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Can Taxes Help Ensure a Fair Globalization?

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Abstract

This paper analyzes whether taxation can be successfully used to reduce the incidence of labor informality and achieve higher equality in a globalized economy. To this purpose, it develops a two-area model: a developed country and an emerging country. The two areas differ according to the size of the informal sector, which is characterized by a more flexible labor market and lower productivity. To illustrate the potential role of taxation in achieving a more fair income distribution, the paper introduces a trade shock to simulate the effects of trade liberalization. Trade expansion has often been blamed for leading to an expansion of the informal sector and a widening of wage income disparities. In this context, the paper analyzes whether a budget-neutral tax reform—switching the tax burden from payroll taxes paid by firms operating in the formal sector to a consumption tax—can mitigate possible adverse effects of trade liberalization and support labor formalization. The effects of taxation are seen in the context of the trade-offs between growth, labor formality and equity. The analysis suggests that small improvements in formalization, resulting from the tax reform, come at the cost of widening income inequality. To reduce the incidence of low-quality jobs, tax policy interventions should go hand in hand with more effective social protection systems and labor laws.

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Can taxes help ensure a fair globalization? *

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1 Introduction

In the three decades prior to the global financial crisis, household income inequality increased in a large majority of OECD countries. Emerging countries have income inequality significantly higher than the OECD average, although some countries (such as Brazil, Indonesia and, on some indicators, Argentina) have recorded significant progress in reducing inequality over the past 20 years (OECD, 2011).

In addition, during the late 20^{th} century there was a general increase in the informal economy in many countries around the world (see Schneider and Enste (2000)). Heintz and Pollin (2005), for example, show that within a data set of 23 countries, 19 showed increases in informality. Similarly, ILO data show that from 2002 self-employment increased in all developing regions, and world-wide it increased from about one-quarter to one-third of non-agricultural employment during 1980-2000 (ILO, 2013). The high incidence of informality is an issue of concern especially in developing countries, where on average, more than 50 percent of the labor force is informal.[1]

Among the drivers of rising informality, the conventional view blames trade liberalization for being responsible for the fall in wages for unskilled and low-income workers, as well as the rise in informal and less protected forms of employment. Therefore, despite its uncontroversial expansionary effects on global growth, trade expansion has not always been translated into more equal incomes and better working conditions.[2]

In these circumstances, an efficient tax system is indeed an important tool for addressing rising inequality and informality and restoring robust economic growth. On the one side, taxation is a powerful policy tool to redistribute income and make the post-tax income distribution less unequal. On the other side, taxation is a potential tool to lessen the costs of operating in the formal sector, since formality choices are very elastic to marginal tax rates. Indeed, a targeted and well-balanced tax code is an essential element in making further progress in achieving the Sustainable Development Goals by providing a stable funding base for high-quality public services for all and effective transfers targeted to those most in need.

In this context, our analysis contributes to the literature by investigating whether taxation may be an efficient policy tool to support labor formalization in a globalized economy without widening income disparities. Our analysis is based on a Dynamic Stochastic General Equilibrium (DSGE) model with two asymmetric countries: a developed and an emerging country. These two countries differ according to the size of the informal sector in the intermediate-good sector. The informal sector is characterized by a more flexible labor market (i.e. rapid entry and exit and more flexible adjustment to change in demand) and lower productivity. In this respect, our paper relates to the recent theoretical literature embedding the informal sector in DSGE models (e.g. Conesa et al. (2002), Busato and Chiarini (2004), Orsi et al. (2014), Pappa et al. (2015), Dellas et al. (2017)). Within this strand

[1] In many Latin American countries informal employment exceeds 50 percent of total urban labor force (Gasparini and Tornarolli (2007)). Estimates for Sub-Saharan Africa and Asia are even higher (Jütting et al. (2008)). For an overview on job quality in emerging economies, see OECD (2015).

[2] For a more comprehensive discussion, see Bacchetta et al. (2009).

of literature, very few works enrich DSGE models with both informality and a fully-fledged labor market with search and matching frictions. The few exceptions, to the best of our knowledge, are Cook and Nosaka (2005), Zenou (2008), Satchi and Temple (2010), Batini et al. (2011), Colombo et al. (2018), Bosch and Esteban-Pretel (2015) for Mexico, Anand and Khera (2016) for India and Poirier and Trupkin (2018) for Argentina. However, most of the aforementioned theoretical works have a different focus and very often analyze the role of regulation, while none of them analyzes the effect of taxation on informality. In addition, models developed in the aforementioned studies describe closed economies and none of them is suitable to analyze the impact of policies in a globalized economy from both a developed and a developing country perspective.

The novelty of our paper is to focus on the role of taxation in reallocating labor between formal and informal activities in countries which participate in international trade. The effects of taxation are seen in the context of the trade-offs between growth, labor formality and equity. We start from a model à la Melitz (2003) and we extend it in two directions. First, we propose a dynamic model as in Ghironi and Melitz (2005), with search and matching frictions as in Helpman, Itskhoki and Redding (2010) and Cacciatore and Ghironi (2015). Second, we distinguish two asymmetric areas, a developed and an emerging country, characterized by different incidence of informality. We model informality as proposed by Charlot, Malherbet and Terra (2015)[3] in a closed economy static model. Our model closely follows Cacciatore and Ghironi (2015). However, Cacciatore and Ghironi (2015) focus on developed economies where a representative agent can be employed in only one sector, the presence of informality being not considered. In order to fully capture the impact of a tax reform in emerging economies, it seems to be crucial to model the interplay between the formal and informal sectors. Therefore, our main contribution is that we embed the informal sector, as we believe that the analysis of labor market dynamics cannot be limited solely to the formal sector, given the high incidence of informality especially in developing and emerging countries. Furthermore, in order to assess whether a fiscal reform can enable transition to formalization, we add taxation as well as hand-to-mouth agents in the model, which is not embedded in Cacciatore and Ghironi (2015).

Our work is related to the literature analyzing the impact of taxation on informality. Empirical evidence points out that reducing taxation on formal businesses eases the migration of entrepreneurs from the informal to the formal sector, where productivity is higher, with positive effect on output and economic efficiency (see Slonimczyk (2012) for the Russian Federation and Araujo and Rodrigues (2016) for Brazil). Higher tax rates among firm-owners induce not only substantial movements to the informal sector, but also under-reporting of taxable earnings and income shifting to tax-favored business forms, which may ultimately lead to inefficient allocation or resources (see Waseem (2018) for an analysis of the Pakistani tax reform introduced in 2009). If informality is voluntary, lower taxation rates should reduce firms' incentives to enter the informal sector. However, even if informality is involuntary, lower tax rates could reduce informality by encouraging formal sector firms to expand em-

[3]These authors limit their analysis to a closed economy static model.

ployment and create more formal jobs. This strand of the literature suggests that the best approach to reduce the size of the informal sector is using taxation to reduce the costs of being formal and create the right incentives for companies and workers intending to switch to the formal sector. However, different tax instruments may have different effects in promoting the transition to the formal economy. For instance, lower taxes on social security contributions or on capital translates to a lower degree of informality, whereas cutting taxes on labor income has the opposite effect. Reducing personal income taxes increases gross wages, thus making the informal sector – which is labor intensive – more attractive.

Our analysis highlights a number of interesting results. We start by introducing a trade shock which simulates the effect of trade liberalization in a globalized economy. Simulations in our model point out that in the short term trade liberalization boosts economic activity and employment in both the formal and informal sectors. However, this employment expansion is biased toward the informal sector, which is not subject to labor regulation and hence is more flexible. In addition, in the long run – after the strong employment gains recorded during the initial phase of trade expansion – there is a phase characterized by a contraction on the labor market. We then investigate whether it is possible to correct this bias in favor of the informal sector by reducing payroll taxes paid by firms operating in the formal sector. This policy exercise simulates the effects of several programs implemented in emerging economies (e.g. SIMPLES and SUPERSIMPLES in Brazil and the Monotax in Argentina) aiming at reducing the tax burden for small enterprises which are more likely to operate in the informal sector.[4] We show that an increase of the consumption tax could be a relevant strategy to finance the payroll tax cuts. Although this budget-neutral tax reform supports the formalization process on the labor market, we observe that small improvements in formalization come at the cost of widening income inequality.

The rest of the paper is structured as follows. In Section 2 we describe the model, while in Section 3 we discuss the calibration. In Section 4 we introduce the trade shock to simulate the effect of trade liberalization. The impact of a budget-neutral tax reform is discussed in Section 5. Finally, Section 6 concludes. Some technical aspects are reported in the Appendix.

2 Model

We develop a two-country model, calibrated on a developed and an emerging country. The two economies are modeled exactly symmetrically, so that the following description in this Section holds for both economies. We assume a dual labor market, with formal and informal workers. The two countries differ for the incidence of labor informality, since emerging countries are characterized by higher informality than advanced economies. Variables appearing with an asterisk refer to the modeled foreign economy.

[4]These types of programs, such as microcredit and tax reliefs for small enterprises, have been blamed for limiting growth opportunities in emerging economies, since they increase the incentives for small enterprises to remain small (see Hsieh and Olken (2014)). For an analysis on the difficulties of Brazilian small firms to surpass the threshold of medium-size plants, see Coelho et al. (2017).

There are four actors in each country: households, firms producing intermediate goods, firms producing final goods and the government. The model features heterogeneous households: Ricardian and non-Ricardian. Ricardian households hold bonds but do not supply labor, whereas non-Ricardian households do not have access to financial markets to finance their consumption needs. Therefore, non-Ricardian households need to supply labor in order to finance their consumption needs. Since recent evidence shows that there is no segmentation between the formal and the informal sector (see Charlot et al. (2015)), we assume that workers can move between the two sectors.[5] They may decide to either supply labor in the formal sector, or supply labor in the informal sector or be unemployed. Labor is hence supplied only by non-Ricardian households to intermediate good producers. Intermediate good producers operate in a perfect competitive market and hire labor – either on the formal or informal market – to produce intermediate goods which are sold to final good producers. Final good producers combine intermediate goods into a final good which is sold on a monopolistically-competitive market.[6] Finally, to provide public goods and unemployment benefits, the government collects taxes paid on consumption by all households as well as payroll taxes paid only by employees and employers (i.e. intermediate good producers) operating in the formal sector.

For the sake of simplicity, the model does not feature nominal price rigidities and goods are produced using only labor without capital.

