a negative CV and a positive EV. In a single-country model context, economy-wide welfare benefits/costs of a policy reform are obtained by aggregating the CVs and EVs across individuals. In a multi-country context, overall welfare benefits/costs of a policy reform are measured by summing up the CVs or EVs across countries. It is common to adopt a sign convention so that a positive value for either measure indicates an increase in welfare. Then,

$$CV = \frac{(U^1 - U^0)}{U^1} I^1 \quad (5.1)$$

and

$$EV = \frac{(U^1 - U^0)}{U^0} I^0 \quad (5.2)$$

where  $U^1$ ,  $U^0$  and  $I^1$ ,  $I^0$  denote the new and old levels of utility and income respectively.

As a practical illustration of these measures, consider the following situation. A country is examining whether it should remove the tariff on an imported product or not. The compensating variation (5.1) of removing the tariff is the level of income that would have to be added or removed in order to retrieve the pre-tariff-drop level of welfare using the post-tariff-drop prices and incomes. The equivalent variation (5.2) of removing the tariff is the change in income, using current prices that would have the same impact on the welfare of households as the removal of the tariff. These variation measures have an appealing feature, since they are a monetary measure of the change in welfare, i.e. capable of being expressed in dollars and cents. Not only is a monetary measure more intuitively comprehensible, it also provides an important means of dealing with the problem of interpersonal comparisons of welfare in a multi-country model. It provides a standard transfer from the winners to the losers that will leave all countries at least as well off as before.

Suppose that a specific multilateral trade liberalization scenario has been simulated and the results indicate that one set of countries would see their level of welfare (as measured by the equivalent variation) increased compared to the baseline while another set of countries would see their level of welfare decline. By adding up these measures of equivalent variation, it is possible to assess the global welfare impact of this specific trade liberalization scenario. If this global total is positive, it is in principle possible for the winners to make transfers to the losers that would leave the latter as well off as before the trade liberalization and thus remove their objection to policy change and still have enough left over for the winners to experience net gains. Thus the liberalization policy is desirable from a global welfare perspective. If the global total is negative, however, there is no possible way of effecting transfers from the winners to the losers that will leave all countries at least as well off as before. Thus, the liberalization policy is undesirable from a global welfare perspective.

Note that this welfare evaluation has been conducted without having to weigh individual countries' well-being and making judgments about whether one country should count more than another. So long as the change in trade policy has the potential to increase global incomes enough so that winners can "bribe" losers to accept the change in policy, that change is desirable because in principle all can stand to gain.

#### v. *Dynamics*

CGE models can either be static or dynamic. In their static form, the impact of a policy reform (e.g. a tariff reduction) is established by comparing equilibrium properties before and after that reform. In other words, the comparison occurs after the adjustment process without considering the behaviour of the economy during that process. This is also what simulations based on dynamic models do eventually. The distinguishing feature of a dynamic CGE model, however, is that growth of output is possible and changes due to policy reforms can be tracked over a given period of time. Changes in economic indicators during the adjustment process can be retrieved. In addition, it becomes possible to compare the impact of various implementation schemes for the policy reform.

There are two types of dynamic CGE models: recursive/sequential and inter-temporal. Sequential/recursive dynamic CGE models are not truly dynamic and consist de facto of multiple static

models linked to each other sequentially. The first model is solved for one period and then all variable values determined at the end of that period are used as initial values for the following one. This is like solving an initial value problem. Current economic conditions (e.g. the availability of capital) are dependent on past outcomes but are unaffected by forward-looking expectations and economic agents have myopic behaviour imposed on them by the modeller. Some of the variables in the model may evolve exogenously following a pre-determined baseline scenario. The latter is identified thanks to a macro econometric model adequately framed to undertake forecast. Changes in variables, whether they are endogenously (e.g. capital) or exogenously determined (e.g. population), will be reflected in the growth path of the modelled economy along its adjustment path towards the new equilibrium. That is, the impact of the policy reform is to be anticipated with respect to the baseline scenario outcomes in each period.

Unlike sequential dynamic CGE, inter-temporal ones are based on optimal growth theory, where the behaviour of economic agents is characterized by perfect foresight. In this type of dynamic CGE model, households choose a consumption plan (a sequence of consumption decisions) during the period under consideration that maximizes the discounted stream of their utilities. This means that in some periods households may consume more than they earn (dissave), while in other periods they may consume less than they earn (save). For their part, firms choose a production plan (a sequence of production decisions) that maximizes their discounted stream of profits. The availability of savings from households makes it possible for firms to turn these savings into new capital stock, thereby augmenting their productive capacity. Thus the growth rate in a dynamic CGE model is endogenously determined by the savings and investment behaviour of households and firms. The evolution of the economy would be driven by trade performance and its linkage to total factor productivity amongst other features considered by the modeller, the level of government investment on infrastructure and its assumed linkage to total factor productivity, as well as the investment in education through its impact on labour productivity. In the context of inter-temporal CGE models there is no need for an extensive baseline scenario. However, forward-looking behaviour could complicate the computational exercise tremendously since some variables in the current period could be affected by variables in the future. Constructing an inter-temporal CGE model is challenging in the sense that it is essential to keep it computationally tractable without compromising on the type or degree of economic detail modelled.

#### *vi. Linking micro-simulation models*

The distributive impact of trade reforms can only be partially assessed using standard macro/CGE models. These models lack the distributive detail found in micro-simulation. The latter refers to modelling of income and consumption of distinct individuals or households instead of resorting to representative household groups as traditional CGE models do. It is based on household surveys, essentially fiscal and labour surveys. Micro-simulation is thus essential in modelling the distributive effects of taxes and transfers. On the other hand it is constrained by the fact that it is often non-behavioural and by its inability to model prices, wages and macro variables.

The solution for qualifying distributional issues properly that is increasingly being advocated is to combine these different forms of modelling. The idea goes back to Orcutt (1957) but was not used for analysis of macro-poverty links until the late 1990s.

In case policy-makers are interested in the distributional impact of removing agricultural protection in developing countries, for instance, they need detailed information that goes beyond results that are obtained strictly from a standard CGE. Tariff removal leads to lower food prices, benefiting poor consumers. However, lower agricultural prices also reduce the wages of agricultural labourers, many of whom are also poor. The result is that some of the poor will benefit and others will lose. CGE is needed to capture the wage and price effects, and micro-simulation is needed to net out gains and losses for individual households, allowing accurate distributional analysis to be performed.

The combination of CGE/macro models and micro-simulation can be based on either their layering (the top-down approach), or on their integration. In the former approach CGE simulation results are passed on to a household model (macro and micro need not be reconciled but there is a possible lack of coherence). The top-down approach solves a traditional CGE with a limited number of household groups and then uses a micro-simulation model to generate household behaviour that reproduces the output of the CGE model. The specification of the micro-simulation model can be based on simple pro-rating, meaning that there is no behavioural response. In this context, only first order effects are captured. At the other extreme, micro-simulation models can be fully behavioural, with behavioural parameters econometrically estimated from a household survey. This means that the labour supply choices of each household are endogenized. With behavioural responses featured, second order effects of a policy reform would also be captured. With the integration approach, the household model is built directly into the CGE. In other words, the integration approach uses the individual households directly in the CGE instead of using representative households. This approach appears to be more promising than the top-down approach for several reasons. First, it comes closer to the vision of true general equilibrium. Second, and probably most interesting from a policy point of view, it has the potential for household heterogeneity to have impacts on sectoral and macro aggregates. Some modellers support the view that eventually this approach presents easily tractable technical difficulties. As standard CGE models, CGE/micro-simulation models can be either static or dynamic. Dynamics can be either in terms of ageing information or behavioural.

The main weakness of CGE models is that they are fundamentally non-testable. The way a CGE is built is first to specify an a priori causal structure ("story") and then calibrate it to a Social Accounting Matrix of a given country. The behavioural parameters are thereby specified in a largely ad hoc manner. Thus any story can be calibrated to any country. The traditional CGE models use a base year SAM to calibrate the share parameters of the model and mostly use unrelated studies or guesstimates for the remaining behavioural parameters; in the best case (e.g. Demery and Demery, 1991), some parameters are estimated from single equation regressions. Because CGE models also aim to represent medium-term equilibriums, the time series they produce (if any) are typically only interpreted in qualitative terms. There are two unfortunate results of this practice. First, models with very different behaviour can be calibrated to the same data, with no ready measure of which formulation best describes a given country (see e.g. the controversy in Sahn et al., 1996; de Maio et al., 1999; Sahn et al., 1999). Second, even if one has settled on a given causal structure, the behavioural parameters cannot be directly calibrated to data. The usual solution is to borrow parameter estimates from unrelated studies, ad hoc sensitivity tests and "reasonable range" guesstimates, none of which seem very satisfactory. A different way of addressing the uncertainty in free parameters is discussed by Harrison et al. (1993), who assume a priori probability distributions

for all free parameters and proceed to do simultaneous sensitivity analysis on all of them, generating probability distributions for output variables. However, this approach seems to have two flaws that limit its use in applied models: first, the a priori probability distributions still have to be guesstimated, and second, doing a full unconstrained sensitivity analysis on all free parameters simultaneously is likely to produce a spread of end results so large as to be of no practical use.

Thus, until the CGE methodology is modified to allow for significance and quality-of-fit measures akin to those of econometrics, CGEs will remain little more than elaborate a priori stories, a medium for narrating the modeller's favourite theories in a consistent framework but with little reason to prefer one such story over another.

## b. Data requirements

To operationalize fully a CGE model of international trade requires building the associated Social Accounting Matrix (SAM) and obtaining estimates of important behavioural parameters governing consumer demands, production technology and the substitutability of imports and domestic products. Those estimates are identified according to the adopted model specification. Some parameter values are likely to be chosen arbitrarily. The final step involves calibrating the model, i.e. calibrating the functional forms to the data in the SAM.

### i. *Social Accounting Matrix*

The first step in operationalizing a CGE model is to organize the data on the structure of the entire economy in a way that takes into account the fundamental relationships between all agents in the economy across all sectors. The SAM is a tool that helps take into account all of these interactions in a systematic way and without error. If a SAM is not available (the usual case), the first step is to build one. This is what takes time. Even if you benefit from an available SAM, it will rarely be for the year you are interested in, or else the level of disaggregation across markets, sectors or households will not correspond to what is needed for the application. Because this is the most time-consuming task, we will devote more time to this aspect here. Choosing the functional form and calibrating is the easier part, at least when competitive behaviour is assumed.

The SAM builds on the circular flow conception of the economic system, where each expense must be matched by a corresponding receipt or income. As its title suggests, the relationships between sectors in a SAM are represented in the form of a table containing rows and columns. The rows correspond to the income or receipts while the columns correspond to the outlay or expenditures of a sector. Each sector of the economy will appear as a row (recipient of income) and as a column (as a source of expenditures). Algebraically, a SAM is thus represented as a square matrix with elements:

$$T = [t_{ij}] \tag{5.3}$$

where  $t_{ij}$  is the value of the transaction with income accruing to account (institution)  $i$  from expenditure by account  $j$ . Each row sum must equal the corresponding column sum, reflecting the

fact that each institution exactly satisfies its constraint – its receipts must equal its expenditures. Algebraically:

$$\sum_j t_{kj} = \sum_i t_{ik} \quad \forall k \quad (5.4)$$

Thus the data is consistent if (5.4) is satisfied. When this is not the case, some reconciliation has to be made.<sup>5</sup> In case study 10, a consistent input–output table was available so all the authors had to do was to net out the public sector accounts.

A SAM is constructed using several basic sources of economic information: the economy's input–output table, the national accounts, government budgetary accounts, balance of payments and trade statistics. The input–output table provides information on the production sector of the economy, showing detailed inter-industry linkages and the contribution made by primary factors of production to each sector. Thus we know how much steel, rubber, plastics, etc. goes into the car industry. The macroeconomic accounts provide a breakdown of aggregate demand according to consumption, investment, government spending and the international sector (exports and imports). The trade account usually contains data on the destination and product composition of exports and imports. These have to be reconciled with the national accounts as well as with the input–output table. This integration means that the resulting SAM, for example, shows not only how much steel, rubber and plastics goes into the car industry but how much of each of those inputs are sourced domestically and how much sourced from abroad and from which trade partner. The government fiscal accounts provide information on public expenditures and revenues. Integrated with the other accounts in the SAM, it is possible to obtain information on government spending on domestically produced goods and imports and to determine how much revenue is generated from taxes applied to international trade (tariffs).

Table 5.1 outlines the schematic form of the SAM. Six accounts are distinguished. The first two accounts are the activities and commodities accounts. The activities account buys intermediate inputs (domestic and imported) and hires factor services to produce commodities generating value added in the process. The commodities account combines domestic supply and imports with intermediate flows aggregated in one cell.

The next two accounts are factor and household accounts. A distinction is made between the two to show the mapping from value added to household expenditure. Households receive net factor income transfers from the government account (tariff and quota rents when these apply).

The last two accounts are the government and ROW accounts. It is thus clear, as mentioned above, that the government's role is purely redistributive since government expenditures have been aggregated into household expenditures. The ROW account includes foreign exchange expenditures and transfers to foreigners as would be the case under voluntary export restraints (VERs), the MFA or any other quantitative restriction under which foreigners get the rents associated with the restriction.