2.1 Households

There are two types of households in the economy: Ricardian and non-Ricardian. Ricardian households (indexed by a) do not work, hold assets and have access to international financial markets. Non-Ricardian households supply labor, but have no access to financial markets. Non-Ricardian households can work in the formal sector (indexed by F), work in the informal sector (indexed by I) or being unemployed (indexed by u).

For all agents, the consumption basket C_t aggregates Home and Foreign consumption in a Dixit-Stiglitz form:

$$C_t = \left[\int_0^1 C_t(i)^{\frac{\phi-1}{\phi}} di \right]^{\frac{\phi}{\phi-1}} \tag{1}$$

[5]For the sake of simplicity, we focus only on labor informality and we abstract from business informality, i.e. we abstract from modeling how firms can switch from the formal to the informal sector and vice versa. Chacaltana et al. (2018) show that business informality does not imply labor informality and vice versa. The decision of a firm to go formal is the product of a complex evaluation based not only on the tax burden but also on other factors, such as the opportunity to have access to credit. Modeling firms' choice to switch between the formal and informal sector would require embedding the financial sector into the model, which will pose challenges to the analytical manageability of the model. Becker (2018) provides an example of a model featuring a sector-switching mechanism.

[6]The distinction between formal and informal labor arises only for firms producing intermediate goods which are used by final good producers as the sole input. Intermediate good producers are not allowed to directly export abroad. This assumption is needed because exporting means some minimal formality and respect of customs requirements and are more subject to control and customs inspection.

where $\phi > 1$ is the symmetric elasticity of substitution across goods. The corresponding consumption-based price index, P_t, is given by:

$$P_t = \left[\int_0^1 P_t(i)^{1-\phi} di\right]^{\frac{1}{1-\phi}} \tag{2}$$

Ricardian agents smooth their consumption, C_{at}, over time and thus maximize the life-time utility function $E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_{at})^{1-\gamma_c}}{1-\gamma_c}\right]$, where γ is the risk aversion parameter and β is the discount factor. Utility maximization is subject to the following budget constraint:

$$\begin{aligned} & A_{t+1} + S_t A^*_{t+1} + P_t \frac{\psi}{2}\left(\frac{A_{t+1}}{P_t}\right)^2 + S_t P^*_t \frac{\psi}{2}\left(\frac{A^*_{t+1}}{P^*_t}\right)^2 + (1+\tau^c_t) P_t C_{at} \\ = \; & (1+i^N_t) A_t + (1+i^{*N}_t) A^*_t S_t + P_t (T^A_t + T^i_t + T^f_t) \end{aligned}$$

Ricardian agents hold domestic assets A_t (denominated in domestic currency) on which they receive the nominal interest rate i^N_t and foreign assets A^*_{t+1} (denominated in foreign currency) on which they receive the interest rate i^{*N}_t. Assets are subject to quadratic adjustment costs, measured by the parameter ψ . These costs are paid to financial intermediaries whose only function is to collect these transaction fees and rebate the revenue to households in lump-sum fashion in equilibrium. Ricardian households pay a consumption tax τ^c_t on their consumption C^a_t. S_t is the nominal exchange rate. Moreover, T^A_t is a lump-sum rebate of costs of adjusting asset holdings from the intermediaries to which it is paid and T^i_t and T^f_t are a lump-sum rebate of profits from intermediate and final goods production.[7][8]

If we denote $\frac{A_{t+1}}{P_t} = a_{t+1}$ and $\frac{A^*_{t+1}}{P^*_t} = a^*_{t+1}$, we can re-write the budget constraint in real terms:

$$\begin{aligned} & a_{t+1} + Q_t a^*_{t+1} + \frac{\psi}{2}\left(a_{t+1}\right)^2 + Q_t \frac{\psi}{2}\left(a^*_{t+1}\right)^2 + (1+\tau^c_t) C_{at} \\ = \; & \frac{(1+i^N_t)}{1+\pi_t} a_t + \frac{(1+i^{*N}_t)}{1+\pi^*_t} Q_t a^*_t + T^A_t + T^i_t + T^f_t \end{aligned}$$

where π_t is the inflation rate and $1+\pi_t = \frac{P_t}{P_{t-1}}$. The term $Q_t = S_t P^*_t / P_t$ stands for the real exchange rate. If we define the domestic and foreign gross real interest rates as $1+i_t = \frac{(1+i^N_t)}{1+\pi_t}$ and $1+i^*_t = \frac{(1+i^{*N}_t)}{1+\pi^*_t}$, we can re-write the budget constraint as:

$$a_{t+1} + Q_t a^*_{t+1} + \frac{\psi}{2}\left(a_{t+1}\right)^2 + \frac{\psi}{2} Q_t \left(a^*_{t+1}\right)^2 + (1+\tau^c_t) C_{at} = (1+i_t) a_t + (1+i^*_t) a^*_t Q_t + T^A_t + T^i_t + T^f_t \tag{3}$$

[7] We assume that Ricardian households are firms' owners.

[8] The definition of this set of lump-sum rebate of costs and profits is the same as in Cacciatore and Ghironi (2015) and hence we refer to their paper for a complete derivation of these variables. The only difference in our model concerns the lump-sum rebate of profits from intermediate goods, which is defined as: $T^i_t = P_t \left(\phi_t Z_{Ft} l_{Ft} - \frac{w_{Ft}}{P_t} l_{Ft} - \frac{w_{It}}{P_t} l_{It} - \kappa_F V_{Ft} - \kappa_I V_{It}\right)$.

where i_t and i_t^* are respectively the real interest rates on domestic and foreign assets.

The Euler equations for domestic and foreign asset holding are respectively:

$$(1+\psi a_{t+1}) = (1+i_{t+1})\beta E_t \left(\frac{C_{at+1}^{-\gamma_c}}{C_{at}^{-\gamma_c}} \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \right) \tag{4}$$

$$(1+\psi a_{t+1}^*) = (1+i_{t+1}^*)\beta E_t \left(\frac{C_{at+1}^{-\gamma_c}}{C_{at}^{-\gamma_c}} \frac{Q_{t+1}}{Q_t} \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \right) \tag{5}$$

On the other hand, non-Ricardian households do not have access to financial markets and hence they can finance their consumption needs either though labor income (w_{Ft} if they supply labor to the formal sector and w_{It} if they supply labor to the informal sector) or through unemployment benefits (b_t) if they do not work.

The following equations define non-Ricardian agents' consumption depending on whether they work in the formal sector, or they work in the informal sector, or they are unemployed:

$$C_{Ft} = \frac{(1-\tau_t^w)}{(1+\tau_t^c)} w_{Ft} \; l_{Ft} \tag{6}$$

$$C_{It} = \frac{w_{It}}{(1+\tau_t^c)} l_{It} \tag{7}$$

$$C_{ut} = \frac{b_t}{(1+\tau_t^c)} (1-l_t) \tag{8}$$

The payroll tax on employees, τ_t^w, is borne only by non-Ricardian agents employed in the formal sector. Total labor supply, l_t, is the sum of labor supplied by non-Ricardian households in the formal and informal sectors, i.e. $l_t = l_{Ft} + l_{It}$. In equilibrium, aggregate unemployment is given by:

$$U_t = 1 - l_{Ft} - l_{It} \tag{9}$$

Total consumption C_t is defined as the weighted sum of consumption of Ricardian households (C_{at}) and non-Ricardian households working in the formal sector (C_{Ft}), in the informal sector (C_{It}) or unemployed (C_{ut}):

$$C_t = \omega C_{at} + (1-\omega)(C_{Ft} + C_{It} + C_{ut}) \tag{10}$$

where ω is the share of Ricardian households.

2.2 Production

There are two vertically integrated production sectors. In the upstream, in both the formal and the informal sector, intermediate goods are produced in perfect competition using only labor. Intermediate goods are then sold to final good producers. In the downstream, each sector i is populated by a representative monopolistically competitive multi-product firm, which uses intermediate goods as inputs to produce differentiated varieties. In equilibrium, some of these varieties are exported while others are sold only on the domestic market.

2.2.1 Intermediate goods

We assume a unit mass of intermediate good producers, which operate both in the formal and informal sectors. Both sectors are subject to search and matching frictions as in the Diamond-Mortensen-Pissarides framework. Unemployed agents search for a job in both sectors and search efforts are endogenous. Wages are set through an individual bargaining process.

We assume a constant-return-to-scale matching technology in each sector j, for $j = F, I$, where F and I refer respectively to the formal and the informal sector. The matching technology converts aggregate unemployed workers, U_t, and aggregate vacancies, V_t, into aggregate matches, M_t. The matching rate in each j sector is:

$$M_{jt} = \chi_j (e_{jt} U_t)^{1-\varepsilon} V_{jt}^{\varepsilon} \tag{11}$$

where U_t is the total number of unemployed workers and V_t is the number of vacancies. The parameters χ and ϵ measure respectively the matching efficiency and the matching function elasticity, with $\chi > 0$ and $0 < \epsilon < 1$. Let e_{jt} denote search efforts for the job type j when agents are unemployed.

The job filling rate, q_t, is:

$$q_{jt} = \frac{M_{jt}}{V_{jt}} = \chi_j \left(\frac{e_{jt} U_t}{V_{jt}} \right)^{1-\epsilon} \tag{12}$$

The job finding rate, ι is:

$$\iota_{jt} = \frac{M_{jt}}{U_t} = \chi_j \left(\frac{V_{jt}}{e_{jt} U_t} \right)^{\epsilon} e_{jt} \tag{13}$$

As in Krause and Lubik (2007), we assume that newly created matches become productive only in the next period. The law of motion of employment, l_{jt}, is:

$$l_{jt} = (1 - \lambda_j) l_{jt-1} + q_{jt-1} v_{jt-1} \tag{14}$$

where $\lambda_j \in (0, 1)$ is the exogenous separation rate and v_{jt} is the number of vacancies posted by the firm in period t. In equilibrium $v_{jt} = V_{jt}$.

Firms, both in the formal and informal sector, hire labor l_t to produce an intermediate good y_{jt} according to the following technology :

$$y_{jt}^{Int} = Z_{jt} l_{jt} \quad \forall \;\; j = F, I \tag{15}$$

where Z_{jt} is an exogenous technology term which follows an autoregressive process AR(1):

$$\log Z_{jt} = \phi^{Z1} \log Z_{jt-1} + \phi^{Z2} \log Z_{jt-1}^{*} + \epsilon_{jt}^{Z}. \tag{16}$$

In both sectors $j = F, I$, intermediate firms choose the number of vacancies, v_{jt}, and employment, l_{jt}, to maximize the discount value of their profits:

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{u_{C,t}}{u_{C,0}} \left(\varphi_t Z_{jt} l_{jt} - w_{jt} l_{jt} (1 + \tau_{jt}^f) - \kappa_j v_{jt} \right) \tag{17}$$

subject to the law of motion for labor: $l_{jt} = (1 - \lambda_j) l_{jt-1} + q_{jt-1} v_{jt-1}$, where φ_t is the real price at which intermediate goods producers sell their goods to final good producers and it is expressed in units of consumption[9]; w_{Ft} is the wage paid to workers in the formal sector (l_{Ft}), while w_{It} is the wage paid to workers in the informal sector (l_{It}). In both sectors, intermediate good producers incur a cost of κ_j units of consumption per vacancy posted v_{jt}. The term τ_{jt}^f represents a payroll tax on employers. These taxes are paid only by firms operating in the formal sector. Hence $\tau_{Ft}^f > 0$, whereas $\tau_{It}^f = 0$.

The first order conditions (hereafter, FOCs) on v_{jt} and l_{jt} in the formal and informal sector are respectively:

$$\frac{\kappa_j}{q_{jt}} = E_t \left[\beta_{t,t+1} \mu_{jt+1} \right] \tag{18}$$

$$\mu_{jt} = \varphi_{jt} Z_{jt} - w_{jt} (1 + \tau_{jt}^f) + E_t \left[\beta_{t,t+1} (1 - \lambda_j) \mu_{jt+1} \right] \tag{19}$$

where μ_{jt} is the Lagrangian multiplier for labor adjustment and measures the current value of an additional worker. Combining both FOCs leads to the job creation conditions in both sectors:

$$\frac{\kappa_F}{q_{Ft}} = E_t \left\{ \beta_{t,t+1} \left[(1 - \lambda_F) \frac{\kappa_F}{q_{Ft+1}} + \varphi_{t+1} Z_{Ft+1} - w_{Ft+1} (1 + \tau_{Ft+1}^f) \right] \right\} \tag{20}$$

$$\frac{\kappa_I}{q_{It}} = E_t \left\{ \beta_{t,t+1} \left[(1 - \lambda_I) \frac{\kappa_I}{q_{It+1}} + \varphi_{t+1} Z_{It+1} - w_{It+1} \right] \right\} \tag{21}$$

where $\beta_{t,t+1} \equiv \beta \frac{u_{C,t+1}}{u_{C,t}}$ is the one period ahead stochastic discount factor.

For both the formal and the informal sector, the job creation conditions state that, in equilibrium, the vacancy creation cost incurred by the firm per current match is equal to the expected discounted value of the vacancy creation cost per future match, further discounted by the probability of current match survival $1 - \lambda$, plus the profits from the match at time t. Profits from the match take into account the future marginal revenue product from the match and its wage cost.

Wages Nominal wages are set through an individual Nash bargaining process. In each t period and in both sectors $J = F, I$, the real value of an existing, productive match for a producer, J_t, is the sum of the marginal product of the match ($\varphi_t Z_{jt}$) and the expected discounted continuation value of the match ($E_t \beta_{t,t+1} (1 - \lambda_j) J_{jt+1}$), net of the wage bill:

$$J_{jt} = \varphi_t Z_{jt} - w_{jt} (1 + \tau_{jt}^f) + E_t \beta_{t,t+1} (1 - \lambda_j) J_{jt+1} \tag{22}$$

[9]Firms are owned by households and $u_{C,t}$ is the marginal utility of consumption. This ensures that first order conditions are measured in the same units.

The worker's value of being matched, in both the formal and informal sector, is given by the sum of real wage received and the expected discounted future value of being matched by the firm:

$$W_{jt} = \frac{(1-\tau_{jt}^{w})}{(1+\tau_t^{c})} w_{jt} + E_t\{\beta_{t,t+1}[(1-\lambda_j)W_{jt+1} + \lambda_j U_{u,t+1}]\} \tag{23}$$

The expected future value of being matched by the firm (the last term on the right-hand side of Eq.(23)) is a weighted average of probability $1-\lambda$ that the match will survive or the probability λ that the worker will become unemployed.

The value of being unemployed is defined as:

$$U_t = \frac{b_t}{(1+\tau_t^{c})} - \vartheta\frac{e_{Ft}^{1+\varrho}}{1+\varrho} - \vartheta\frac{e_{It}^{1+\varrho}}{1+\varrho} + E_t\{\beta_{t,t+1}[\iota_{Ft}W_{Ft+1} + \iota_{It}W_{It+1} + (1-\iota_{Ft}-\iota_{It})U_{u,t+1}]\} \tag{24}$$

where $\vartheta\frac{e_{jt}^{1+\varrho}}{1+\varrho}$ is a convex search cost and ϱ is the elasticity of disutility of searching. Therefore, the value of being unemployed is the sum of unemployment benefits[10] – net of search costs – and the expected discounted future value of future states, where ι_{Ft} and ι_{It} are the probability of becoming employed respectively in the formal or informal sector.

We define worker's surplus $H_{jt} \equiv W_{jt} - U_t$. The worker surplus in the formal and informal sector is given by:

$$H_{Ft} = \frac{(1-\tau_{jt}^{w})}{(1+\tau_t^{c})} w_{jt} - \left(\frac{b_t}{(1+\tau_t^{c})} - \vartheta\frac{e_{Ft}^{1+\varrho}}{1+\varrho} - \vartheta\frac{e_{It}^{1+\varrho}}{1+\varrho}\right) + (1-\lambda_F-\iota_{Ft}-\iota_{It})E_t(\beta_{t,t+1}H_{Ft+1}) \tag{25}$$

$$H_{It} = \frac{w_{It}}{(1+\tau_t^{c})} - \left(\frac{b_t}{(1+\tau_t^{c})} - \vartheta\frac{e_{Ft}^{1+\varrho}}{1+\varrho} - \vartheta\frac{e_{It}^{1+\varrho}}{1+\varrho}\right) + (1-\lambda_I-\iota_{Ft}-\iota_{It})E_t(\beta_{t,t+1}H_{It+1}) \tag{26}$$

Nash bargaining maximizes the joint surplus $J_{jt}^{\eta}H_{jt}^{1-\eta}$ with respect to w_{jt}, where H_{jt} and J_{jt} stand for surpluses respectively for workers and firms and the parameter η measures the bargaining power of firms. The FOC implies:

$$\eta H_{jt}\frac{\partial J_{jt}}{\partial w_{jt}} + (1-\eta)J_{jt}\frac{\partial H_{jt}}{\partial w_{jt}} = 0 \tag{27}$$

where $\frac{\partial J_{jt}}{\partial w_{jt}} = -(1+\tau_{jt}^{f})$ and $\frac{\partial H_{jt}}{\partial w_{jt}} = \frac{1-\tau_{jt}^{w}}{1+\tau_t^{c}}$. Hence, the sharing rule can be rewritten in the following form:

$$(1+\tau_{jt}^{f})\eta H_{jt} = \frac{1-\tau_{jt}^{w}}{1+\tau_t^{c}}(1-\eta)J_{jt} \tag{28}$$

[10]We assume that the informal sector does not allow the worker to be eligible for the unemployment benefits. Given that we have a representative unemployed worker, we set an average unemployment benefits, $b_t = l_{Ft}/(l_{Ft}+l_{It})bW_{Ft}$, where the parameter b is the replacement rate and measures benefit generosity by comparing unemployment benefits received when not working to wages earned when employed.

The bargained wage satisfies the following condition, respectively in the formal and informal sector:

$$w_{Ft} = \frac{\eta}{1-\tau^w_{Ft}}\left[\frac{b_t}{(1+\tau^c_t)} - \vartheta\frac{e^{1+\varrho}_{Ft}}{1+\varrho} - \vartheta\frac{e^{1+\varrho}_{It}}{1+\varrho}\right] + \frac{1-\eta}{1+\tau^f_{Ft}}\left\{\varphi_t Z_{Ft} + E_t\left[\beta_{t,t+1}J_{Ft+1}\left((1-\lambda_F) - (1-\lambda_F-\iota_{Ft})\frac{1+\tau^f_{Ft}}{1+\tau^f_{Ft+1}}\frac{1-\tau^w_{Ft+1}}{1-\tau^w_{Ft}}\right)\right]\right\} \tag{29}$$

$$w_{It} = \eta\left[\frac{b_t}{(1+\tau^c_t)} - \vartheta\frac{e^{1+\varrho}_{Ft}}{1+\varrho} - \vartheta\frac{e^{1+\varrho}_{It}}{1+\varrho}\right] + (1-\eta)\left[\varphi_t Z_{It} + \iota_{It}E_t\left(\beta_{t,t+1}J_{It+1}\right)\right] \tag{30}$$

Wages are a linear combination – determined by the bargaining power parameter η – of worker's outside option and the marginal revenue product generated by the worker plus the expected discounted continuation value of the match to the firm. For high values of η, the bargaining power of firms is higher and the portion of the net marginal revenue product and continuation value to the firm appropriated by workers as wage payments is smaller, hence the outside option becomes more relevant.

Optimal search intensities are given by $\partial U_t/\partial e_{jt} = 0$, which yields:

$$\vartheta e^{\varrho}_{jt} = \frac{\partial \iota_{jt}}{\partial e_{jt}}E_t(\beta_{t,t+1}H_{jt+1}) \tag{31}$$

$$\vartheta e^{\varrho}_{Ft} = \left(\frac{1-\eta}{\eta}\right)\chi_F\left(\frac{V_{Ft}}{e_{Ft}U_t}\right)^{\epsilon}\left(\frac{1-\tau^w_{t+1}}{(1+\tau^f_{t+1})(1+\tau^c_{t+1})}\right)\frac{\kappa_F}{q_{Ft}} \tag{32}$$

$$\vartheta e^{\varrho}_{It} = \left(\frac{1-\eta}{\eta}\right)\chi_I\left(\frac{V_{It}}{e_{It}U_t}\right)^{\epsilon}\left(\frac{1}{1+\tau^c_{t+1}}\right)\frac{\kappa_I}{q_{It}} \tag{33}$$

This set of equations shows that search efforts are increasing in market tightness (V_{jt}/U_{jt}) and decreasing in taxes. We define the tax wedge as $TW_{Ft} = \frac{1-\tau^w_{t+1}}{(1+\tau^f_{t+1})(1+\tau^c_{t+1})}$ in the formal sector and $TW_{It} = \left(\frac{1}{1+\tau^c_{t+1}}\right)$ in the informal sector. Equations above show that the higher the tax wedge, the lower the search effort. However, the tax wedge is not symmetrical between sectors and hence the incentive to search for an informal job are reduced only by an increase in the consumption tax, τ^c_t, but they are not affected by changes in payroll taxes, τ^f_t and τ^w_t.