In a CGE model of trade, the SAMs of different countries will need to be collected, standardized and then combined. This requires using SAMs from the same base year and converting all values into

**Table 5.1 A Social Accounting Matrix for a standard trade model**

<i>Expenditures</i>	1. <i>Activities</i>	2. <i>Commodities</i>	3. <i>Factors</i>	4. <i>Households</i>	5. <i>Government</i>	6. <i>Rest-of-the-world</i>	7. <i>Total</i>
<i>Receipts</i>							
1. Activities		Gross outputs					Total sales
2. Commodities	Intermediate demand			Consumption		Exports	Aggregate demand
3. Factors	Value added					Net factor income and other foreign exchange expenditure	Net factor income
4. Households			Net factor income		Government transfer	QR rents to domestic residents	Household income
5. Government						Tariffs	Government income
6. Rest-of-the-world		Imports					Foreign exchange expenditures
7. Total	Total costs	Aggregate supply	Factors expenditure	Household expenditure	Government expenditure	Foreign exchange receipts	

a single currency. When information is missing or data are inconsistent (like when expenditures exceed incomes, demand differs from supply or consumers' expenditure classifications do not match production classification), analysts need to "adjust" data. This could be a sizeable challenge for multi-regional trade models, given their large size. For example, the current version of GTAP (version 6) has 87 regions and 57 production sectors. A huge effort has to be mounted to collect, standardize and reconcile the data to produce a SAM for a CGE model of this size.

It is important to note that CGE models are built using value data. The general practice is to define quantity units as the amount that can be bought for one unit of currency (say one euro or one dollar) in the baseline dataset. This means that, in most cases, baseline prices will all be set to unity. In CGE models, therefore, only relative prices are important, not absolute prices.

## *ii. Behavioural parameters/elasticities*

After all information about the expenditures and revenues and the interactions of all agents have been included in a SAM, the modeller needs to provide the value of the exogenous parameters (called behavioural parameters) that characterize the behaviour of producers and consumers.

These parameters measure the responsiveness of producers and consumers to relative price and income changes and therefore have an important bearing on the outcome of a CGE simulation. There are at least three (often more) types of behavioural parameters which are needed. First are the elasticities of substitution in value added that govern the substitutability of the primary factors of production. Second are the Armington elasticities that determine the substitutability of the domestic vs. the imported composite product. Third are the demand and income elasticities of the households or consumers.

One of the more important criticisms levelled against CGE models concerns the quality of the information used to derive these behavioural parameters. Hertel et al. (2004) have admitted that the history of estimating the substitution elasticities governing trade flows in CGE models has been “chequered” at best. In some cases, the CGE model builders do not statistically estimate these parameters themselves but take them, usually without much change, from other sources. For example, the substitution and Armington elasticities of the GTAP model are taken from the SALTER project (Jomini et al., 1991), while income elasticities were taken from FAO (1993) and Theil et al. (1989). In the Michigan model, the elasticities are taken from Deardorff and Stern (1990). Ideally, these parameter values should come with additional information (e.g. standard errors, functional form, etc.) which could provide some guidance about the reliability of these estimates. While databases may be regularly updated, the estimates of the parameters are not, so some of the behavioural parameters are based on estimates that are currently about 15 years old.

### c. Calibration

The final stage for operationalizing a CGE model consists in calibrating all parameters remaining unknown. The estimation of such parameters could be done empirically. However, besides the fact that this would represent a considerable and tedious amount of work, most of the required time-series or even cross-sectional series data are rarely, if ever, available. In most CGE applications the adopted procedure to obtain a model's parameter estimates is to use information contained in the SAM itself, supplemented as needed by additional sources or whenever possible by econometric estimates. Thus, calibration involves choosing the values of a subset of the parameters in such a way that, together with the assembled SAM and the values of the behavioural parameters, the model is able to reproduce exactly the data of a reference year – the baseline. This means that there is only one observation for each parameter being estimated. In that context, model calibration is a mathematical procedure, not a statistical one. Usually the parameters that are calibrated are share or scale parameters. The SAM, for instance, includes data on factor payments by factor and sector. Together with data on the sectoral quantity of each sector (labour force, capital stock), factor returns can be computed. Using this procedure, the wage bill divided by the total number of workers in a sector will be the wage prevailing in that specific sector.

When linking micro and CGE models, outputs from the micro model can be used to calibrate the CGE model. These outputs thus provide a microeconomic basis for aggregate behaviour. This represents a powerful feedback relationship between the two linked models. This in turn enables us to assess and qualify the complex interdependence of various policy measures with respect to tariff, distributional, employment and other effects within the same econometric framework.

However, as underlined in Peichl (2009), generating these feedback effects through linking MS and CGE models is not a straightforward task.

The calibration procedure is the necessary final step before being able to compute the general equilibrium model at hand. If the model specification and the calibration exercise are correct, then the data of the SAM together with the characterizing equations of the model will be a solution to the model. Some consistency checks should be passed and could help in identifying possible errors. A CGE is deterministic, meaning that there are no residuals. Slack variables in some equilibrium condition could be used to identify possible leakages. If an equilibrium equation is not satisfied, it simply means that an error exists in the system of equations characterizing the model at work. Another consistency check would be related to the fact that most CGE models are homogeneous of degree zero in their entirety. It implies that multiplying all prices by any whole number should leave all real variables unaffected. This can be done with the numéraire price, and the result should be a doubling of all prices and nominal elements with no change in real values.

Once the consistency of the calibration of the model has been verified, policy experiments can be run. All simulations of the CGE model will be based on a comparison with the baseline.

## C. Application

### Policy simulations and their appraisal: assessing the impact of the Uruguay Round<sup>6</sup>

The Uruguay Round of trade negotiations provided one of the first opportunities for the use of CGE models to simulate the effects of multilateral trade negotiations. This section distills the lessons learned from that body of work. It provides an overview of the CGE models used at the close of the Uruguay Round by international organizations and the simulation results.

Estimates of the impact of the Uruguay Round were produced before, during and after the completion of the negotiations. Early studies conducted by the WTO estimated gains worth US\$ 500 billion annually from the Uruguay Round. A study by the OECD estimated gains of US\$ 200 billion from agricultural liberalization alone. But the preliminary estimates were significantly higher than estimates produced after the Uruguay Round was concluded. One of the most important explanations for this discrepancy was that the actual commitments contained in the final agreement implied a substantially lower degree of liberalization than assumed in the policy experiments conducted in those studies, especially relative to agriculture. Later studies, conducted at the end of the Uruguay Round on the basis of the actual agreement, revised these estimates downwards.

Table 5.2 presents some of these studies conducted after the completion of the Uruguay Round. A number of factors may be identified to explain differences in the simulation results. First of all, different studies covered different aspects of the Uruguay Round. For example, the Rural Urban North South (RUNS)-based models (Burniaux and van der Mensbrugge, 1991), developed by the OECD and the World Bank, focused especially on the agricultural sector. Fifteen out of

the 20 sectors modelled covered agricultural products, with three of the remaining five sectors consisting of important agricultural inputs (fertilizers, energy and equipment). Most of the industrial liberalization took place in a single aggregated sector, "other manufactures", thus making it impossible to capture adequately the reallocation taking place across different manufacturing products. Due to the high level of aggregation of the manufacturing sector, possible gains deriving from phasing out textile quotas and other non-tariff barriers in industrial products could not be modelled. As a consequence, overall global gains were mainly driven by agricultural liberalization. In the study by Goldin and van der Mensbrugge (1996), agricultural liberalization yielded 85 per cent of total gains. This is in striking contrast with those of other studies where the impact of manufacturing liberalization is better accounted for, with the contribution of agricultural liberalization to overall gains of the Round estimated to be less than 10 per cent (as in Francois et al., 1996). An attempt to quantify the impact of services liberalization is made in only two studies (Brown et al., 1996 and Nguyen et al., 1995).

The degree of regional aggregation in the models also affected the distribution of the gains. Important differences in the CGE estimates stemmed from whether sub-Saharan Africa was singled out or not. Agricultural reforms, and in particular the removal of subsidies, would lead to higher food prices, thus negatively affecting net food importing countries. In models with a high level of regional aggregation, this effect does not appear in the results, as losses are compensated for by the positive welfare gains of other countries in the region. Therefore, it would be misleading to claim that CGE simulations show that there are no losers from trade liberalization when the simulation entails a high level of regional aggregation. Yet overall, positive gains suggest that there is a margin for cross-country compensation, although in practice there is no reason to suppose that such compensation would occur.

A second factor that explains different CGE results is the different assumptions about market structure. Two approaches dominate. One approach assumes that products are differentiated both across firms and across countries. In this case, each firm has a certain degree of market power, so competition among firms is imperfect. Estimates of the degree of market power and scale economies are required in order to calibrate the model. Errors in the estimates of these parameters add to the degree of uncertainty in the results and affect their reliability. However, these models may provide a better approximation of reality than those based on perfect competition. An alternative approach is to assume that products within the same product category produced domestically are homogeneous, while products originating in different countries are imperfectly substitutable. This assumption is compatible with perfect competition; therefore, economies of scale do not need to be estimated. In contrast, this approach requires estimating the so-called Armington elasticities, i.e. trade substitution elasticities.

The third important element driving differences in results in the analysis of the impact of the Uruguay Round is the assumption about dynamics in the models. Some models hold capital stock fixed (static models) while others allow for capital accumulation in response to changes in investment. In general, models where capital stock changes with investment generate larger overall effects than those where capital is fixed. The reason is as follows: if trade liberalization results in higher savings, investments will increase. This, in turn, will add to capital and increase output. This process will take place over time. Therefore, the results portrayed in this case refer to a longer time

Table 5.2 CGE studies of the Uruguay Round

<i>Publications</i>	<i>Data/evaluation</i>	<i>Model structure</i>	<i>Sectors liberalized</i>	<i>Results</i>
Brown, Deardorff, Fox and Stern (1996)	Data and evaluation at 1990	<ul style="list-style-type: none"> <li>▪ Michigan model</li> <li>▪ 29 sectors (1 ag, 1 proc. food, 1 prim, 20 manuf., 6 services)</li> <li>▪ 8 regions</li> <li>▪ Perfect competition, CRS, Armington elasticities in ag, monopolistic competition and IRS in Manuf.</li> <li>▪ Static</li> </ul>	<ul style="list-style-type: none"> <li>▪ Industrial tariff cut according to schedule. MFA not covered</li> <li>▪ Agricultural tariffs including NTM-equivalents cut according to commitments</li> <li>▪ Services: NTMs cut by 25 per cent</li> </ul>	<ul style="list-style-type: none"> <li>▪ GDP growth: US 0.9 per cent, EU 0.9 per cent, Japan 1.4 per cent, Australia and New Zealand 3.6 per cent, Mexico 2.8 per cent, Asian NICs 3.6 per cent, ROW 1 per cent</li> </ul>
Francois, McDonald and Nordstrom (1996)	Data version 1992	<ul style="list-style-type: none"> <li>▪ GTAP model</li> <li>▪ 19 sectors</li> <li>▪ 13 regions</li> <li>▪ Model 1: CRS, perfect competition</li> <li>▪ Model 2: IRS, monopolistic competition</li> <li>▪ Saving-driven investment (i.e. dynamic model)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Industrial Stariff cuts according to schedules, MFA quotas lifted</li> <li>▪ Agricultural tariff cuts according to commitment, subsidies cut by 36 and 24 per cent in developed and developing countries respectively</li> </ul>	<ul style="list-style-type: none"> <li>▪ GDP growth: World 0.45 per cent (Model 1) and 0.9 per cent (Model 2), US 0.6 per cent, EU 0.5 per cent, Japan 0.4 per cent, Australia and New Zealand 0.9 per cent, Latin America 1.9 per cent, South-East Asia 1.8 per cent</li> <li>▪ Decomposition of welfare effect: 10 agriculture, 50 textile and clothing, 40 other manufacturing</li> <li>▪ Trade growth: increase by 6 per cent (Model 1), approximately 15 per cent (Model 2)</li> </ul>
Goldin and van der Mensbrugge (1996)	1985–93 data are used to validate the model. Projections are made for the period 1993–2002	<ul style="list-style-type: none"> <li>▪ RUNS model</li> <li>▪ 20 sectors (15 of which are agricultural sectors)</li> <li>▪ 22 countries</li> <li>▪ Perfect competition</li> <li>▪ Static</li> </ul>	<ul style="list-style-type: none"> <li>▪ Industrial tariffs cut according to schedules</li> <li>▪ Agricultural reforms: tariffs including NTMs cut according to schedules. Subsidies cut by 36 per cent in OECD and 24 per cent in other countries</li> </ul>	<ul style="list-style-type: none"> <li>▪ GDP growth: US 0.1 per cent, EU 0.6 per cent, Japan 0.4 per cent, Australia and New Zealand 0.1 per cent, Mexico 0.5 per cent, Upper Income Asia 1.3 per cent</li> <li>▪ Decomposition of welfare effect 85 per cent from agriculture</li> </ul>

*(Continued)*

Table 5.2 (Continued)

<i>Publications</i>	<i>Data/evaluation</i>	<i>Model structure</i>	<i>Sectors liberalized</i>	<i>Results</i>
Hertel, Martin, Yanagishima and Dimaranan (1996)	1992 data, evaluated at 2005 Using data exogenous of regional growth of capital, population and technology, the world economy is estimated with and without the Uruguay Round policy change	<ul style="list-style-type: none"> <li>▪ GTAP model</li> <li>▪ 10 sectors</li> <li>▪ 15 regions</li> <li>▪ CRS, perfect competition, Armington trade elasticities</li> </ul>	<ul style="list-style-type: none"> <li>▪ Industrial and agricultural tariffs cut according to schedules. MFA quotas are lifted</li> </ul>	<ul style="list-style-type: none"> <li>▪ GDP growth: World 0.89 per cent, US and Canada 0.4 per cent, EU 0.7 per cent, Japan 1.04 per cent, Latin America NICs 3.8 per cent</li> <li>▪ Trade growth: World 59 per cent, US and Canada 48 per cent, EU 42 per cent, Japan 22 per cent</li> <li>▪ Decomposition of welfare effect: Agriculture 5 per cent, Industrial tariff 81 per cent, MFA 14 per cent</li> </ul>
Harrison, Rutherford and Tarr (1995)	1992 data and evaluation	<ul style="list-style-type: none"> <li>▪ GTAP model</li> <li>▪ 22 sectors</li> <li>▪ 24 regions</li> <li>▪ Model 1: CRT, PC, Armington</li> <li>▪ Model 2: IRT, monopolistic competition, intraregional, Armington-based trade</li> <li>▪ Model 1 both static and dynamic</li> </ul>	<ul style="list-style-type: none"> <li>▪ Industrial and agricultural tariff cut according to schedule</li> <li>▪ Export (domestic) subsidies cut by 36 (20) per cent and 24 (13) per cent in developed and developing countries respectively</li> </ul>	<ul style="list-style-type: none"> <li>▪ GDP growth: World 0.4 per cent (M1 static), 0.7 per cent (M1 dynamic), 0.42 per cent (M2 static); Model 1 regional results: US 0.4 per cent, EU 0.7 per cent, Japan 0.7 per cent, Lat. America 1.7 per cent, South-East Asia approx. 2.5 per cent</li> <li>▪ Decomposition of welfare effect. Model 1 static: Agriculture 68 per cent, Industrial tariff 18 per cent, MFA 15 per cent; Model 1 dynamic: Agriculture 38 per cent, Industrial tariff 49 per cent, MFA 12 per cent; Model 2 static: Agriculture 61 per cent, Industrial tariff 23 per cent, MFA 17 per cent</li> </ul>

horizon than in the case of static models. In static models, the adjustment process is not modelled and there is no clear indication of how long after the full implementation of a policy change it will take for the effects to be realized. It is commonly believed that the effects of a static model should be realized within five to ten years after full implementation of the policy change, as time is required for adjustments in employment to take place. When capital also needs to adjust, there is some convergence in thinking that the time required will be longer – within ten to 15 years.

## Endnotes

1. This chapter reproduces and expands Piermartini and Teh (2006). We also refer the reader to Shoven and Whalley (1984), Wing (2004) and Robinson et al. (1999) for complementary readings.
2. See also Shoven and Whalley (1984) for a similar discursive approach.
3. See Kuiper and van Tongeren (2006) for a detailed discussion.
4. Zai (2008) addresses this problem by introducing the Melitz (2003) theoretical framework with firm heterogeneity and fixed exporting costs into a global CGE model.
5. For example, in the construction of SAMs for their archetype economies, Dervis et al. (1982) had to carry out reconciliation at two levels: (i) production accounts because the input–output tables were not consistent; (ii) the income and expenditure accounts. As described in their appendix A, altogether this involved ten steps. Reinert and Roland-Holst (1997) give an introduction to SAMs for CGE modelling.
6. For a detailed review and critical discussion of the assessment of the ongoing Doha Round we refer the reader to Piermartini and Teh (2006), section IV.B, and Bouët and Laborde Debuquet (2010).

## References

- Anderson, K. and Martin, W. (eds.) (2005), *Agricultural Trade Reform and the Doha Development Agenda*, Washington D.C.: The World Bank.
- Anderson, K., Dimaran, B., Francois, J., Hertel, T., Hoekman, B. and Martin, W. (2003), "The cost of rich (and poor) country protection to developing countries", *Journal of African Economies* 10(3): 227–57.
- Anderson, K., Martin, W. and van der Mensbrugge, D. (2005), "Market and welfare implications of the Doha reform scenarios", in Anderson, K. and Martin, W. (eds.), *Agricultural Trade Reform and the Doha Development Agenda*, Washington D.C.: The World Bank.
- Arrow, K. J. and Debreu, G. (1954), "Existence of an equilibrium for a competitive economy", *Econometrica* 22: 265–90.
- Baldwin, R. and Venables, A. (1995), "Regional economic integration", in Grossman, G. and Rogoff, K. (eds.), *Handbook of International Economics*, vol. 3, Amsterdam: North-Holland.
- Bouët, A. and Laborde Debucquet, D. (2010), "Eight years of doha trade talks" 'where do we stand?', International Food Policy Research Institute Discussion Paper 00997, Washington D.C.: IFPRI.
- Brockenmeier, M. (2001), "A graphical exposition of the GTAP model", GTAP Technical Paper No. 8, Purdue University, West Lafayette.
- Brown, D. K., Deardorff, A. V., Fox, A. K. and Stern, R. M. (1996), "The liberalization of services trade: potential impacts in the aftermath of the Uruguay Round", in Martin, W. and Winters, L. A. (eds.), *The Uruguay Round and the Developing Countries*, New York: Cambridge University Press.
- Brown, D. K., Deardorff, A. V. and Stern, R. M. (2003), "Multilateral, regional and bilateral trade policy options for the United States and Japan", *The World Economy* 26(6): 803–28.
- Burniaux, J. M. and van der Mensbrugge, D. (1991), "Trade policies in a global context: technical specifications of the Rural/Urban-North/South (RUNS) applied general equilibrium model", Organisation for Economic Co-operation and Development Technical Papers No. 48, Paris: OECD.
- Cline, W. R. (2004), *Trade Policy and Poverty*, Washington D.C.: Institute for International Economics.
- Deardorff, A. V. (1998), "Determinants of bilateral trade: does gravity work in a neoclassical world?", in Frankel, J. A. (ed.), *The Regionalization of the World Economy*, Chicago and London: The University of Chicago Press.
- Deardorff, A. V. and Stern, R. M. (1986), *The Michigan Model of World Production and Trade: Theory and Applications*, Cambridge, MA: MIT Press.
- Deardorff, A. V. and Stern, R. M. (1990), *Computational Analysis of Global Trading Arrangements*, Ann Arbor: University of Michigan Press.
- Debreu, G. (1959), *The Theory of Value: An Axiomatic Analysis of Economic Equilibrium*, Cowles Foundation Monograph No. 17, New York: John Wiley & Sons.
- Debreu, G. and Scarf, H. (1963), "A limit theorem on the core of an economy", *International Economic Review* 4(3): 235–46.
- de Melo, J. and Robinson, S. (1989), "Product differentiation and the treatment of foreign trade in computable general equilibrium models of small economies", *Journal of International Economics* 27: 47–67.
- de Melo, J. and Roland-Holst, D. (1990), "Industrial organization and trade liberalization: evidence from Korea", in Baldwin, R. E. (ed.), *Empirical Studies of Commercial Policy*, University of Chicago Press and NBER.
- de Melo, J. and Tarr, D. (1992), *A General Equilibrium Analysis of US Foreign Trade Policy*, Cambridge, MA: MIT Press.
- de Melo, J., Roland-Holst, D. and Haddad, M. (1993), "Réforme fiscale dans un pays à faible revenu: le cas de Madagascar", *Revue d'Economie du Développement*.

- Dervis, K., de Melo, J. and Robinson, S. (1982), *General Equilibrium Models for Development Policy*, Cambridge University Press.
- Devarajan, S., Go, D., Lewis, J., Robinson, S. and Sinko, P. (1997), "Simple general equilibrium modeling", in Francois, J. and Reinert, K. (eds.), *Applied Methods for Trade Policy Analysis*, Cambridge University Press.
- Dixon, P. B. and Parmenter, B. R. (1996), "Computable general equilibrium modelling for policy analysis and forecasting", in Amman, H. M., Kendrick, D. A. and Rust, J. (eds.), *Handbook of Computational Economics*, vol. I, Amsterdam: North-Holland.
- Eaton, J. and Kortum, S. (2002), "Technology, geography and trade", *Econometrica* 70(5): 1741–79.
- Food and Agriculture Organization (FAO) (1993), "World Food Model", supplement to the Food and Agriculture Organization Agriculture Projections to 2000, Rome: FAO.
- Francois, J. (2000), "Assessing the results of general equilibrium studies of multilateral trade negotiations", United Nations Conference on Trade and Development Policy Issues in International Trade and Commodities Study Series 3, Geneva: UNCTAD.
- Francois, J. and Hoekman, B. (1999), "Market access in the service sectors", unpublished manuscript, Tinbergen Institute.
- Francois, J. and Reinert, K. (eds.), *Applied Methods for Trade Policy Analysis*, Cambridge University Press.
- Francois, J., McDonald, B. and Nordstrom, H. (1996), "The Uruguay Round: a numerically-based qualitative assessment", in Martin, W. and Winters, L. A. (eds.), *The Uruguay Round and the Developing Economies*, New York: Cambridge University Press.
- Francois, J., van Meijl, H. and van Tongeren, F. (2003), "Trade liberalization and developing countries under the Doha Round", Centre for Economic Policy Research Discussion Paper No. 4032, London: CEPR.
- Ginsburg, V. and Keyser, M. (1997), *The Structure of Applied General Equilibrium*, Cambridge, MA: MIT Press.
- Goldin, I. and van der Mensbrugghe, D. (1996), "Assessing agricultural tariffication under the Uruguay Round", in Martin, M. and Winters, L. A. (eds.), *The Uruguay Round and the Developing Economies*, New York: Cambridge University Press.
- Goulder, L. H. and Eichengreen, B. (1992), "Trade liberalization in general equilibrium: inter-temporal and inter-industry effects", *Canadian Journal of Economics* 25(2): 253–80.
- Hansen, T. and Scarf, H. (1973), *The Computation of Economic Equilibria*, Cowles Foundation Monograph No. 24, New Haven: Yale University Press.
- Harrison, G. W., Tarr, D. and Rutherford, T. F. (1995), "Quantifying the outcome of the Uruguay Round", *Finance & Development* 32(4): 38–41.
- Harrison, G. W., Rutherford, T. F. and Tarr, D. (1996), "Quantifying the Uruguay Round", in Martin, W. and Winters, L. A. (eds.), *The Uruguay Round and the Developing Countries*, New York: Cambridge University Press.
- Hertel, T. W. (1997), *Global Trade Analysis: Modeling and Applications*, Cambridge University Press.
- Hertel, T. W. and Winters, A. L. (eds.) (2005), "Poverty impacts of a WTO agreement: putting development back into the Doha Development Agenda", Washington D.C.: The World Bank.
- Hertel, T. W., Martin, W., Yanagishima, K. and Dimanaram, B. (1996), "Liberalizing manufactures in a changing world economy", in Martin, W. and Winters, L. A. (eds.), *The Uruguay Round and the Developing Economies*, New York: Cambridge University Press.
- Hertel, T. W., Hummels, D., Ivanic, M. and Keeney, R. (2004), "How confident can we be in CGE-based assessments of free trade agreements?", GTAP Working Paper No. 26.
- Hummels, D. (2001), "Toward a geography of trade costs", mimeo, Purdue University.