2.2.2 Final goods

In this subsection variables denoted by the letter d refer to a country's own goods consumed or produced domestically, whereas x refers to quantities and prices of exports.

Producer i is a multi-product firm that produces a set of differentiated product varieties, indexed by ω, $y(\omega, i)$, which is defined over a continuum Ω:

$$Y_t(i) = \left(\int_{\omega\in\Omega}^{\infty} y_t(\omega,i)^{\frac{\theta-1}{\theta}}d\omega\right)^{\frac{\theta}{\theta-1}} \tag{34}$$

where $\theta > 1$ is the symmetric elasticity of substitution across varieties. To save notation, from now on, we omit the index i, since consumption-producing sectors are symmetric in the economy.

We define P_t^y, the cost of the product bundle Y_t:

$$P_t^y = \left(\int_{\omega \in \Omega}^{\infty} p_t^y(\omega)^{1-\theta} d\omega \right)^{\frac{1}{1-\theta}} \tag{35}$$

where $p_t^y(\omega)$ is the nominal marginal cost of producing variety ω.

To create a new variety ω, each retailer needs to create a new plant, facing a sunk investment, $f_{e,t}$, denominated in units of intermediate input. Each plant produces using different technologies indexed by relative productivity $z(\omega)$, which is drawn from a common distribution $G(z)$ with support on $[z_{min}, \infty)$. For the sake of simplicity, from now on we omit ω. This relative productivity level remains fixed thereafter. Productivity level of foreign plants are drawn from an identical distribution. Each plant uses intermediate inputs to produce its differentiated product variety, facing the real marginal cost:

$$\varphi_{z,t} \equiv \frac{p_t^y(z)}{P_T} = \frac{\varphi_t}{z} \tag{36}$$

The number of products created and commercialized by each retailer is endogenous. At each point in time, only a subset of varieties $\Omega_t \subset \Omega$ is actually available to consumers. Therefore, at time t, each Home retailer commercializes $N_{d,t}$ varieties and creates $N_{e,t}$ new products that will be available for sale at time $t+1$. New and incumbent plants can be hit by a "death" shock with probability $\delta \in (0,1)$ at the end of each period. The law of motion for the stock of producing plants is:

$$N_{d,t+1} = (1-\delta)(N_{d,t} + N_{e,t}) \tag{37}$$

where δ is the firm's exit rate. When serving the foreign market, each retailer faces per-unit iceberg trade costs, $\tau_t > 1$, as well as fixed export costs, $f_{x,t}$ paid for each exported product and denominated in units of intermediate input. We define total fixed costs $\bar{f}_{x,t} = f_{x,t} N_{x,t}$, where $N_{x,t}$ denotes the number of product varieties exported abroad. If fixed export costs are absent ($\bar{f}_{x,t} = 0$), each producer would find it optimal to sell all its product varieties both domestically and abroad. Fixed export costs imply that only varieties produced by plants with sufficiently high productivity (above a cutoff level $z_{x,t}$, determined below) are exportable.

We define two special "average" productivity levels (weighted by relative output shares): an average $\widetilde{z}_d$ for all producing plants and an average $\widetilde{z}_{x,t}$ for all exporting plants:

$$\widetilde{z}_d = \left(\int_{z_{min}}^{\infty} z^{\theta-1} dG(z) \right)^{\frac{1}{\theta-1}} \qquad \widetilde{z}_{x,t} = \left[\frac{1}{1-G(z_{x,t})} \right] \left(\int_{z_{x,t}}^{\infty} z^{\theta-1} dG(z) \right)^{\frac{1}{\theta-1}}$$

We assume that $G(\cdot)$ is Pareto with shape parameter $k_p > \theta - 1$.[11] As a result, $\widetilde{z}_d = \kappa^{\frac{1}{\theta-1}} z_{min}$ and $\widetilde{z}_{x,t} = \kappa^{\frac{1}{\theta-1}} z_{x,t}$, where $\kappa = k_p/[k_p - (\theta - 1)]$. The share of exporting plants is given by:

$$N_{x,t} = [1 - G(z_{x,t})]N_{d,t} = \left(\frac{z_{min}}{\widetilde{z}_{x,t}}\right)^{-k_p} \kappa^{\frac{k_p}{\theta-1}} N_{d,t} \tag{38}$$

The real costs of producing the bundles $Y_{d,t}$ and $Y_{x,t}$ are respectively:

$$\frac{P^y_{d,t}}{P_t} = N_{d,t}^{\frac{1}{1-\theta}} \frac{\varphi_t}{\widetilde{z}_d}, \qquad \frac{P^y_{x,t}}{P_t} = N_{x,t}^{\frac{1}{1-\theta}} \frac{\varphi_t}{\widetilde{z}_{x,t}} \tag{39}$$

The final producer determines $N_{d,t+1}$ and the productivity cutoff $z_{x,t}$ to minimize the present discount value of costs:

$$\sum_{s=t}^{\infty} \beta_{t,s} \left[\frac{P^y_{d,s}}{P_s} Y_{d,s} + \tau_s \frac{P^y_{x,s}}{P_s} Y_{x,s} + \left(\frac{N_{s+1}}{1-\delta} - N_s \right) f_{e,s} \varphi_s + N_{x,s} f_{x,s} \varphi_s \right] \tag{40}$$

subject to (38), (39), and $\widetilde{z}_{x,t} = \kappa^{\frac{1}{\theta-1}} z_{x,t}$.

The FOC with respect to $z_{x,t}$ yields:

$$\tau_t \frac{P^y_{x,t}}{P_t} \frac{Y_{x,t}}{N_{x,t}} = \frac{(\theta - 1)k_p}{k_p - (\theta - 1)} f_{x,t} \varphi_t \tag{41}$$

In equilibrium, the marginal revenue from adding a variety with productivity $z_{x,t}$ to the export bundle has to be equal to the fixed cost. Thus, varieties produced by plants with productivity below $z_{x,t}$ are distributed only in the domestic market. The composition of the traded bundle is endogenous and the set of exported products fluctuates over time with changes in the profitability of export.

The FOC with respect to $N_{d,t+1}$ determines product creation:

$$\varphi_t f_{e,t} = (1-\delta)\beta_{t,t+1} \left[\begin{array}{l} \varphi_{t+1} \left(f_{e,t+1} - \frac{N_{x,t+1}}{N_{d,t+1}} f_{x,t+1} \right) \\ + \frac{1}{\theta-1} \left(\frac{P^y_{d,t+1}}{P_{t+1}} \frac{Y_{d,t+1}}{N_{d,t+1}} + \tau_{t+1} \frac{P^y_{x,t+1}}{P_{t+1}} \frac{Y_{x,t+1}}{N_{x,t+1}} \frac{N_{x,t+1}}{N_{d,t+1}} \right) \end{array} \right] \tag{42}$$

In equilibrium, the cost of producing an additional variety, $\varphi_t f_{e,t}$, must be equal to its expected benefit, which includes expected savings on future sunk investment costs augmented by the marginal revenue from commercializing the variety, net of fixed export costs, if it is exported.

[11] Hence, $G(x) = \left(\frac{z}{z_{min}}\right)^{-k_p}$.

Domestic and export prices Let $P_{d,t}$ and $P_{x,t}$ be the price of the product bundle $Y_{d,t}$ and $Y_{x,t}$. Each final producer faces the following domestic and foreign demand for its product bundles:

$$Y_{d,t} = \left(\frac{P_{d,t}}{P_t}\right)^{-\phi} Y_t^C, \qquad Y_{x,t} = \left(\frac{P_{x,t}}{P_t^*}\right)^{-\phi} Y_t^{C*} \tag{43}$$

where Y_t^C and Y_t^{C*} stand for aggregate demands of the consumption basket in the domestic and foreign country. The elasticity of substitution across sectoral bundles for the aggregate demand, $\phi > 1$, is equal to the elasticity of substitution for the consumption basket, although aggregate demand in each country includes sources other than consumption. This assumption ensures that the consumption price index for the the consumption aggregator is also the price index for aggregate demand of the basket.

We assume producer currency pricing (PCP): final producers set the price of the product bundle, $P_{d,t}$, and the the price of the export bundle, $P_{x,t}^h$, in their own domestic currency, letting the price in the foreign market move with the nominal exchange rate, that is: $P_{x,t} = \tau P_{x,t}^h / S_t$. Because of fixed export costs, the composition of domestic and export bundles is different, and hence producers face different marginal costs of producing these bundles. Therefore final producers set two different prices for the Home and Foreign markets. The optimal price for domestic sales and exported sales satisfies respectively:

$$\frac{P_{d,t}}{P_t} = \frac{\phi}{\phi - 1}\frac{P_{d,t}^y}{P_t}, \qquad \frac{P_{x,t}^h}{P_t} = \frac{\tau_t}{Q_t}\frac{\phi}{\phi - 1}\frac{P_{x,t}^y}{P_t} \tag{44}$$

where $Q_t = S_t P_t^* / P_t$ is the real exchange rate.

We define the average price of a domestic variety, $\tilde{\rho}_{d,t} \equiv N_{d,t}^{\frac{1}{\theta-1}}(P_{d,t}/P_t)$ and the average price of an exported variety, $\tilde{\rho}_{x,t} \equiv N_{x,t}^{\frac{1}{\theta-1}}(P_{x,t}/P_t^*)$. Combining the equations (39) and (44), we obtain the average price of a domestic and an exported variety, respectively defined as:

$$\tilde{\rho}_{d,t} = \frac{\phi}{\phi - 1}\frac{\varphi_t}{\tilde{z}_d}, \qquad \tilde{\rho}_{x,t} = \frac{\phi}{\phi - 1}\frac{\tau_t}{Q_t}\frac{\varphi_t}{\tilde{z}_{x,t}} \tag{45}$$

Finally, the average output of, respectively, a domestic and exported variety are defined as:

$$\tilde{y}_{d,t} = \tilde{\rho}_{d,t}^{-\phi} N_{d,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^C, \qquad \tilde{y}_{x,t} = \tilde{\rho}_{x,t}^{-\phi} N_{x,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^{C*} \tag{46}$$

2.3 Government

In each period, we assume that government spending and unemployment benefits are funded by taxation on consumption and wage income:

$$G_t = \tau_t^c \left[\omega C_{at} + (1-\omega)(C_{Ft} + C_{It} + C_{ut})\right] + (\tau_t^w + \tau_t^f) w_{Ft} l_{Ft} - b_t U_t \tag{47}$$

2.4 Closing conditions

Aggregate demand is the sum of private and public consumption and is defined as:

$$Y_t^C = \omega C_{at} + (1-\omega)(C_{Ft} + C_{It} + C_{ut}) + \kappa_F V_{Ft} + \kappa_I V_{It} + G_t \tag{48}$$

We assume that the cost of opening new vacancies are socially shared.

Assets are in zero net supply, which implies the equilibrium condition:

$$a_{t+1} + a_{t+1}^* = 0 \tag{49}$$

Net foreign assets are determined by:

$$(a_{t+1} - a_t) + Q_t(a_{t+1}^* - a_t^*) = i_t a_t + Q_t i_t^* a_t^* + \left(Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N_{x,t}^* \tilde{\rho}_{x,t}^* \tilde{y}_{x,t}^*\right) \tag{50}$$

where the last term in brackets represents the trade balance: $TB_t = Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N_{x,t}^* \tilde{\rho}_{x,t}^* \tilde{y}_{x,t}^*$.

3 Calibration

We calibrate the model using quarterly data from the U.S. and Brazilian economies. We believe that Brazil is an illustrative example of an emerging country which, starting form high level of informality in the late 1990s, has adopted a set of policy initiatives to facilitate the move to formality.[12] A first program, called SIMPLES, was launched in 1996 and was followed by a second one, the SUPERSIMPLES program, in 2006. Since, in Brazil there is a strong correlation between size of company and prevalence of informality, these programs aimed at reducing the costs of formalization through a simplification and a reduction of tax rates and tax regulations for Brazilian micro firms with no more than five paid employees.[13] Since the SUPERSIMPLES came into force in July 2007, some 9 million businesses have joined this system of taxation and the formal rate has increased by 11 percentage points (see Fajnzylber et al. (2011)).[14]

In this section we discuss the calibration strategy. Broadly speaking, we choose some parameter values from the literature, while other parameters are set so to match macroeconomic series observed for the United States and Brazil. We assume that the two countries are asymmetric, hence some parameters describing labor and goods markets may differ across countries. Table 1 summarizes the asymmetric calibration.

[12] See ILO (2014) for a discussion and an evaluation of other programs launched in emerging countries to move to formalization.

[13] The SIMPLES program combined six different federal taxes and social contributions into a single monthly-based rate. The two reforms also reduced the tax burden considerably.

[14] While Fajnzylber et al. (2011) find very large effects of the SIMPLES program on formality rates, Monteiro and Assunção (2012) find positive and significant effects on formalization rates only among firms in the retailer sector. For a reconciliation of these two studies, see Piza (2016).

We set the discount factor β at 0.99, implying that the annual real interest rate is 4 percent. The value of the risk aversion parameter, γ_c, is equal to 2. Following Bernard et al. (2003), we set the elasticity of substitution across product varieties, θ, equal to 3.8. Following Ghironi and Melitz (2005), we set the elasticity of substitution across Home and Foreign goods, ϕ, equal to θ, and the dispersion of firm productivity k_p equal to 3.4. We normalize z_{min} to 1. We set iceberg trade costs τ equal to 1.7, following the estimates of trade costs reported by Anderson and van Wincoop (2004). We calibrate the fixed export costs f_x so that the shares of exporting plants in the developed and emerging country are respectively equal to 21 percent and 18 percent, consistently with data reported in Bernard et al. (2003) for the United States and in the World Bank Enterprise Survey for Brazil.[15] To ensure steady-state determinacy stationarity of net foreign assets, we set the parameter ψ measuring asset adjustment costs equal to 0.0025 as in Ghironi and Melitz (2005). Following Ebell and Haefke (2009), we set entry costs, f_e, so that regulation costs amount to 5.2 months of per capita output. To pin down the firm exit rate δ, we target the portion of worker separation due to firm exit equal to 30 percent in the United States and to 37 percent in Brazil: these values fall within the range of estimates reported by Haltiwanger et al. (2008). Empirical evidence indicates that informal firms are less productive than formal ones. We normalize the productivity parameter in the informal sector to unity and we assume that the productivity in the formal sector is 30 percent higher than in the informal sector.[16]

Regarding the parameters specific to the search and matching framework, the gross replacement rate for unemployment benefits b in the formal sector is set to 13 percent for the United States and 15.2 percent for Brazil. The parameter measuring firms' bargaining power, η, is equal to 0.4, as estimated by Flinn (2006). The elasticity of the matching function ε is equal to 0.4, so that it falls within the range of estimates reported by Petrongolo and Pissarides (2006) and the Hosios condition holds. We set the costs of vacancy posting (κ_F and κ_I), matching efficiency (χ_F and χ_I) and exogenous separation rate (λ_F and λ_I) in the formal and informal sectors so to match the underlying structure of the two countries, with the values of steady-state ratios summarized in Table 1. We choose a calibration based on the long-run averages (1992-2017) from ILO data. Steady-state unemployment rates are respectively 6 percent and 8.7 percent in the United States and Brazil, while the ratio of informal employment to total employment is respectively 7 percent and 30 percent in the United States and Brazil.[17] This calibration yields an informal wage gap (i.e. difference between wages for formal and informal workers) equal to 66 percent in the United States and 11 percent in Brazil. This latter value is very close to estimates in Bargain and Kwenda (2010, 2014) who conclude that earning differentials driven by the informal wage penalties are quite modest in Brazil and remain below 10 percent all along the distribution. Labor market regulations and high employer costs attached to formal employment in Brazil may simultaneously explain the large extent of informal work and the relatively modest informal

[15] As a *caveat*, we point out that the World Bank Enterprise Survey covers only firms of the formal private sector with five or more employees. Hence informal and micro firms are excluded from the sample.

[16] This assumption allows us to reproduce a wage premium equal to 30 percent as in Charlot et al. (2015).

[17] We use vulnerable employment as a proxy for informal employment.

wage gap. Firms tend to recoup high employers' payroll taxes paid to hire formal workers, which could partly explain low informal wage gaps. In Brazil informal wage penalties may only partly be related to the firm size effect, since many informal workers are to be found in large formal firms.

Finally, we set the initial value of tax rates at their respective steady-state levels. The United States employs a retail sales tax rather than a value added tax (VAT) as the principal consumption tax. The retail sales tax in the United States is not a federal, but it is a tax imposed at the state and local government levels. The total tax rate ranges between 0 percent (e.g. in Delaware, Oregon, New Hampshire, Montana) and 13.5 percent (in Alabama). We decide to set τ^c for the United States at the average rate, 7.8 percent. Brazil operates a multiple rate system with ICMS (Imposto de Circulação de Mercadorias e Serviços) tax levied at the state level. The standard state rate of ICMS is 17 percent (18 percent in São Paulo, Minas Gerais and Paraná and 19 percent in Rio de Janeiro). Therefore, for Brazil we set τ^c equal to 17 percent. The personal income tax rate ranges between 0 percent and 37 percent in the United States and between 0 percent and 27.5 percent in Brazil. We choose the average value of the personal income tax rate and we set τ^w equal to 18 percent for the United States and 14 percent for Brazil. In the United States, the social security tax rate is 12.4 percent (6.2 percent on employees and 6.2 percent on employers). On top, there is a tax of 2.9 percent (half imposed on employer and half withheld from the employee's pay) of all wages for Medicare. In Brazil, the employer's contribution is determined at the rate of approximately 20 percent of salary to be paid to the National Institute of Social Security (Instituto Nacional do Seguro Nacional, INSS). On top, the FGTS is the Fundo de Garantia por Tempo de Serviço which is the Employee Indemnity Guarantee Fund and an employee compulsory fund. All Companies are obligated to deposit the FGTS contribution into their employers account. The tax corresponds to an 8 percent rate on top of the gross salary. Since in our model we consider only the share of payroll taxes paid by employers, we set the steady-state payroll tax rate, τ^f equal to 7.65 percent for the US and 28 percent for Brazil.

Table 1: Calibration

Targets and parameters	Notation	Developed	Emerging	Source
Calibration targets				
Formal employment	$l_F/(l_F+l_I)$	93%	70%	ILO, Trends Econometric Models
Informal employment	$l_I/(l_F+l_I)$	7%	30%	ILO, Trends Econometric Models
Unemployment rate	U	6%	8.7%	ILO, Trends Econometric Models
Share of exporting firms	N_x/N_d	21%	18%	World Bank and Bernard et al. (2003)
Final good Market				
Sunk entry costs	f_e	0.4	0.4	Ebell and Haefke (2009)
Fixed export costs	f_x	0.0062	0.0090	Calibration targets
Iceberg trade costs	τ	1.7	1.7	Anderson and van Wincoop (2004)
Pareto shape	κ_p	3.4	3.4	Ghironi and Melitz (2005)
Plant exit	δ	0.026	0.026	Haltiwanger et al. (2008)
Elasticity of substitution	$\theta=\phi$	3.8	3.8	Bernard et al. (2003)
Taxation				
Consumption tax	τ^c	7.8%	17%	
Income tax	τ^w	18%	14%	
Payroll tax	τ^f	7.65%	28%	
Labor market				
Bargaining power	η	0.4	0.4	Flinn (2006)
Matching function elasticity	ε	0.4	0.4	Petrongolo and Pissarides (2006)
Vacancy costs, formal	κ_F	2.5	2.5	Calibration targets
Vacancy costs, informal	κ_I	1.5	1.5	Calibration targets
Matching efficiency, formal	χ_F	0.30	0.28	Calibration targets
Matching efficiency, informal	χ_I	0.35	0.38	Calibration targets
Separation rate, formal	λ_F	0.032	0.055	Calibration targets
Separation rate, informal	λ_I	0.27	0.15	
Disutility of search, scale	ϑ	2	2	
Disutility of search, elasticity	ϱ	1.3	1.3	
Unemployment benefits, formal	b	13	15.2	Aleksynska and Schindler (2011)
Other parameters				
Risk aversion	γ_c	2	2	
Discount factor	β	0.99	0.99	
Bond adjustment cost	ψ	0.0025	0.0025	Ghironi and Melitz (2005)

4 The impact of trade liberalization

In this section we introduce a trade shock which simulates the effects of trade liberalization.[18] Since trade liberalization has often been blamed to be biased toward informality and to favor skilled/high-income workers, we believe that a trade shock is suitable to illustrate the possible role of taxation in supporting labor formalization and achieving higher equality.[19]