- Jean, S., Laborde, D. and Martin, W. (2005), "Consequences of alternative formulas for agricultural tariff cuts", in Martin, W. and Anderson, K. (eds.), *Agricultural Trade Reform and the Doha Development Agenda*, Washington D.C.: The World Bank.
- Johansen, L. (1960), *A Multi-Sectoral Study of Economic Growth*, Amsterdam: North-Holland.
- Jomini, P., Zeitsch, F., McDougall, R., Welsh, A., Brown, S., Hambley, J. and Kelly, J. (1991), *A General Equilibrium Model of the World Economy*, vol. 1, Model Structure, Database and Parameters, Canberra: Industry Commission.
- Kehoe, T. J. (2003), "An evaluation of the performance of applied general equilibrium models of the impact of NAFTA", Federal Reserve Bank of Minneapolis Research Department Staff Report 320.
- Koopmans, T. C. (1951), *Activity Analysis of Production and Allocation*, New York: Wiley.
- Kuznets, S. (1955), "Economic growth and income inequality", *American Economic Review* 45(1): 1–28.
- Leontief, W. (1941), *The Structure of the American Economy, 1919–1939*, Oxford University Press.
- Löffgren, H., Harris, R. and Robinson, S. (2002), "A standard computable general equilibrium model in GAMS", IPRI, available for download with the GAMS code and the GAMS software (free demo system) at <http://www.ifpri.org/pubs/microcom/micro5.htm>
- Martin, W. J. (1997), "Measuring welfare changes with distortions", in Francois, J. F. and Reinert, K. A. (eds.), *Applied Methods for Trade Policy Analysis*, Cambridge University Press.
- Martin, W. J. and Anderson, K. (2005), *Costs of Taxation and the Benefits of Public Goods: The Role of Income Effects*, Washington D.C.: The World Bank.
- McKibbin, W. J. and Sachs, J. (1991), *Global Linkages: Macroeconomic Interdependence and Co-operation in the World Economy*, Washington D.C.: Brookings Institution.
- McKibbin, W. J. and Wilcoxon, P. (1992), "G-cubed: a dynamic multi-sector general equilibrium growth model of the global economy (quantifying the costs of curbing CO2 emissions)", Brookings Discussion Paper in International Economics No. 98, Washington D.C.: Brookings Institution.
- Nguyen, T. T., Perroni, C. and Wigle, R. M. (1995), "An evaluation of the draft final act of the Uruguay Round", *The World Economy* 18: 25–30.
- Organisation for Economic Co-operation and Development (OECD) (2003), "The Doha Development Agenda: welfare gains from further multilateral trade liberalization with respect to tariffs", TD/TC/WP(2003)10/FINAL, Paris: OECD.
- Powell, A. A. and Snape, R. H. (1993), "The contribution of applied general equilibrium analysis to policy reform in Australia", *Journal of Policy Modeling* 15(4): 393–414.
- Reinert, K. A. and Roland-Holst, D. W. (1997), "Social accounting matrices", in Francois, J. F. and Reinert, K. A. (eds.), *Applied Methods for Trade Policy Analysis*, Cambridge University Press.
- Robbins, L. (1938), "Interpersonal comparisons of utility: a comment", *Economic Journal* 48: 635–41.
- Roberts, M. J. and Tybout, J. R. (1996), *Industrial Evolution in Developing Countries: Micro Patterns of Turnover, Productivity and Market Structure*, Oxford University Press.
- Robinson, S. (2002), "Comments on 'An evaluation of the performance of applied general equilibrium models of the impact of NAFTA'", unpublished note.
- Shoven, J. and Whalley, J. (1984), "Applied general equilibrium models of taxation and international trade: an introduction and survey", *Journal of Economic Literature* 22: 1007–51.
- Shoven, J. and Whalley, J. (1984), *Applied General Equilibrium*, Cambridge University Press.
- Smith, A. (1776), *An Inquiry into the Nature and Causes of the Wealth of Nations*, London: W. Strahan and T. Cadell.
- Thiel, H., Chury, C. F. and Seale, J. L. (1989), "International evidence on consumption patterns", Supplement 1 to *Advances in Econometrics*, Greenwich, CT: JAI Press.

- Thierfelder, K. and Shiells, C. (1997), "Trade and labor market behavior", in Francois, J. and Reinert, K. (eds.), *Applied Methods for Trade Policy Analysis*, Cambridge University Press.
- Tomz, M. J., Goldstein, J. and Rivers, D. (2004), "Membership has its privileges: understanding the effects of the GATT and the WTO on world trade", unpublished manuscript downloadable at <http://www.stanford.edu/~tomz/working/TomzGoldsteinRivers2005a.pdf>
- United Nations Conference on Trade and Development (UNCTAD) (2003) *Back to Basics: Market Access Issues in the Doha Agenda*, Geneva: UNCTAD.
- Van der Mensbrugge, D. (2004), "LINKAGE technical reference document: version 6.0", mimeo, Washington D.C.: The World Bank, accessible at <http://siteresources.worldbank.org/INTPROSPECTS/Resources/334934-1100792545130/LinkageTechNote.pdf>
- Walras, L. (1896), *Éléments d'économie politique pure; ou, Théorie de la richesse sociale*, Lausanne: Rouge, 3rd edition.
- Whalley, J. (1985), *Trade Liberalization among Major World Trading Areas*, Cambridge University Press.
- Whalley, J. (2000), "What can the developing countries infer from the Uruguay Round? Models for future negotiations", *Policy Issues in International Trade and Commodities*, United Nations Conference on Trade and Development Study Series 4, Geneva: UNCTAD.
- Wing, I. S. (2004), "Computable general equilibrium models and their use in economy-wide policy analysis", MIT Joint Program on the Science and Policy of Global Change, technical note no. 6.
- Wright, P. G. (1928), *The Tariff on Animal and Vegetable Oils*, New York: Macmillan.

## CHAPTER 6: Analyzing the distributional effects of trade policies

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### TABLE OF CONTENTS

A. Overview and learning objectives	211
B. Analytical tools	212
1. General equilibrium transmission of tariff changes	212
2. Simple model linking trade policy to household welfare	214
3. Empirics	215
C. Data	218
1. Survey data	218
2. Trade policy data	220
D. Applications	221
1. Calculating the effect of change in tariffs on consumption and agricultural sales	221
2. Measuring the impact of tariffs at the household level	227
E. Exercise	229
Assessing the progressivity of trade taxes	229
Endnotes	231
References	232

## LIST OF FIGURES

Figure 6.1.	Trade policies and households' welfare	212
Figure 6.2.	Consumption effect by per capita expenditures (log)	223
Figure 6.3.	Income effect by per capita expenditures (log)	224
Figure 6.4.	Share of income from subsistence activities and wages	224
Figure 6.5.	Overall effect by regions	225
Figure 6.6.	Tariff on consumption	229

## LIST OF TABLES

Table 6.1.	Income, consumption and overall effects by deciles	226
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## LIST OF BOXES

Box 6.1.	Design of surveys	219
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## A. Overview and learning objectives

This chapter provides an overview of the measurement of the distributional effects of trade policies on social welfare, in particular on inequality and poverty. The economic literature has emphasized open trade policies' positive impact on economic growth and development for many years. While these results generally hold when measured on average, empirical evidence suggests that trade liberalization is unlikely to produce beneficial results across all households. In practice, trade policies generally have strong redistributive impacts, often benefiting some individuals while penalizing others.

Trade policies impact individuals because of two main factors. First, the impact of a trade policy depends on the extent to which the policy influences domestic prices. For example, the existence of administrated prices (or fixed wages) has the effect of isolating economic sectors (and individuals) from many price shocks such as those originating from trade policies. Similarly, weak infrastructure, high transportation costs and poorly developed or uncompetitive markets may dampen the effect of trade policies in remote areas. Second, the redistributive effects of trade policies trickle down to households and individuals depending on how those households' fortunes are tied to specific factors of production or to specific economic sectors. For example, reducing trade barriers may put pressure on the wages of workers in import-competing sectors while benefiting workers whose skills are sought by the export-oriented sectors. Similarly, imposing tariffs on food items would disproportionately affect poor households (because they spend a larger share on their income on food items), while only minimally taxing high-income individuals.

This chapter provides a brief overview of some quantitative methods that will enable analysts to give answers to some simple policy questions – namely, what is the redistributive impact of the existing trade policy and does the current structure of a country's tariff penalize some segments of the population relative to others? It also illustrates the framework for assessing the general equilibrium effects of trade policy reforms.

The learning objective of this chapter is to provide an overview of:

- how to think about the transmission of trade shocks to individual households in simple terms
- what needs to be estimated and what are the data requirements for analyzing the distributional effects of trade reforms
- what statistical techniques are required when dealing with household survey data
- how to assess the impact of trade policies on population groups
- how to assess the regressiveness or progressivity of trade taxes.

The relationship between trade policy and social welfare is clearly much more complex than what is discussed in this chapter. Its analysis also requires more advanced econometrics and modelling techniques than are appropriate to the purpose of this chapter. The interested reader is encouraged to read the relevant literature, especially Chapter 5 in Deaton (1997), the papers in Harrison (2007) and those of Winters (2002), Porto (2003) and Nicita (2007).

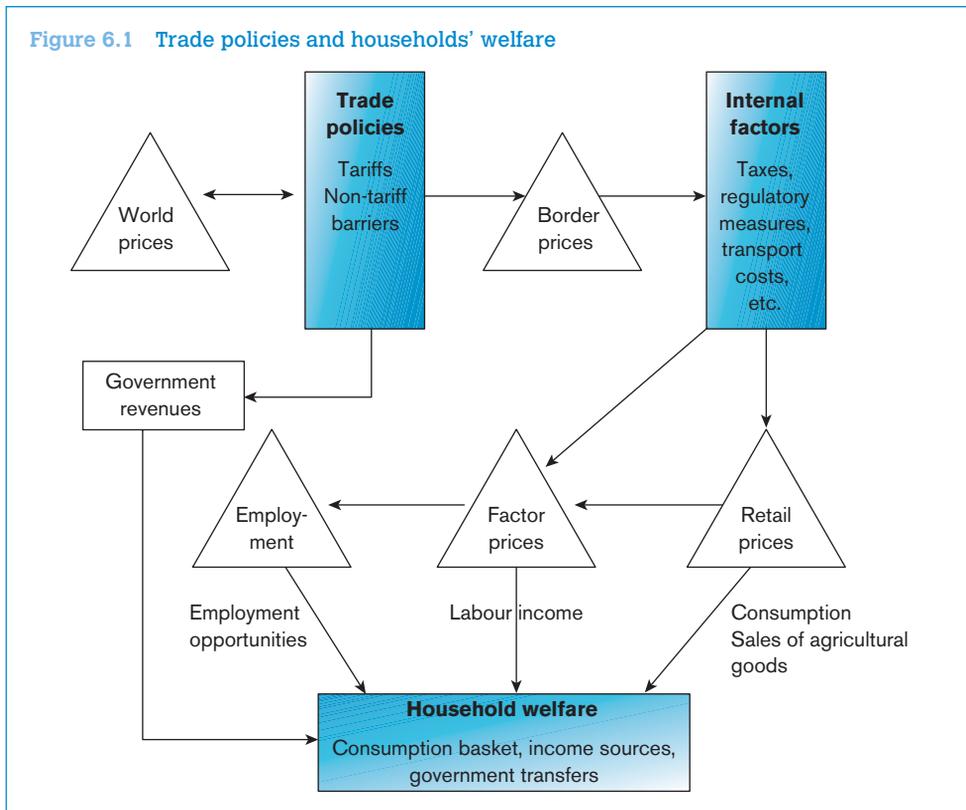
The rest of this chapter is organized as follows: first, the chapter describes some of the analytical tools in analyzing trade and poverty; second, it discusses the data; and finally, it presents some applications and exercises.

## B. Analytical tools

### 1. General equilibrium transmission of tariff changes

The textbook treatment of trade policy is usually cast in terms of its aggregate welfare effects. However, policymakers are often also interested in its *distributional* effects, i.e. in how the impact of a trade reform differs across the various segments of the population. The general framework describing the effects of trade policies on household welfare is illustrated by Winters (2002) and reproduced in Figure 6.1.

Trade policies affect the domestic economy by their impact on domestic prices of goods and factors and by affecting government revenues. A change in a tariff translates into a change in the border price of traded goods. This change affects domestic prices (retail and factor prices) to a variable extent, generally referred to as "pass-through". The magnitude of the pass-through is determined by factors that influence the extent to which trade policies can affect domestic prices. Domestic policies, institutions, geography, market competitiveness and infrastructures all have an important role in the extent to which trade policies affect domestic markets. Because these factors are specific to each country, similar trade policies can produce dissimilar outcomes



in different countries. Moreover, these factors can also be different within the domestic economy. For example, the effects of trade policies on prices are often different across geographic areas.

In summary, the effect of trade policies on households and individuals is schematized through three links:

- the *consumption effect*: the effect of trade policies on the prices of goods consumed by the household
- the *income effect*: the effect of trade policies on the income of the household (wages, sales of products and employment opportunities)
- the *revenue effect*: the effect of trade policies on government revenues and indirectly on households via government transfers.

Analysis of the distributional effect of trade policy often starts by estimating its effect on consumption. An advantage in the analysis of consumption effects is the data requirement. Disaggregated consumption data are generally widely available in most household surveys. However, consumption data are not sufficient to capture the impact of trade policies. Consumption effects are generally positive in the case of trade liberalization since tariff reduction will reduce the price of foreign goods, thereby increasing households' purchasing power.

Both from a poverty and a distributional perspective, the income effect is generally more important. However, analyzing the effects of trade policy on factor endowments and labour markets is more difficult. In practice, one would need to link policy-driven changes in prices to wages and employment opportunities. Proper econometric identification is often problematic, and economic models linking trade policy and labour returns do not provide much guidance. Economic models rely on several large assumptions such as full employment and perfect competition and thus they are seldom confirmed by empirical observations. Moreover, the effect of trade policies on labour markets depends greatly on the pre-existing structure of protection and on market distortions that will have to be taken into account in the analysis. Still, regardless of the sophistication of the analysis, empirical studies find that trade liberalization is often associated with a rise in the skill premium, changes in industry wage premiums and increases in employment opportunities for individuals. These are general findings, however. Given each country's different economic and social environment, the effects could be quite diverse for any given country. In practice, the effects of trade policy on labour markets cannot be generalized but should be estimated through microeconomic models accounting for countries' idiosyncrasies.