The conventional view posits that trade liberalization causes an expansion of labor informality. However, the mechanism through which trade affects workers in the presence of informality is not clear. Intuitively, on the one side trade liberalization induces lower-productivity formal firms to switch to the informal sector to remain profitable. The incidence of informality will increase accordingly. On the other side, trade liberalization induces lower-productivity informal firms to exit the market and hence the incidence of informality will decrease. The net effect on informality remains ambiguous. According to Bacchetta et al. (2009), trade expansion has not led to a corresponding improvement in working conditions and living standards for many. In many developing economies job creation has mainly taken place in the informal economy. The empirical literature provides mixed evidence on the effects of trade liberalization on informality, most likely because these effects are country- and/or industry-specific. Therefore, the relationship between trade liberalization and informality strictly depends on the data underlying the empirical analysis. Some papers find little or no effect of trade liberalization on informality (e.g. Goldberg and Pavcnik (2003), Menezes-Filho and Muendler (2011), Bosch et al. (2012)), whereas some others find significant effects of trade liberalization on informality. According to some studies trade reduces informal employment. Among these, Aleman-Castilla (2006) finds that a decline in US tariffs reduces informality in Mexico especially in export-oriented sectors. Currie and Harrison (1997) reach similar conclusions for government-owned firms in Morocco. Conversely, some other studies reach opposite conclusions and state that trade liberalization is associated with an increase in the share of informal workers (e.g. Ponczek and Ulyssea (2015) for Brazil and Acosta and Montes-Rojas (2014) for manufacturing firms in Argentina). Finally, some studies provide mixed evidence. Among these, Fugazza and Fiess (2010) show that macro-founded data tend to support the conventional view according to which trade liberalization causes a rise in informality, while micro-founded data do not. Using Brazilian data, Paz (2014) finds that while a cut in trading partner import tariffs decreases the share of domestic informal employment, a cut in domestic import tariffs has the opposite effect.

Concerning the distributional effects of trade liberalization, the empirical literature provides mixed evidence. On the one side, trade liberalization is deemed to have boosted the demand of skilled workers and hence triggered an increase in the relative wage of skilled

[18] We acknowledge that the calibrated parameters already reflect the effects of past liberalization in Brazil. By introducing a trade shock, we simulate the effects of possible further opening of the economy.

[19] We consider a deterministic (perfect foresight), permanent reduction of policy parameters. Given the large size of the shocks, transition dynamics from the initial equilibrium to the final equilibrium are found by solving the model as a nonlinear forward looking deterministic system using a Newton method. This method solves simultaneously all equations for each period.

to unskilled workers, the so called skill premium. As a consequence, income inequality has widened (see Epifani and Gancia (2006), Matsuyama (2007), Verhoogen (2008), Goldberg and Pavcinik (2007) and the literature mentioned herein). On the other side, other studies find that trade liberalization reduces the skill premium and hence inequality especially in middle and low-income countries (see McCaig (2011) for Vietnam, Zhang and Wan (2006) for China, Amiti and Cameron (2012) for Indonesia, Robertson (2005) for Mexico, Gonzaga et al. (2006) for Brazil, Kumar and Mishra (2008) for India).

In our set-up, trade liberalization is captured by a reduction in fixed export costs in both countries and it is modeled in the following way: in a first phase, the "Home" country, which is the developed country (i.e. the United States), cuts its per-unit iceberg trade costs (i.e. τ_t decreases from 1.7 to 1.5). This process starts at the beginning of the simulation period and ends 70 quarters later (i.e. 17.5 years later). The cut in iceberg trade costs gives a competitive advantage to the developed country. In a second phase, which starts 5 years later (i.e. 20 quarters later), the emerging country (i.e. Brazil) experiments the same decline in its own iceberg costs. Hence, 22.5 years after the initial reduction of trade costs observed in the developed country, iceberg costs in the emerging country will have converged to those observed in the developed country. At this third phase, the two countries benefit from the same reduction in trade costs and trade liberalization becomes symmetrical. For the sake of clarity, we first analyze the dynamics in the developed country and then in the emerging country.

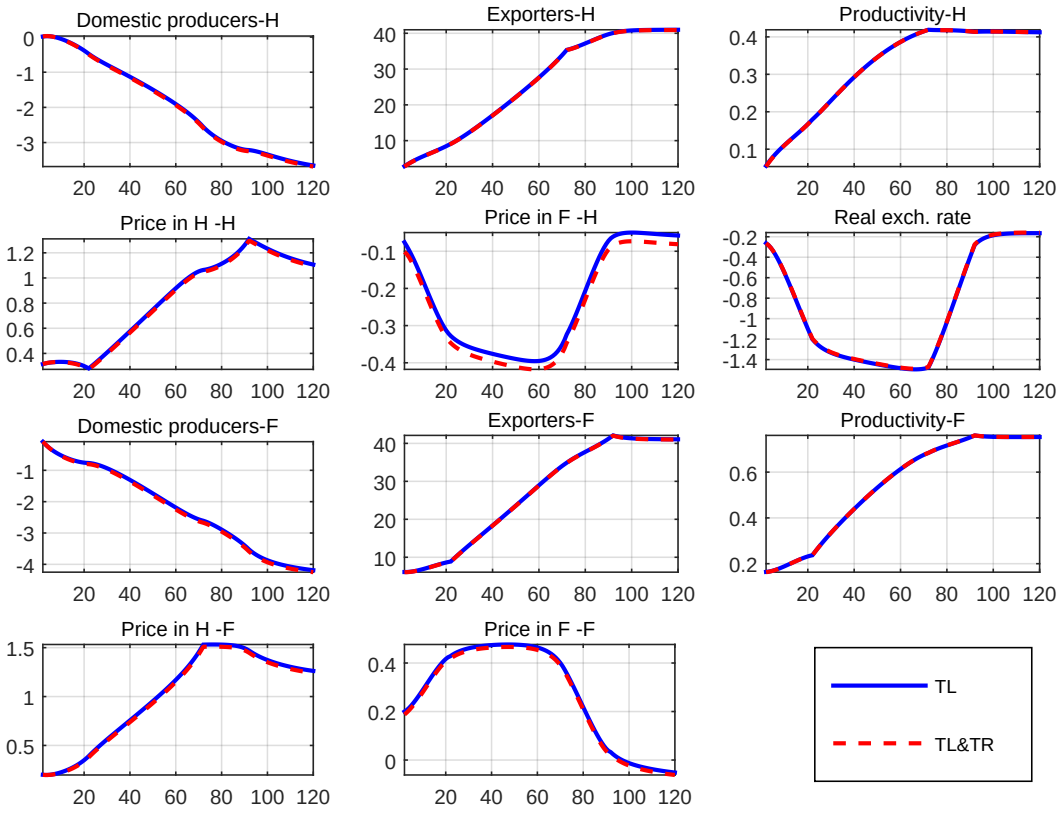
We discuss the dynamics both in the short term, i.e. before than the emerging country benefits from trade liberalization, and in the medium to long term, i.e. when both countries can take advantage for the trade cost reductions. Simulations for the good sector and prices are displayed in Figure 1, while for the labor market are displayed in Figure 2 and Figure 3. Responses to the trade shock are represented by the blue solid lines.

The impact on the goods sector. In the first phase of trade liberalization, the developed country cuts its trade costs, but the emerging country still does not benefit from new technologies allowing it to reduce its trade costs. In this phase, lower trade costs in the developed country allow exporters to have higher profits. Trade translates into increased profitable opportunities for exporting firms, which induces more firms to enter the export market. These firms face lower costs and hence increase their labor demand, which ultimately leads to higher real wage. Higher production costs, in turn, brings down the profits of the least productive firms and hence, at a second stage, firm entry is reduced. Notice that lower-productivity firms do not export and produce only for the domestic market. Hence, as it is shown in the Figure 1, the number of firms producing only for the domestic market in the developed country declines, but at the same time the number of exporters in this country increase (the export-cutoff decreases).

A higher proportion of exporting firms in the developed country leads to higher average quality of goods and higher productivity, as indicated also in other studies (e.g. Aleman-Castilla (2006)).

In the short run, the emerging economy does not observe a decline of trade costs. In-

Figure 1: The final good sector



Note: H and F indicate respectively the "Home" country (i.e. the developed country) which is represented by a solid line and the "Foreign" country (i.e. the emerging country) which is represented by a dotted line. The blue lines display the dynamics with only trade liberalization, and the red lines display the dynamics when the tax reform is implemented.

stead, higher home prices in the developed country, combined with the decrease in the real exchange rate, lead consumers in the developed country to redirect their demand toward their trade partner (i.e. the emerging economy). This increase in demand addressed to emerging economy motivates more exporting firms in the emerging country. This, in turn, leads to a rise in input demand, and thus to a rise in the production costs (see Figure 1). As a consequence, input demand and production costs increase, which ultimately reduce profits for low-productive domestic firms. As a consequence, the number of new firm entries: the number of firms (N_f = "Domestic producers - F") declines in the emerging country.

In the medium run, trade liberalization also affects the emerging country, where iceberg costs also decline, although with a delay. Hence, higher firms' profits worldwide boost income and labor demand leading to higher wages. The increase in labor costs leads both economies to be more selective: the number of firms declines, but the share of exporting firms, which are more productive, increases.

In the emerging economy, in the medium run, trade liberalization ultimately induces more firms to export, thereby increasing labor demand and real wages. As in the developed economy, this leads to high share of exporters and informality in emerging economy.

In the long run, when the developed country has reached its long-run level of iceberg costs, in the emerging country trade expansion is still ongoing. In the emerging country, revenue growth is now driven by iceberg cost reduction which takes place only in the emerging country and still generates growth gains. Growth gains, in this phase, are obviously more modest than during the first phase of trade expansion.

The impact on prices and exchange rate. In the developed country, at each period, domestic market prices ($\rho_{d,t}$ in the model notation and "Price in H - H" in the figures) and export prices ($\rho_{x,t}$ in the model notation and "Price in F - H" in the figures) are given by the following equations:

$$\begin{aligned} \rho_{d,t} &= \frac{\phi}{\phi-1}\frac{\varphi_t}{\widetilde{z}_d} \\ \rho_{x,t} &= \frac{\tau_t}{Q_t}\frac{\phi}{\phi-1}\frac{\varphi_t}{\widetilde{z}_{x,t}} \end{aligned}$$

Hence, the increase in input prices, φ_t, generated by the expansion in final good producers' demand explains the rise in domestic market prices $\rho_{d,t}$. On the other hand, export prices $\rho_{x,t}$ drops as trade liberalization, through the decline in trade costs τ_t, compensates the increase in input prices as well as the decline in productivity ($\widetilde{z}_{x,t}$) of export firms. Finally, lower iceberg costs in the developed country leads to a decline in the real exchange rate (Q_t) underlining the gains in competitiveness of this country.