The revenue effect is often more difficult to quantify due to lack of available data on government transfers at the household level. Moreover, to the extent that changes in revenues are proportionally distributed to individuals, their impact on inequality is negligible and thus can be ignored. Still, the revenue effect should be considered (and analyzed) when a large share of government revenues depends on trade policy and when government transfers are targeted on anti-poverty programmes. In such cases, trade policy-driven changes in government revenues could have a substantial impact on these programmes and thus indirectly on welfare and inequality. This chapter's analysis focuses on the income and consumption effects. The rest of the chapter does not analyze the revenue effect, so the interested reader should refer to Deaton (1997).

## 2. Simple model linking trade policy to household welfare

The empirical analysis of the effects of trade policy on social welfare relies on a relatively simple model (Porto, 2003, 2004). Consider a small open economy that produces and consumes two goods: a traded one with price  $p_T$  and a non-traded one with price  $p_N$ . Let  $e(\mathbf{p}, u)$  be the household's expenditure function.<sup>1</sup> Let  $w$  be the wage earned by a single-person household,  $\tau$  the tariff on the traded good and  $p^*$  the traded good's international price.

The model's four basic equations are an income-expenditure identity, a wage equation, a non-traded good pricing equation (implicitly based on a zero-profit condition) and a pass-through equation. That is,<sup>2</sup>

$$\underbrace{e(p_T, p_N, u)}_{\text{Expenditure}} = \underbrace{t + w}_{\text{Income}} \quad (6.1)$$

$$w = \underbrace{w(p_T)}_{\text{Stolper-Samuelson effect}} \quad (6.2)$$

$$p_N = \underbrace{p_N(w)}_{\text{zero-profit cond.}} \quad (6.3)$$

$$p_T = \underbrace{p_T(p^*, \tau)}_{\text{pass-through}} \quad (6.4)$$

In practical calculations the researcher does not need to know what forms the functions (6.2) to (6.4) take: the data will inform. Differentiating totally (6.1)–(6.4) and substituting (6.2) into (6.1), the change in real income consequent to a change in tariff is:

$$\frac{\Delta t}{e} = (s_T + s_N \eta_{N,T} - \mu_{w,T}) \zeta \Delta \tau \quad (6.5)$$

where  $\eta_{N,T}$  and  $\mu_{w,T}$  are the elasticities of the non-traded good's price and of the wage to the traded good's price respectively,  $s_T$  and  $s_N$  are the traded and non-traded goods' shares in the household expenditure and  $\zeta \leq 1$  is the pass-through parameter. In practice, (6.5) takes on a more complicated form because there are several traded goods, non-traded goods and sources of labour income. The change in real income is also referred to as “compensating variation” – the amount of money a household would need to keep its purchasing power intact.<sup>3</sup>

A useful way of thinking about how households are affected by trade policies is in terms of the farm household model. The farm household produces goods and services, sells its labour, and consumes. In this setup, an increase in the price of an item (or factor of production) that the household is a net seller of increases the household's real income, while a decrease in this price reduces that income.

In practice, household utility  $u_h$  can be expressed as a function of a vector of prices faced by the household and the household's income, which includes the income from farm activity and non-farm

activity (Singh et al., 1986). The change in utility  $\Delta U_{hr}$  of household  $h$  in region  $r$  depends on the changes in local prices (of goods and factors) and on the household's specific labour income, agricultural production and consumption. In practice, as households are generally consumers, producers and wage earners at the same time, the change in utility for each household  $h$  residing in region  $r$  can be simply calculated as:

$$\Delta U_{hr} = \sum_{sk} L_{sk}^{labour} \Delta W_{sr} + \sum_T (s_T^{Prod} - s_T^{Consum}) \Delta p_{Tr} + \sum_N (s_N^{Prod} - s_N^{Consum}) \Delta p_{Nr} \quad (6.6)$$

where  $s^{Consum}$  is the share of income spent on good  $g$  by household  $h$ ;  $s^{Prod}$  is the share of income of household  $h$  obtained by selling each traded (T) and non-traded (NT) goods at their respective price  $p_{Tr}$  and  $p_{Nr}$ . The difference  $s^{Prod} - s^{Consum}$  can be thought of as the net exposure of the household to the change in price of that particular good.  $L_{sk}^{labour}$  is the share of income of the household  $h$  obtained by selling (skilled and/or unskilled, denoted by  $sk$ ) labour. Finally, changes in prices ( $\Delta p_{Tr}$ ,  $\Delta p_{Nr}$ ) and wages ( $w_{sr}$ ) in region  $r$  are expressed in percentage terms and are estimated in equations (6.2), (6.3) and (6.4). Social welfare is simply the sum of the welfare of all households (each weighting according to its number of individuals). Ultimately, the exposure of the households (and individuals) to price and wage changes depends on the structure of their income and the allocation of expenditures. Equation (6.6) provides the change in utility and would need to be calculated for each household.

This simple model does not take into account second-order effects, i.e. the fact that trade policies are likely to affect not only prices but also consumption and production decisions as well as the amount of labour offered by the households. To measure second-order effects properly is complex and requires a great deal of data on households' behaviours. Thus, second-order effects are generally not included in the analysis. The effects we are discussing here are so-called "first-order effects" (or "short-run effects") since we do not allow for any change in the allocation of resources of the households.<sup>4</sup>

### 3. Empirics

The analysis of the effects that trade liberalization has on welfare is generally conducted in two exercises requiring two different sets of data. The first exercise is the estimation of the changes in the prices of goods and factor returns resulting from trade liberalization. This is the estimation (or assumption) of the magnitude of pass-through from international to domestic prices (of traded and non-traded goods) and from domestic prices to wages. The second exercise consists of two steps. In the first step, the income sources and consumption baskets of each household are carefully disaggregated to construct budget and income shares. In the final step, the changes in the prices of goods and factors are mapped onto each household's budget and income shares to produce an estimate of the changes in the welfare of the households.

The first exercise starts with an estimation of the effect of trade policy on the prices of traded goods (equation (6.4)). Particularly in developing countries, domestic markets are often segmented and price transmission mechanisms are often different across various domestic markets. For example, trade policy may have a much larger impact in areas where markets are more competitive (near the border or in large cities) than in remote areas where isolation and remoteness can dampen any

price effect or in places or sectors where overall competition is lower. It is therefore preferable, when possible, to estimate changes in domestic prices at the regional level.

The measurement of the effects of trade on domestic markets is generally based on econometric estimation using time series data. The econometric approach aims to isolate the movement in prices due exclusively to changes in trade policy and requires a great deal of information on prices, domestic production and economic policies. Unfortunately, the data for properly estimating such effects (especially at the regional level) is often not available; thus analysts are obliged to simplify their assumptions.<sup>5</sup> For example, due to lack of data, researchers may be constrained to estimate an average pass-through for the country as a whole rather than for the different regional markets. More commonly, the extent of the pass-through of a change in trade policies into domestic prices is often not estimated but assumed. Often the pass-through of trade policies to prices is assumed to be full, so that a 10 per cent reduction in the tariff of an imported good would reduce the domestic price of that good by 10 per cent. In some cases, the analysis makes use of existing estimates of pass-through coefficients. For example, if previous studies have estimated an imperfect pass-through of 40 per cent, this will imply that a 10 per cent increase in the tariff will affect domestic prices by only 4 per cent. The interested reader can find more details on how to estimate pass-through equations in Feenstra (1989), Goldberg and Knetter (1997), Campa and Goldberg (2002) and Nicita (2009).<sup>6</sup>

Having estimated (or assumed) the pass-through of trade policies to domestic prices, the second step consists in estimating the relationship between the price of traded and non-traded goods (equation (6.3)), and between prices and wages (equation (6.2)). In practice, this estimation is based on the long-term relationship between the variables of interest (prices and wages) and often makes use of time series econometrics (see Robertson, 2004 for a discussion). As in the case of the pass-through, the estimation may be hindered by the paucity of data. When the estimation is not possible, the analyst would have to make some simplifying assumption (or to rely on previous estimates of the elasticities between prices and wages). For example, prices of non-traded goods may be assumed to vary only to a fraction of the prices of trade goods, while wages may be assumed to vary in proportion to the overall changes in prices (and thus being not influential in terms of purchasing power). As trade policies have redistributive effects, the analyst should try to identify the relationships between prices and wages according to assumptions on the working of the labour markets. There are several possible assumptions on segmentation of the labour markets: which one is more plausible depends on the country being analyzed. In most cases the labour market is assumed to be segmented by skills, with workers able to move freely across economic sectors. Other approaches assume a segmentation of the labour markets across sectors (i.e. worker skills are sector specific), or segmentation may be assumed across geographic areas (i.e. no internal migration of workers). Further complications arise when modelling labour markets in developing countries where there is a large pool of reserve labour (unemployed or semi-employed). In such cases, wages may be insensitive to prices as wages are kept at subsistence levels (Nicita, 2008).

Having estimated (or assumed) the reaction of prices and wages to changes in trade policies, the analysis now moves to calculate their impact on each household. Equation (6.6) shows us how to measure the change in utility for each household resulting from a change in trade policy. The components of equation (6.6) are:

1.  $\Delta p_{Tr}$  is the percentage change in prices for each traded good in region  $r$ . This is obtained by estimating a pass-through model or by assuming a uniform price change proportional to the change in tariff. That is,  $\Delta p_{Tr} = \zeta \Delta \tau_{Tr}$  where  $\Delta \tau_{Tr}$  is the change in tariff for good  $T$  obtained from trade policy data, and  $\zeta$  is the pass-through coefficient. This can be estimated econometrically or assumed to be a fixed value between 0 and 1. As a rule of thumb the pass-thru can be assumed to be 40 percent for rural areas and 60 percent for urban areas.
2.  $\Delta p_{nr}$  is the percentage change in prices for non-traded goods in region  $r$ . This is estimated econometrically according to (6.3).
3.  $\Delta w_{sr}$  is the change in wages for each skill, or economic sector,  $s$ , in region  $r$ .<sup>7</sup> This is estimated econometrically according to (6.2). This is often estimated using a Mincer-type equation. That is, labour returns are estimated by skills (or even by economic sector) as a function of prices of traded goods (or tariffs) controlling for a series of individual characteristics.
4.  $s_T^{Consum}$  is the share of income spent on each traded good  $T$  by household  $h$ ;  $s_T^{Prod}$  the shares of household income from the sales of products (generally agricultural).  $s_T^{Prod}$  is the share of sales of traded goods in total income. This information comes from household surveys. In general, traded goods are considered those to which tariffs are applied. That is, physical goods that can enter the domestic market from abroad.
5.  $s_N^{Consum}$  is the share of income spent on non-traded goods  $N$  by household  $h$ . This is also observable in the household survey data. Non-traded goods are usually lumped together to form a single group. In practice, the share of non-traded goods is often approximated by the share of household expenditures in services as these are generally considered non-tradables. Moreover,  $s_N^{Prod}$  (sales of non-traded goods) is often assumed to be zero, as data on households' direct sales of services is generally not available from household surveys. In the data, sales of services are often comprised in "returns from own enterprises" and assumed to follow labour returns (wages).
6.  $\Delta u_{hr}$  is the change in utility of the household  $h$  measured as change in real income or compensating variation (CV) – the compensation that would be needed for a given household to maintain its real income unchanged, expressed here relative to the household's expenditure.

The resulting compensating variation, calculated for each household, can then be displayed in a graph in which households are sorted by the variable of interests (income, gender, region, age, etc.).<sup>8</sup> For example, the relationship between the compensating variation and the level of income tells us whether trade reform benefits and costs are correlated with household income.

Depending on the assumptions taken in estimating the effect of trade policies on prices and wages, it is important to check the robustness of the results. Assumptions should be taken on the basis of a priori knowledge of the functioning of markets, and should be justified in the discussion of the analysis. However, assumptions may severely affect the results. It is therefore important to test whether some of the assumptions have a large impact on the overall results. To check robustness of results, the easiest method is to provide different estimates according to different assumptions. For example, if the pass-through of trade policy to domestic prices was assumed to be full, it would be necessary to check the consistency of the results when pass-through is assumed to be lower, say 0.5. Similarly, several welfare estimates should be calculated for assumptions on wages. For example, estimates should be calculated for sticky wages as well as for wages that follow changes in prices completely.

## C. Data

### 1. Survey data

The data needs of studies dealing with distributional effects are frequently filled through surveys (household surveys, labour surveys and firm-level surveys). Survey data are often collected for reasons that are different from that of analyzing the effect of trade policies and thus may not contain the relevant information required for an exhaustive analysis. It is therefore important first to scrutinize a household survey in order to determine whether it contains the relevant information for the analysis. The analysis of household surveys can be a daunting task for the inexperienced analyst. A comprehensive book on the topic is provided by Deaton (1997).

Note that surveys are quite heterogeneous. In practice, every survey has its peculiarities and survey structures vary greatly across countries as well as across time. Even repeated surveys (that is, multiple rounds of surveys done for the same purpose in the same country) can be different, since survey methodologies have evolved. Moreover, surveys are conducted for reasons that can vary both across countries and across time. Before initiating the analysis, it is important to familiarize yourself with the survey's structure, its original purpose, its limitation and its coverage. When using multiple surveys, it is also important to verify any incompatibilities and to ascertain to what extent they can be used for panel estimation or for comparison purposes.

Most of the household surveys collect the type of information required for household-level trade policy analysis. However, not all surveys are well suited for this purpose and, in many cases, the depth of analysis depends very much on the richness and quality of the data. To be appropriate for the analysis of distributional effects of trade policy a survey should include, besides information on consumption, information on the income shares each household derives from the sale of labour and/or the sale of agricultural products. Since trade policy impacts products and economic sectors differently, the more disaggregate the data are in the survey, the better it is suited for distributional analysis of trade policy. Household survey data should also provide information on subsistence activities, i.e. the amount of produced goods (usually agriculture) consumed within the household. Although subsistence activities are not directly affected by trade policy, they will have to be included as part of total household income and expenditures when income and budget shares are calculated since they contribute to the well-being of the household.

Survey data are based on the concept of a representative sample since they are collected only from a sub-sample of the represented population. Still, by using appropriate statistical techniques it is possible to infer the behaviour of the population it represents. A clear summary of the techniques required in the analysis of survey data is provided by Deaton (1997). In practice, analysis of survey data is facilitated by statistical software packages. Survey data are constructed in a way so that inferences drawn from them (through descriptive statistics or regressions) can be directly applied to the whole population. Surveys can be designed as clustered and/or stratified, as explained in the Box 6.1.

**Box 6.1 Design of surveys**

Survey data are based on the concept of a representative sample since they are collected only from a sub-sample of the represented population. In a *stratified* sample, a heterogeneous population is first divided into homogenous groups on the basis of a certain trait (geographical units, ethnic affiliation, rural/urban environment). Households within each group are then randomly selected to be part of the sample. The result is not one random sample drawn from the whole population but rather a collection of random samples, one for each group. It is as if we were dealing with several populations, heterogeneous across but homogenous within, instead of a single homogenous one, and designing sub-samples accordingly. The advantage of stratification is that it increases the precision of estimates and statistics. It also enables users to generate statistics and inferences for population subgroups (the strata), ensuring that there will be enough observations in each subgroup to do so.

In a *clustered* sample, by contrast, the population is first divided into groups that are *similar*: each cluster should be a small-scale replica of the total population. The surveyor then randomly selects some clusters to be in the sample. In a further stage, in each cluster, households are randomly selected to be in the sample. The advantage of clustering is that it reduces the cost of implementing the survey.

A sample that is both stratified and clustered is called a three-stage sample design:

- first, the population is partitioned into strata
- second, in each stratum, clusters are formed and some of them selected at random
- third, in each selected cluster, households are selected at random.

A large number of commands in STATA are dedicated to the use of survey data. This vastly simplifies the work of the statistician, who simply needs to indicate survey design once; STATA then takes care of the appropriate modifications to the most common formulae. A list of STATA survey commands is easily accessible by typing “help survey”. Particular attention needs to be given to weights (or the “expansion factor”). STATA allows four different types of weights (frequency, probability, analytical and importance weights). Specifying the appropriate weight is important for obtaining the correct standard error. Most surveys use probability (or sampling) weights (pweight). These can be interpreted as the number of population units represented by that particular observation.

Understanding the survey's design becomes important once you want to draw statistical inferences from it, whether these are regressions or descriptive statistics. Results will be biased if the survey's structure is not taken into account. The reason is that when households are not randomly selected from the whole population, each household in the sample “represents” a different number of samples in the population. Some types of households will be over-represented and some under-represented.

How is this source of bias corrected in practice? The answer is to give each household (or individual) in the sample a weight that represents the number of households (individuals) it truly represents. A typical survey therefore assigns a weight to each household, which is inversely proportional to the probability of the household to be in the sample (if a household of a certain type has a *high* probability of being in the sample, that type is likely to be over-represented, which calls for a *small* weight). These weights are provided with the survey data.

In practice, statistical packages greatly simplify the analysis of survey data and everything that the analyst needs to understand when identifying the variables indicating the strata, the clusters (often referred to as primary sampling unit) and the weights. This information is often embedded in the survey and should be clearly explained in the documentation accompanying the dataset. Once the researcher has positively identified the variables indicating any strata, clusters and sampling weight, these are entered in the software package.

In summary, STATA greatly facilitates the analysis by providing a set of common econometric and statistical routines that take into account the design of the survey so as to obtain results that will fit for the whole population. Survey data and design has to be understood, scrutinized and then analyzed with the proper statistical and econometric techniques. That is, the task of drawing inferences from survey data always requires human skills and knowledge with the possibility of misinterpreting the data and the results.

Household survey data are generally the property of the respective governments. In some cases, the data can be accessed only by submitting a formal request to the competent statistical offices. In other cases, the use of survey data does not require any permission or permission is automatically granted. There are two websites that are very helpful in obtaining survey data, both managed by the World Bank: <http://www.internationalsurveynetwork.org> and <http://go.worldbank.org/ZTOE0XCJ20>. These websites provide information on the availability and access of various types of surveys.

## 2. Trade policy data

The trade data needed to study the effects of trade policies are of two types: trade data and trade policy data. A good discussion of trade and trade policy data is provided by Nicita and Olarreaga (2007).

Trade data consist of trade flows and it is important to understand which goods are being imported and which are not. Trade policy data consist of information regarding the trade policy that is the subject of the analysis. In general these data consist of tariffs, since the analysis is often limited to traditional trade policies such as tariffs and specific duties.<sup>9</sup> However, non-tariff measures (i.e. standards, quotas, anti-competitive measures, etc.) and any trade-related costs can also be analyzed. As explained in Chapter 2, the pre-requisite is first to convert the information about particular non-tariff measures or trade costs into *ad valorem* equivalents, i.e. how much (in percentage terms) a determined non-tariff measure (or any other trade costs) affects the price of a product. Estimating *ad valorem* equivalents is not an easy task and requires a considerable amount of data.<sup>10</sup>

As discussed in Chapters 1 and 2, detailed trade and trade policy data (tariffs and trade flows) can be obtained from different sources such as government websites, UNCTAD TRAINS or the UN COMTRADE databases. An easy way to access these data is to use the World Integrated Trade Solution (WITS): <http://wits.worldbank.org>.

One challenge when working with different datasets is to merge the data into a single file. Survey data and trade policy data need to be harmonized, since they do not come under the same classification. While trade policy data generally follow the Harmonized System (HS) classification, survey data follow a classification peculiar to their needs. In practice, tariff changes will need to be aggregated into broader categories that can be matched with expenditure and income categories in the household survey. At a minimum, the aggregation should use imports as weights so as to give more importance to sub-products that are most traded. For a better aggregation, one should use both trade flows and import demand elasticities (see Kee et al., 2009 for details). Another aggregation issue is likely to arise when estimating wage-price and non-traded elasticities. For example, depending on the assumptions taken, there would be a need to aggregate the data into traded or non-traded goods, broad economic sectors, skilled and unskilled and so on.

## D. Applications

### 1. Calculating the effect of change in tariffs on consumption and agricultural sales

Here we present a simple method of calculating the effect of a tariff reduction on households. The analysis is based on data for Ethiopia. The purpose of this exercise is to illustrate in some detail the mechanics of working with trade policy and household survey data. The exercise is divided into two steps. In the first step we will calculate the change in domestic prices due to the tariff reduction. In the second step we will assess the impact of the change in prices on the consumption baskets of households as well as on the income from agricultural sales. For tractability, the analysis adopts some simplifications. First, we assume a perfect price pass-through. That is the domestic price given by the world price multiplied by  $1 + \text{tariff}$ . Second, we abstract from effects on the labour market. Finally, as we are only interested in point estimates, we do not consider the sampling structure of the household surveys. The STATA code for this application is detailed step by step in the file `DE_Application(Ethiopia).do` that can be found in the subfolder `Chapter6\Applications\` (all other do files relevant for this application can be found here too). Then we provide some discussion and some possible extensions.

The analysis first calculates the change in prices resulting from a change in tariff. This is based on trade policy data and it is detailed in the first few commands in the `Ethiopia.do` file. Trade policy data (in the file `Chapter6\Datasets\tariff_9501.dta`) consists of tariffs in 1995 and 2001. Trade policy data follows the HS classification at the six-digit level for a total of about 5,400 different products. The trade policy data file also contains the concordance (the variable is labelled "type") between the HS six-digit classification and the product groups important for Ethiopian households. The change in price is simply calculated as the percentage change in tariff between 1995 and 2001, taking into account that the domestic

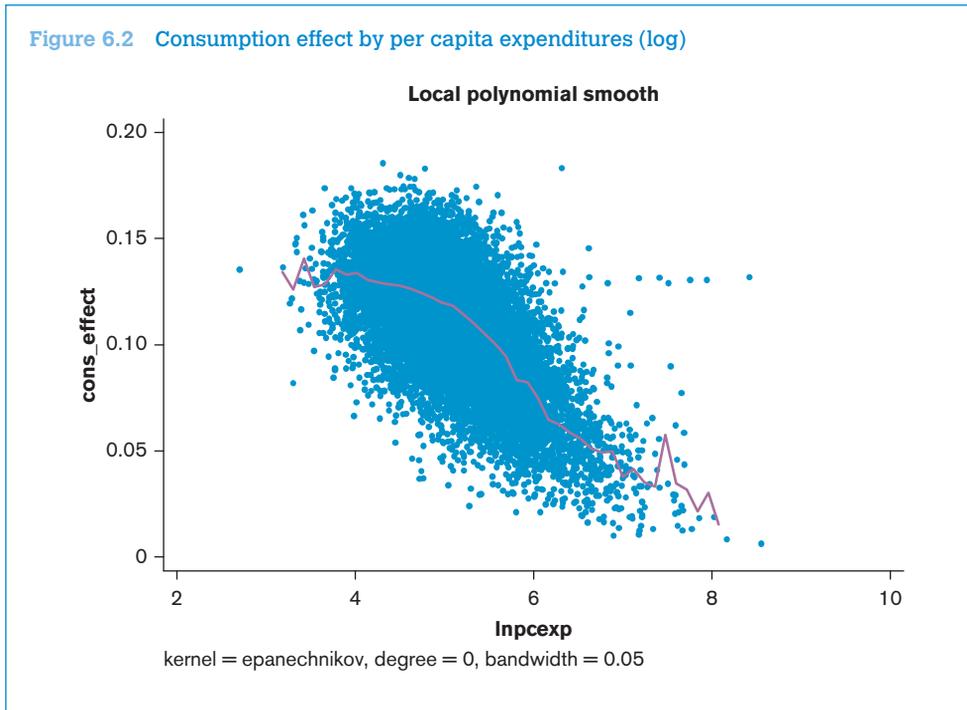
price is given by the world price multiplied by  $1 + \text{tariff}$ . The change in price at the product level is then saved in the file `deltaprice.dta`.

An extension to the analysis could assume a different price pass-through. This could be assumed uniform across the country, say 0.6 (this can be simply implemented by multiplying the observed change in tariff between 1995 and 2001 by 0.6 and then recalculating the change in domestic prices). Alternatively, an option would be to use pre-estimated pass-through coefficients at the regional level, i.e. the price transmission is assumed to vary across regions (kilil in the case of Ethiopia). These are provided in the file `passthru_coeff.dta`. A further extension could entitle the estimation of pass-through coefficients for different products, say agriculture and manufacturing, or mainly imported and exported goods.

The second step of the analysis uses the data from the Ethiopia households survey (`Ethiopia_hhsurvey.dta`). These data have been already cleaned and formatted for the analysis. The data file contains three main sets of variables. First, the identification variables which provide some characteristics of the household: location, household head's gender, the number of people living in the households, etc. Second, a set of variables detailing the expenditures of the households aggregated in 18 categories. And third, a set of variables detailing the sources of income of the households aggregated in 13 categories. The data file also contains information on survey design (weights and strata). Note that the dataset contains only part of the data in the official Ethiopia households survey. The original file contains more information than those provided in the file.

The first point of this second step is to divide the households according to their purchasing power. This is generally done by using expenditures or alternatively per capita income. In the STATA do file, this is done first by summing up all expenditure categories with the inclusion of subsistence activities. We can call this variable `totexpend_hh`. Note that it is important to add subsistence activities as these contribute to the well-being of the household. These are generally cumbersome to calculate since subsistence activities do not have a manifest monetary price, so some reference price has to be used. The data file already contains a variable that provides the monetary equivalent (calculated at market prices) of all products produced and consumed by the household. The total expenditure of the households then needs to be divided by the number of household members so as to obtain per capita expenditures. This can be done by simply dividing by the number of people living in the household or, more properly, by using equivalence scales. Equivalence scales take into account the economies of scale that occur in the households. For example, children or elderly could have fewer expenses than adults, so that for maintaining a given living standard a family with a large number of children does not need the same level of consumption as a family of the same size but with a large number of adults. Deaton (1997) treats this argument at length. The do file also splits households across per capita expenditure deciles; this is useful especially for producing summary statistics and graphs. This is done by using the `"xtile"` command in STATA.

The next step is to focus on consumption effects so as to compute changes in the cost of the expenditure basket of each household due to the change in trade policy. This is done by merging the household survey data on consumption with the price change calculated in step 1, and then



recalculating the new cost of the expenditure basket for each household. The gain or loss for each household will be given simply by the difference between the old and the new cost of the expenditure basket. This statistic is generally reported in percentage terms. In practice, a decline in the import tariff will reduce the price of the good in the domestic market, so it will have a positive effect on the purchasing power of households because the household budget will allow purchase of more of the goods for which the tariff has declined. The effect on consumption (the percentage change in the cost of the consumption basket) is then plotted against the log of per capita expenditures so as to analyse possible differences across household distributions. The data are plotted using the “lpoly” command and illustrated in Figure 6.2.