In the emerging country, at each period, the price of domestic goods ($\rho^*_{d,t}$ and "Price in H - F" in the figures) and the price of exported goods ($\rho^*_{x,t}$ and "Price in F - F" in the figures)

are modeled as in the developed economy, in a symmetric way:

$$\begin{aligned}\rho^*_{d,t} &= \frac{\phi}{\phi-1}\frac{\varphi^*_t}{\widetilde{z^*}_d} \\ \rho^*_{x,t} &= \tau_t Q_t \frac{\phi}{\phi-1}\frac{\varphi^*_t}{\widetilde{z^*}_{x,t}}\end{aligned}$$

It is clear that the rise of input price causes the rise in the domestic price (ρ^*_d). The increase of the input price (φ^*) as well as the decline of productivity of exporters ($\widetilde{z}^*_x$) raises the export price, even though the real exchange rate (Q_t) declines.

In the medium run, the larger participation of the emerging country to the world trade stabilizes export prices in the developed country: the real exchange rate is more stable and the bias cost in favor of the developed country slows down (see Figure 1).

In the long run, when the developed country has reached its long-run level of iceberg costs, in the emerging country trade expansion is still ongoing. Therefore, the emerging country still benefits from decreasing iceberg costs. Hence, its competitiveness is restored and the real exchange rate increases (see Figure 1).

The impact on the labor market. In the developed country, higher input prices for final producers translate into higher marginal revenues for the intermediate good producers, and ultimately into higher wages. Figure 2 shows that labor demand increases in both the formal and the informal sector, driven by the increase in the price of intermediate goods sold to final producers. A part of this increase in the job surplus is redistributed to workers via wage increases. Figure 2 shows that wages increase in both the formal and the informal sector. Given that these wage increases are driven by the rise in the price of intermediate goods in both sectors, they are similar across the formal and the informal sector and thus wage inequalities remain stable (see Figure 4 in Appendix B).

Although employment increases in both sectors, in the informal sector the increase is relatively larger, due to lower labor costs, which ensures that more job vacancies are opened in the informal sector. Indeed, expanded job creation in the informal sector encourages unemployed agents to search for a job more intensively in this sector, thus reinforcing the sector's advantage in the hiring process (see Figure 3). Therefore, at the beginning of the process trade liberalization induces higher informality in the developed country, along with a reduction in unemployment (see Figure 3).

Tightness in labor market increases in the emerging country, although for reasons different from those observed in the developed country, and consequently employment and wage rise. As in the developed country, lower labor costs in the informal sector favor this sector during the expansion (see Figure 2). Moreover, unemployment declines, while the share of informality goes up (see Figure 3). Note that the rise in informality is of small amplitude in the emerging economy. This is due to the initial share of informal employment. As the emerging economy has a larger share of informality, it causes a more negative "congestion" effect: the job filling rate falls more rapidly with vacancy postings. Hence, this curbs job openings in the informal sector.

In the medium run, the increasing participation of both countries in the world trade, by increasing incomes and thus the demand for goods, boosts labor demand (see Figure 2) and reduces unemployment (see Figure 3).

In the long run, when trade costs drop only in the emerging country, income growth generated by new exports is marginal: employment gains become smaller and smaller in both countries (i.e. developed and emerging) and both sectors (i.e. formal and informal). When iceberg costs converge to their long-term levels in both countries, variables converge towards the new steady-state levels. This phase is characterized by an over-adjustment, which is the result of vacancy-posting strategies adopted by firms (see Figure 2). As long as profit opportunities grow, there are strong incentives to post vacancies to benefit from growth. This competition leads firms to over-hiring. Once growth falters, employment starts decreasing through the exogenous rate of destruction and the slowdown in new job opportunities. This process takes time and explains why, after the strong employment gains recorded during the period of trade expansion, both countries enter a phase characterized by a contraction on the labor market. Since the separation rate is higher in the informal sector than in the formal sector, the decline in employment is faster in the informal sector, which explains the rise in the share of formal employment in this phase of the long-term adjustment.

To sum up, we observe that following a decline in trade costs wages increase in both the formal and the informal sector without changing the wage gap. Lower trade costs, although not harmful to equity, are biased toward labor informality.

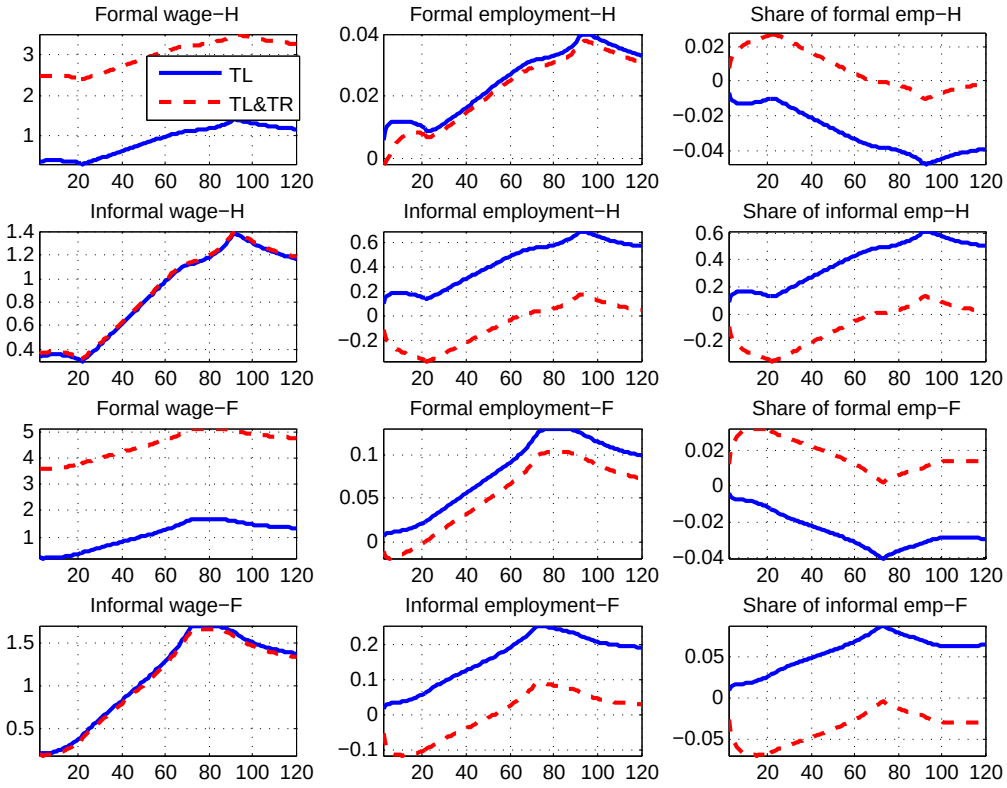
5 Tax reform

In order to reduce the increasing incidence of informality induced by trade liberalization, both countries should introduce incentives to develop businesses in the formal economy. An easy way to promote formal employment is to reduce the payroll tax paid by firms operating in the formal sector. Nevertheless, the cost of this policy is a reduction of public revenues which the government may use to finance public expenditures on social security. An alternative solution might be implementing a "budget-neutral" tax reform, consisting in increasing the consumption tax to fund the cut in payroll taxes. An advantage of this strategy is that the consumption tax has a larger base, it is easier to collect and more difficult to evade. This policy mix, called "social VAT", has been implemented in many European countries, for instance in Denmark in 1988, in Sweden in 1993, in Germany in 2006 and in France in 2012.

In the rest of the paper, the tax reform is implemented in both countries at the beginning of their respective trade liberalization process. The tax reform is country-specific and budget-neutral. Given these constraints, the payroll tax is reduced from 8.0 percent to 5.8 percent with an increase in the consumption tax from 8 percent to 9.8 percent in the developed countries, whereas in the emerging country, the payroll tax is reduced from 28.0 percent to 24.0 percent with an increase in the consumption tax from 17.0 percent to 18.8 percent.

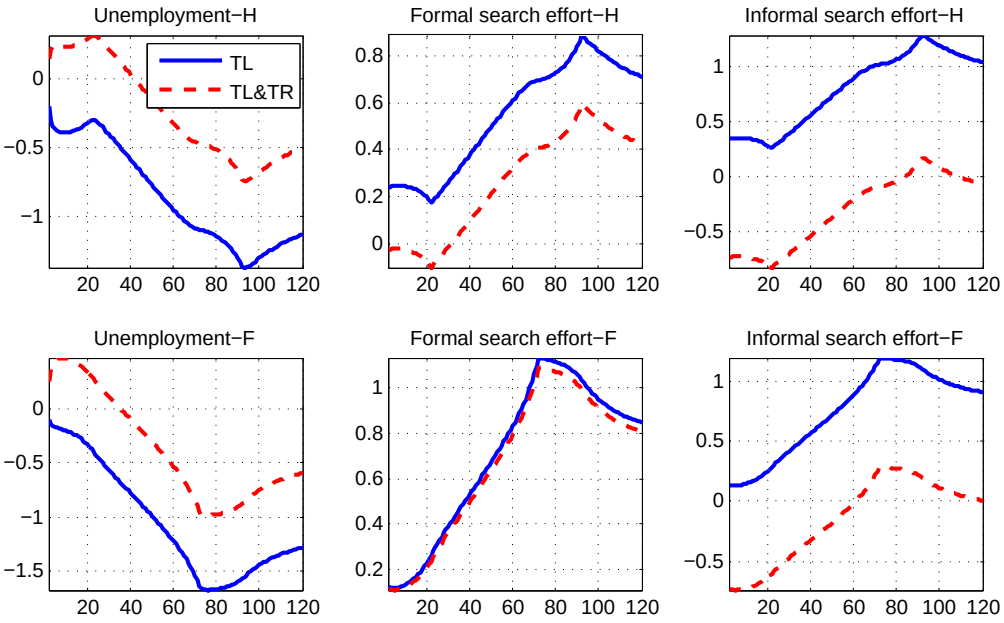
Simulations for the goods sector are displayed in Figure 1, while for the labor market

Figure 2: The labor market



Note: H and F indicate respectively the "Home" country (i.e. the developed country) and the "Foreign" country (i.e. the emerging country). The blue lines display the dynamics with only trade liberalization, and the red lines display the dynamics when the tax reform is implemented.