The plot indicates the effect of the tariff reduction inversely correlated with household expenditure; thus the reduction of the tariff has benefited the poor proportionally more. This plot is informative for poverty purposes but it is only one way of presenting the results. In practice, the results could be calculated and presented for households divided according to any other characteristic (location, gender, size, etc.).

The income effect is similarly calculated. The various goods produced by households are merged with the change in their respective prices and then the percentage change in the value of agricultural income is calculated. As subsistence activities are assumed not to be affected by trade policy, it is important to include them in total income. The income effect is plotted against the log of per capita expenditure in Figure 6.3.

Figure 6.3 Income effect by per capita expenditures (log)

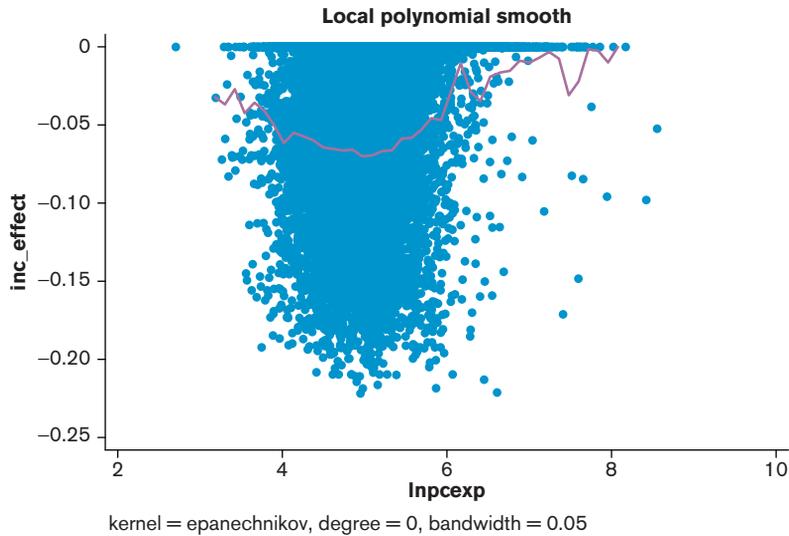
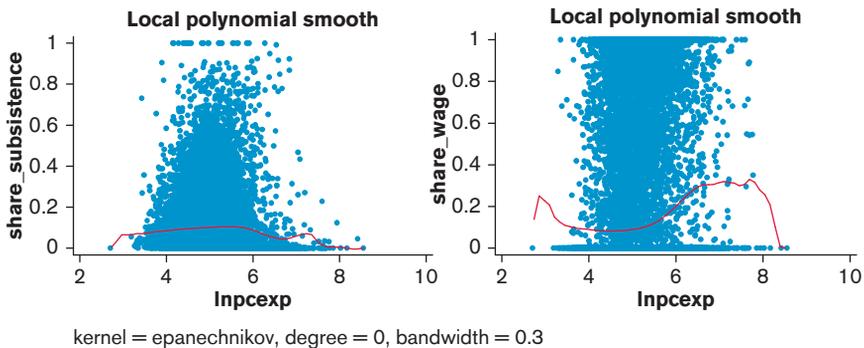
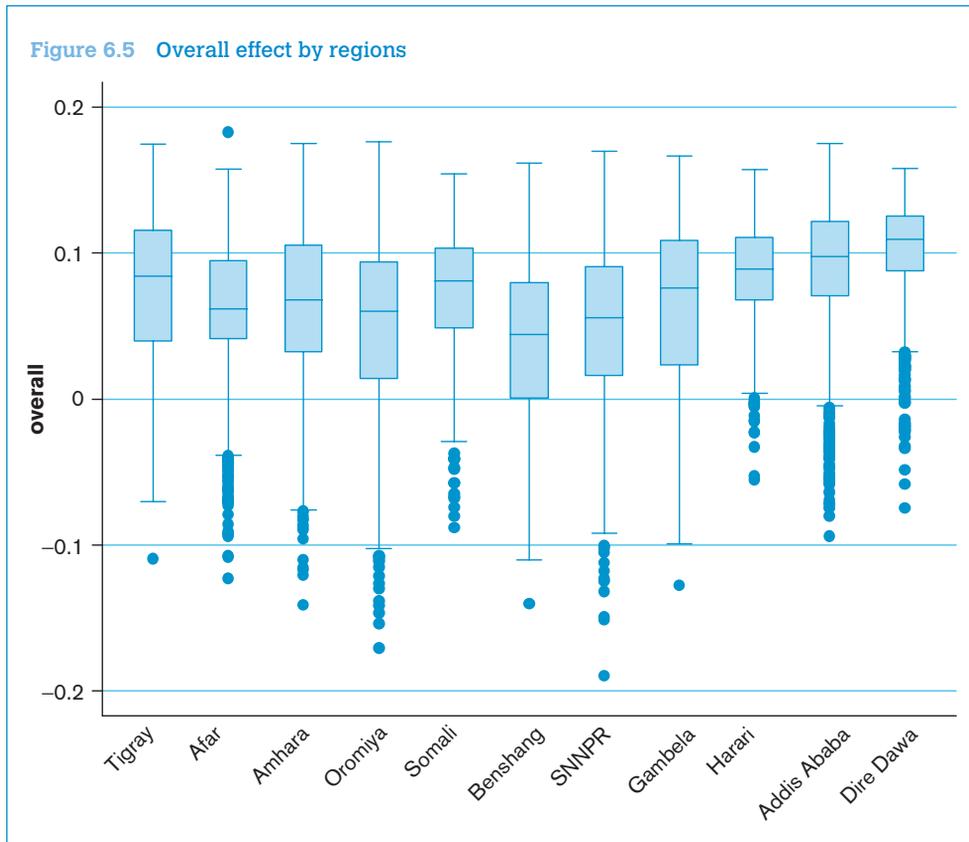


Figure 6.4 Share of income from subsistence activities and wages



The reduction in tariff will translate into more competition from foreign products, and thus into lower domestic prices, which then translate into lower income for households producing agricultural products. Regarding the distribution of the income effect, the plot in Figure 6.3 suggests two points. First, the income effect of agricultural sales is mostly zero for richer households. This is due to the fact that agricultural sales do not play a large role in the income of richer households. Second, the larger effects are for households in the middle of the distribution. This may be due to poorer households being landless or, more likely, disproportionately engaging in subsistence activities and thus their income is unaffected by changes in prices. For richer



households, the lack of effects is most likely due to the fact that agricultural sales represent a small part of their total income. Another explanation might be that tariffs on products produced by the poor have not changed as dramatically as those produced by households in the middle of the income distribution. Some of these hypotheses can be roughly verified by plotting the share of income originating from subsistence activities and from wages. These plots are presented in Figure 6.4.

Figure 6.4 suggests that, with the exception of the first data point on the left side of the distribution and for richer households, income from subsistence activities does not substantially vary across households. On the contrary, income from wages presents a bipolar distribution. Wages are important for both the poorest and the richer households. This allows us to conclude that the main reason behind the weak income effects in Figure 6.3 is the fact that a substantial share of the income of poor households as well as of richer households is from wages, which in the analysis so far have been assumed to be unaffected by trade policy. This issue may lead us to analyze the effect of trade policies on wages. Unfortunately, as discussed above, this is a complex exercise which requires a time series of data linking prices

to wages (Robertson, 2004). This exercise would also require some assumptions on the functioning of the labour markets (say, if labour markets are segmented by skill, industries, regions, etc.). In practice, some insights may be obtained by regressing a Mincer equation (wages on individual characteristics and prices) with time series data so as to try to isolate properly the effect of tariff changes on wages (see Nicita, 2008 and 2009, and Ural Marchand, 2012 for a few applications).

The last part of the analysis consists in calculating the overall effects of trade policy. This is simply done by summing up income and consumption effect. For this exercise, the results are presented in terms of deciles, i.e. the consumption, income and overall effect on households divided according to their level of expenditures. Table 6.1 provides the results.

Table 6.1 indicates two points. First, results are positive overall: the benefit of a cheaper consumption basket outweighs the cost of lower prices of agricultural sales. Second, effects are larger for poorer households. This implies that the tariff changes have benefited poor households proportionally more than richer households and thus that the change in trade policy has been pro-poor. Note that these are averages by deciles and so it is still possible that single households might lose from the tariff reduction. This can be shown in several ways; for illustrative purpose here we also can plot the results by regions (kilil) – see Figure 6.5.

The box plot shows the distribution of the overall effects across 11 Ethiopian regions (kilil). The boxes in the figure display the 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentile, the lines extend to the 5<sup>th</sup> and 95<sup>th</sup> percentiles and dots represent outliers. The figure suggests that the overall effects are similar across regions. However, the effects are slightly more positive in the regions with a larger share of urban population (Addis and Dire Dawa). For these regions, there are very few households that will lose from the tariff change. Regions with the largest number of households that will lose from the effect of tariff change are Oromiya, Benshang and SNNPR, with a negative overall result for about 20 per cent of households. The next step would be to identify these households more precisely, analyze their means of living and try to devise complementary policy to alleviate the trade policy costs that fall on these households. This is clearly beyond the purpose of this illustrative exercise.

**Table 6.1** Income, consumption and overall effects by deciles

<i>decile</i>	<i>inc_effect</i>	<i>cons_effect</i>	<i>overall_effect</i>
1	-0.051	0.137	0.086
2	-0.057	0.135	0.077
3	-0.061	0.133	0.072
4	-0.061	0.130	0.069
5	-0.057	0.128	0.071
6	-0.063	0.124	0.060
7	-0.071	0.123	0.052
8	-0.065	0.117	0.052
9	-0.046	0.108	0.062
10	-0.023	0.072	0.050

## 2. Measuring the impact of tariffs at the household level

Whether a given trade policy has a regressive or “anti-poor” bias, i.e. whether it penalizes poor households more than rich ones, is an important policy question in the context of trade reform. In general, various tools can be used to quantify the effects of trade barriers on domestic residents’ incomes. Here we abstract from effects on the labour market and limit ourselves to a tool that is simple to use — although its data requirements can be non-trivial — but nevertheless provides a clear answer to the question of progressivity/regressivity.<sup>11</sup>

Consider for instance a simplified version of equation (6.6), where a farm household consumes  $n$  products indexed by  $k$ , and let  $s_{h,k}^{Consum}$  stand for the share of good  $k$  in the household’s expenditure.<sup>12</sup>

Suppose that the farming household also produces those  $n$  products for either self-consumption or for sale (we will show later in this section that extending the analysis to the case where goods produced and consumed are not the same is straightforward). Let  $s_{h,k}^{Prod}$  be the share of good  $k$  in the household’s income. By income, we mean “full income” including self-subsistence activities evaluated at market prices.<sup>13</sup> Again, the share of some goods — i.e. crops in the context of a farming household — in household income may rise with income, say because growing that crop requires access to credit, some degree of training or other factors typically correlated with income; or it may fall. The former case will apply when the income elasticity of the crop in question is higher than one, the latter when it is lower than one. Thus, there are “necessities” and “luxuries” on the production side, although the terminology is not very telling here.

From the above discussion it should be clear that tariffs on goods produced by households *protect* (benefit) them whereas tariffs on consumption goods *tax* them. In practice, if the tariff structure protects the goods *produced* by rich households disproportionately (relative to those produced by non-rich households), these tariffs are pro-rich (i.e. high tariffs on crops grown predominantly by large and high-income farmers, and low tariffs on products produced by poor, small-scale farmers). On the other hand, if tariffs are relatively higher on goods *consumed* by the rich, these tariffs are pro-poor (e.g. high tariffs on luxury goods).

Formally, one can construct a production-weighted average tariff for each household as

$$\bar{\tau}_h^{Prod} = \sum_k S_{h,k}^{Prod} \tau_k \quad (6.7)$$

where  $\tau_k$  is the tariff on good  $k$ , and a consumption-weighted average tariff as

$$\bar{\tau}_h^{Consum} = \sum_k S_{h,k}^{Consum} \tau_k \quad (6.8)$$

The net effect of the tariff structure on household  $h$  ( $\bar{\tau}_h$ ) is then the difference between the two:

$$\bar{\tau}_h = \sum_k (s_{h,k}^{Consum} - s_{h,k}^{Prod}) \tau_k \quad (6.9)$$

Note that the sets of goods produced and consumed need not overlap; for instance, an urban, salaried household would simply have zero production weights on all goods, i.e. for some goods  $s_{h,k}^{Prod} = 0$  while for others  $s_{h,k}^{Consum} = 0$ . Finally, note that the effect of trade reform would be assessed in this framework by replacing tariff levels  $\tau_k$  by tariff changes  $\Delta\tau_k$ .

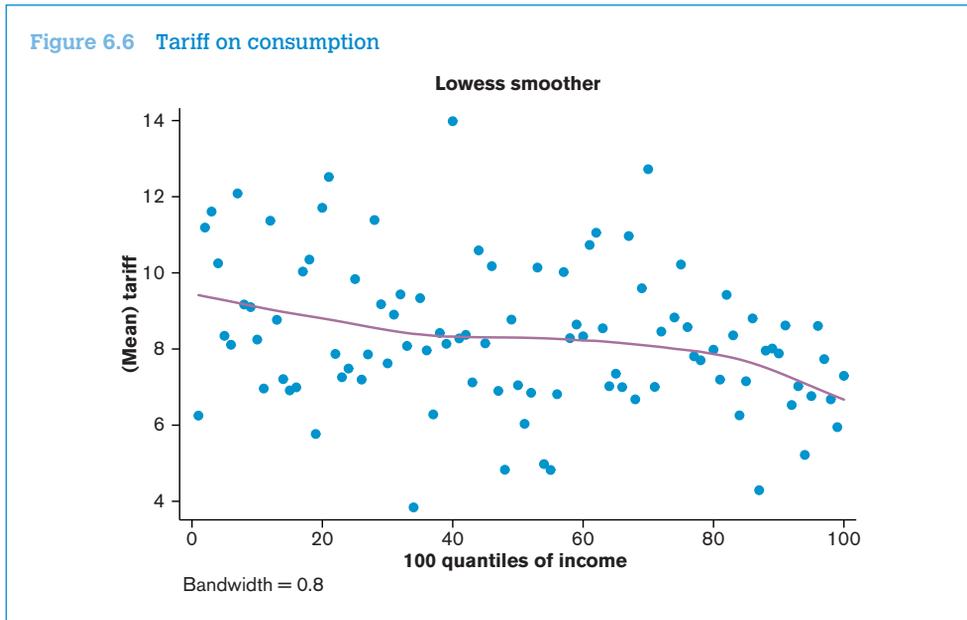
All three (consumption effect, production effect and net effect) can be plotted against income levels in order to get a picture of the regressive or progressive nature of tariffs. One way of doing this might be simply to regress  $\bar{\tau}_h$  on income levels. However, nothing guarantees that the relationship between the two will be linear or even monotone, as it may well have one or several turning points. As an alternative to linear or polynomial regression, you may fit what is known as a “smoother” regression, which essentially runs a different regression for each observation, using a sub-sample centred on that observation.<sup>14</sup>

A “smoother” regression is a non-parametric regression technique designed to generate a fitted curve that imposes no a priori functional form (linear, quadratic or other) on the relationship between two variables  $X$  and  $Y$ . It is thus a useful exploratory tool for detecting highly nonlinear relationships. This can be done, but only in the case of a large sample (such as the one originating by survey data), by performing a so-called LOWESS smoother (for LOcally WEighted Scatterplot Smoothing). In short, the value of the regression function for each point is estimated only by using a subset of the data. Moreover, the estimation is performed by using weighted least squares, giving more weight to observations near the point for which a response is being estimated and less weight to observations further away. The value of the regression function for the point is then obtained by evaluating the local polynomial using the explanatory variable values for that data point.

The result is a “regression curve” on which no particular shape is imposed and which can therefore have as many turning points as needed to fit the data. In addition, for readability, households can be grouped into centiles and the smoother regression is run on the average incomes of the centiles rather than on individual household incomes. This is done by employing STATA’s `xtile` command using appropriate *weights*. If *tariff* is the consumption-weighted tariff, the mean by centile of the income distribution is obtained by:<sup>15</sup>

```
use "EPM.dta", clear
collapse income tariff [w=prod_exp] , by ( strata_id comm_id weights)
xtile centile = income [w=weights], nquantiles(100)
collapse tariff [w=weights] , by ( centile)
lowess tariff centile
```

Note that this procedure reports the results at the household level. More commonly, for poverty and inequality purposes, results are to be reported at the individual level, i.e. larger households should be given more weight. Individual-level results can be obtained by multiplying the weights by number



of individuals or by using multipliers depending on equivalence scales so as to capture economies of scale within the household (see Deaton, 1997 for more details).

Figure 6.6 shows the Lowess smoother for Madagascar based on an extraction from Madagascar's 2001 household survey. The downward trend indicates that the tariff structure is regressive (it taxes poor households more than rich households), at least for what regards consumption. While the poor households are taxed almost 10 per cent, the richer households are taxed about 7 per cent. Clearly this is only part of the analysis; the overall tariff structure of Madagascar could still be progressive (more favourable to the poor) to the extent that income sources of the poor enjoy higher tariff protection than those of richer households.

## E. Exercise

### Assessing the progressivity of trade taxes

The household survey used in the practical exercise is Madagascar's 2001 *Enquête Permanente des Ménages*. The population was stratified into groups according to the environment (urban/rural) and to the district. With six districts, the number of strata is 12 (you can verify this by using the survey description command `svydes`). Then, in each stratum, clusters were defined according to communities. Among them, some were selected with a probability proportional to the community's size. Finally, in each selected community, households were randomly selected.

In the database used in the practical exercise, the strata are identified by the variable *strata\_id*, the clusters by *id\_comm* and the sampling weights by *weights*. The command to specify the survey structure is then:

```
svyset id_comm [pweight=weights], strata(strata_id)
```

Use the datafile EMS.dta provided in the folder Chapter 6\Exercises. It is an extraction from Madagascar's 2001 *Enquête Permanente des Ménages* (EPM). A STATA do file explains the commands involved in each step (DE\_Exercice(Madagascar).do).

1. Using the `svydes` command, answer the following questions:
  - a. What is the total number of strata, units (communities in the database) and households in the sample? What type of sample is this?
  - b. What is the average number of households per unit (community)?
  - c. In which stratum is the smallest unit (community)? How many households are in it?
2. Without taking account of the survey's design, assess the progressivity or regressivity of Madagascar's tariff structure on the consumption side. The steps are as follows:
  - a. Calculate the weighted-average tariff for each household; call it `c_tariff`.
  - b. Generate centiles of the income distribution in the sample.
  - c. Calculate the average of this consumption-weighted tariff for each centile using the command `collapse c_tariff, by(centile)`.
  - d. Regress this centile average on income using STATA's `lowess` command, using a bandwidth of 0.8.
  - e. In view of the smoother regression curve, is Madagascar's tariff structure progressive or regressive on the consumption side?
3. Redo Question 2 but taking into account the survey's design. What do you observe?
4. Using the household expenditure data, determine which of the 81 goods in the database are necessities (income elasticity lower than one) and which ones are luxuries (income elasticity above one).  
 [*Hint:* Calculate average product weights by centiles and perform a simple regression of product weights on centiles for each product.]
5. Using your findings from Questions 2–3 and from Question 4, suggest a trade-policy reform. Assuming a budget-neutral tariff reform designed to bring more equity in the system, on what products would you suggest raising tariffs? On which ones would you suggest cutting them?

## Endnotes

1. The expenditure function gives the minimum expenditure needed to attain a level of utility  $u$  given prices  $p$ . Its derivative with respect to the price of each good, by Shephard's lemma, is the household's consumption of that good.
2. In the equations below, we will abuse notation by using the same letter to designate a variable (say,  $w$ ) and the function that determines it from its argument (say,  $p_j$ ).
3. Imagine that a benevolent government were to pay losing households the amount they lost as a result of the trade shock and to tax winning households by the amount they won. This "transfer" would thus be a positive number in the budget constraint of losing households and a negative one in that of winning households.
4. See Porto (2003) and the references therein for a discussion of that assumption's implications. In practice, second-order effects are taken into account for case studies confined to few markets and sectors, and only when large effects are expected. Nicita (2008) provides an empirical methodology for assessing the effect of employment changes on households' welfare.
5. Household surveys are collected on a regular basis and thus they can provide some information on trends in prices of goods of importance to the households. Time series on prices (often at the local level) can be extracted from household surveys. Surveys collect information on purchases, and proxies of prices can be obtained by dividing expenditures by quantities. These unit values would have to be corrected for quality and aggregated in cohorts so as to reduce measurement errors (see Deaton, 1997).
6. See also Nicita (2007) for a simpler calculation of regional pass-through.
7. Generally, wage responses to prices are estimated for skilled and unskilled (often based on years of education, with workers having less than nine years of education considered to be unskilled). Skills can also be assumed to be sector specific; thus the estimation can be performed segmenting the labour markets by economic sector instead of skill.
8. With a sample of several thousand households this graph is likely to be unclear, so observations can be averaged by groups (based on income, gender, region, etc.).
9. Specific duties (i.e. \$10 per metric ton) would need to be converted in *ad valorem* equivalents (i.e. 8% tariff). AVEs can be calculated with an algebraic formula where the key parameter is the price of the good. Users can query WITS to perform this calculation.
10. See Kee et al. (2009) for estimating *ad valorem* equivalents of non-tariff barriers.
11. A progressive tax is one whose average rate goes up with income, and conversely for a regressive tax.
12. Those shares are themselves likely to vary with income levels (goods are "necessities" if their budget shares go down with income, i.e. if their income elasticity is less than one, and "luxuries" otherwise).
13. Evaluating the monetary equivalent of the food crop output can be done using producer or (typically higher) consumer prices. The logic for using the former is that if the food crop was sold instead of consumed it would be sold at producer prices. The logic for using the latter is that if the food crop was purchased instead of grown it would be purchased at consumer prices. So which one to use is a matter of judgment and data availability. What is important is that the analyst makes his/her choices clear in the writing.
14. Although it sounds complicated, this procedure is in practice very simple because it is pre-programmed as the "lowess" and "lpoly" command in STATA.
15. As we are not interested about standard errors this example does not use the "svy" STATA commands. See the practical exercise for a similar exercise using svy commands.

## References

- Deaton, A. (1997), "The analysis of household surveys: a micro-econometric approach to development policy", Washington D.C.: The World Bank.
- Feenstra, R. C. (1989), "Symmetric pass-through of tariffs and exchange rates under imperfect competition", *Journal of International Economics* 27: 27–45.
- Goldberg, P. and Knetter, M. (1997), "Good prices and exchange rates: what have we learned?", *Journal of Economic Literature* 35: 1243–72.
- Grosh, M. E. and Glewwe, P. (1995), "A guide to living standards surveys and their data sets", Living Standard Measurement Working Paper 120, Washington D.C.: The World Bank.
- Harrison, A. (2007), *Globalization and Poverty*, Chicago: University of Chicago Press for National Bureau of Economic Research.
- Nicita, A. (2004), "Who benefited from trade liberalization in Mexico? Measuring the effects on household welfare", Policy Research Working Paper 3265, Washington D.C.: The World Bank.
- Nicita, A. (2007), "Ethiopia", in Hoekman, B. and Olarreaga, M. (eds.), *Global Trade and Poor Nations: The Poverty Impacts and Policy Implications of Liberalization*, Washington D.C.: Brookings Institution.
- Nicita, A. (2008), "Who benefits from export-led growth? Evidence from Madagascar's textile and apparel industry", *Journal of African Economies* 17(3): 465–89.
- Nicita, A. (2009), "The price effect of tariff liberalization: measuring the impact on household welfare", *Journal of Development Economics* 89(1): 19–27.
- Porto, G. (2003), "Using survey data to assess the distributional effects of trade policy", Policy Research Working Paper 3137, Washington D.C.: The World Bank, published in the *Journal of International Economics* (2006) 70(1): 140–60.
- Porto, G. (2004), "Informal export barriers and poverty", Policy Research Working Paper 3354, Washington D.C.: The World Bank, published in the *Journal of International Economics* (2006) 66(2): 447–70.
- Robertson, R. (2004), "Relative prices and wage inequality: evidence from Mexico", *Journal of International Economics* 64(2): 387–409.
- Singh, I., Squire, L. and Strauss, J. (eds.) (1986), *Agricultural Household Models — Extensions, Applications and Policy*, Baltimore: The Johns Hopkins University Press.
- Ural Marchand, B. (2012), "Tariff pass-through and the effect of trade liberalization on household welfare", *Journal of Development Economics*, forthcoming.
- Winters, L. A. (2002), "Trade liberalization and poverty: what are the links?", *The World Economy* 25(9): 1339–67.



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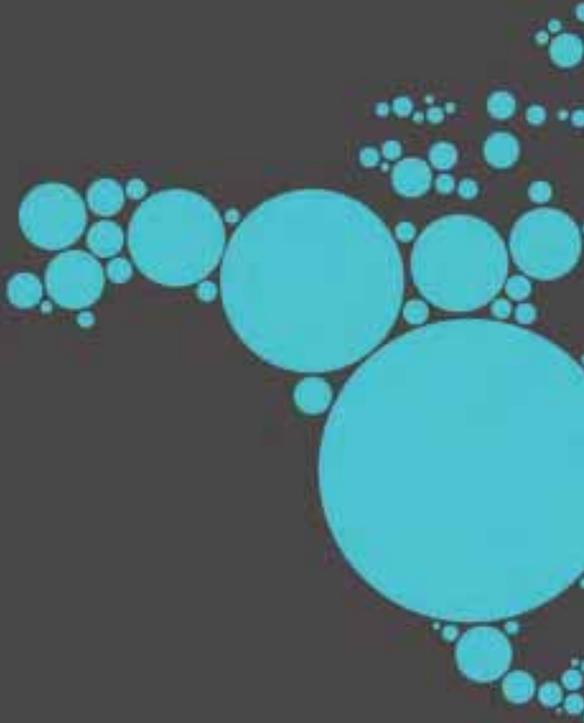
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