Figure 3: Unemployment



Note: H and F indicate respectively the "Home" country (i.e. the developed country) and the "Foreign" country (i.e. the emerging country). The blue lines display the dynamics with only trade liberalization, and the red lines display the dynamics when the tax reform is implemented.

they are displayed in Figure 2 and Figure 3. The scenario simulating the effects of the tax reform when the two countries are hit by a trade shock is represented by the red dotted lines.

The impact on the final good sector. Figure 1 depicts the effects of trade liberalization in the final good sector when the government implements a budget-neutral tax reform. Taxation has no direct impact on the behavior of final goods producers. The comparison with the pre-reform scenario (represented by the blue solid lines in Figure 1) points out that the dynamics of variables in the final good sector remain unchanged because the main driver of both short-run and long-run changes in productivity and prices is trade liberalization. The tax reform only affects the distribution of jobs, across the formal and informal sector leaving the aggregate demand of intermediate goods unchanged.[20] This is due to the ambiguous effect of a budget-neutral tax reform on the tax wedge: on the one hand, it reduces the tax wedge by lowering the taxes paid by the employers, on the other hand it increases it by increasing the tax on consumption.

The impact on labor markets. Figure 2 reports the effects of trade liberalization on labor markets when the government implements a budget-neutral tax reform. Recall that wages in both sectors are determined by the following equations:

$$\begin{aligned} w_{Ft} &= \frac{\eta}{1-\tau_{F0}^{w}}\left(\frac{b}{(1+\tau_1^c)}-\vartheta\frac{e_{Ft}^{1+\varrho}}{1+\varrho}-\vartheta\frac{e_{It}^{1+\varrho}}{1+\varrho}\right)+\frac{1-\eta}{1+\tau_{F1}^{f}}\left(\varphi_t Z_{Ft}+\kappa_F\frac{\iota_F}{q_{Ft}}\right) \\ w_{It} &= \eta\left(\frac{b}{(1+\tau_1^c)}-\vartheta\frac{e_{Ft}^{1+\varrho}}{1+\varrho}-\vartheta\frac{e_{It}^{1+\varrho}}{1+\varrho}\right)+(1-\eta)\left(\varphi_t Z_{It}+\kappa_I\frac{\iota_{It}}{q_{It}}\right) \end{aligned}$$

where τ_{F0}^{w} is the tax paid by employees before the reform (indexed by 0). This tax rate remains unchanged, while the payroll tax paid by employers and the consumption tax jump instantaneously to their new post-reform values (respectively τ_{F1}^{f} and τ_1^c).

As observed for the baseline simulation without the tax reform (Figure 2, blue solid lines), wages increase in both sectors. However, when the tax reform is implemented, the increase in wages is more remarkable in the formal sector than in informal sector (Figure 2, red dotted lines). As a consequence, the wage gap between formal and informal workers is getting wider. Figure 4 shows that, before the tax reform, the wage gap between the formal and the informal sector was 65.7 percent in the advanced economy and 10.6 percent in the emerging country (see blue solid lines). After the reform, this gap rises to 69.2 percent in the advanced economy and to 14.4 percent in the emerging country (see red dotted lines). Widening wage gaps across the two sectors stem from the reduction of tax wedges, leading to a larger job surplus and thus higher wages. The tax reform also changes the sharing rule between firms and workers, at the advantage of the workers. The underlying mechanism is due to two channels: on the one hand, the drop in the tax paid by employers increases

[20] To be more precise, changes in tax rates alter the equilibrium level of the production of intermediate goods. However, these changes have a second-order magnitude.

the share of productivity paid to employees in the formal sector. On the other hand, the increase in the consumption tax reduces the disposable wage. However, this moderation is proportional to the weight of the unemployment benefits in the wage: as it is weak for workers in the formal sector, this wage moderation induced by the increase of the consumption tax is of small amplitude for the formal sector. The first channel clearly dominates and leads to wage increases in the formal sector after the tax reform.

Given that the search effort is endogenous, the tax reform also changes workers' reservation wage. Indeed, the cut in payroll taxes stimulates firms to open new vacancies in the formal sector, which in turn increases the chance for unemployed agents to find a job in the formal sector. The optimistic job prospect in the formal sector encourages unemployed to focus their search efforts more on this sector. Hence, search efforts increase in the formal sector and decline in the informal sector (see Figure 3, red dotted lines). Overall, the tax reform ultimately redirects the labor force toward formal employment.[21]

Figure 3 shows that, following the tax reform, unemployment increases on impact and in the short-run. The underlying reason is that benefits from trade liberalization are gradual, while the tax reform is immediate: given the lack of attractiveness of the informal sector, search efforts – devoted to find a job in the informal sector before the implementation of the tax reform – now decrease, leading to an increase of unemployment in the short run (see Figure 3, red dotted lines). At the beginning of the trade liberalization process, the marginal value of intermediate goods and workers' productivity, although higher, are not large enough to absorb the excess of unemployed workers who stop searching for an informal job. This explains why unemployment increases on impact and in the short-term especially in the emerging country, which is characterized by higher incidence of informality.

To sum up, we observe that a tax reform switching the tax burden from payroll taxes to the VAT supports labor formality. Overall, output and economic efficiency improve as the share of formality increases by 1 percentage point. However, as shown in Figure 4, these gains in formalization come at the cost of widening inequality between formal and informal workers. Our model estimates that the wage gap will rise from 65.7 to 69.2 percent in the advanced economy and from 10.6 to 14.4 percent in the emerging economy. Widening inequality may be attributed to the specific design of this tax reform, since the VAT has traditionally deemed to be regressive and hence harmful to equity. However, more recently some commentators and especially international organizations have pointed out that the VAT is not necessarily bad for redistribution. For instance, the distributional consequences of a tax reform switching the tax burden on the VAT have to be assessed in the perspective of the whole tax-spending system, of which the VAT is just one part (OECD (2010)). The VAT can still be progressive, if VAT revenues are used to finance benefits targeted for poorer households. Notwithstanding these caveats, the empirical evidence (albeit limited) for a few

[21]Similar conclusions are drawn in Antón (2014) who analyzes the effects of the 2012 tax reform in Colombia. He suggests that the reform would increase total employment by between 0.3 to 0.5 percent and formal employment by between 3.4 to 3.7 percent over the pre-reform scenario. In Brazil, tax cuts for small firms introduced by the reforms in 1996 and 2006 have led more than 9 millions of businesses into the formal sector.

developing countries finds that the VAT is not necessarily regressive. Empirical evidence from Bangladesh based on household income expenditure survey data finds that the VAT may have progressive elements (Faridy and Sarker (2011)). Therefore, as pointed out by the International Tax Dialogue (2013), the incidence of this regressivity is very country specific and generalizations can be misleading. Moreover, Ciminelli et al. (2019) find that the labor market response does matter to assess the redistributive effects of the VAT. The VAT can reduce income inequality by triggering a positive labor supply channel. Higher indirect taxes increase the price of the consumption basket and create incentives for agents to increase their labor supply. This effect tends to be stronger for middle-aged women.

6 Conclusions

In this paper, we show that trade liberalization boosts economic activity in both developed and emerging countries. However, we find that trade liberalization is associated to higher informality, which ultimately implies less job security and lower employment quality.

Policy makers should consider placing a high priority on promoting job quality and income equality. Policy interventions to curb informality should follow a comprehensive approach that rests on three pillars: increasing the benefits of formality, decreasing the costs of formalization and improving enforcement methods. In this respect, we investigate whether taxation may smooth the way for formalization of jobs. To this purpose, we extend the Melitz (2003) model and develop a two-country DSGE model, featuring a developed and emerging (or developing) country as in Cacciatore and Ghironi (2015). In addition, we embed the tax system and the informal labor sector in the model with the aim to analyze whether taxation may correct the bias toward informality introduced by trade liberalization. We argue that a fiscal reform can mitigate these adverse effects of trade on the labor market. A "Social VAT", switching the tax burden from payroll taxes paid by firms in the formal sector to the consumption tax, can increase the incentives to operate in the formal sector. Overall, output and economic efficiency improve as the share of formality increases by 1 percentage point. However, these (small) gains in formalization come at the cost of widening inequality between formal and informal workers. Our model estimates that the wage gap will rise from 65.7 to 69.2 percent in the advanced economy and from 10.6 to 14.4 percent in the emerging economy.

Our results suggest that (budget-neutral) tax reforms might play only a minor role in improving formalization rates in emerging countries. To reduce the incidence of informality, tax policy interventions should go hand in hand with other more effective spending and regulatory policies. Extending unemployment benefits to all workers in the formal sector including those working part-time and/or on temporary contracts, could prevent the unemployed from looking for an informal job. Another step to enhance the quality of existing jobs is intensifying labor inspections in those sector where the incidence of informal work is higher.

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A Dynare equations

To solve the model, we use the Dynare software (see Adjemian et al. (2011)). After solving the steady state of the model, we use the following equation set in order to obtain the equilibrium paths.

- The equilibrium price index

$$1 = \tilde{\rho}_{d,t}^{1-\theta} N_{d,t}^{\frac{1-\phi}{1-\theta}} + \tilde{\rho}_{x,t}^{*1-\theta} N_{x,t}^{*\frac{1-\phi}{1-\theta}}$$

- Average export productivity

$$\tilde{\rho}_{x,t}^{-\theta} N_{x,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^{C*} = \frac{\theta-1}{k_p-(\theta-1)} \frac{\tilde{z}_{x,t}}{\tau_t} f_{x,t}$$

- Labor market clearing

$$Z_F l_{Ft} + Z_I l_{It} = N_{d,t} \frac{\tilde{y}_{d,t}}{\tilde{z}_d} + N_{x,t} \frac{\tilde{y}_{x,t}}{\tilde{z}_{x,t}} \tau_t + N_{e,t} f_{e,t} + N_{x,t} f_{x,t}$$

- Law of motion of employment

$$l_{jt} = (1-\lambda_j) l_{jt-1} + q_{jt-1} V_{jt-1}$$

- New variety (product) creation

$$1 = (1-\delta)\beta E_t \left[\frac{C_{t+1}^{-\gamma_c}}{C_t^{-\gamma_c}} \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \frac{\tilde{\rho}_{d,t+1}}{\tilde{\rho}_{d,t}} \left(\begin{array}{l} \frac{f_{e,t+1}}{f_{e,t}} - \frac{N_{x,t+1}}{N_{d,t+1}} \frac{f_{x,t+1}}{f_{e,t}} \\ + \frac{1}{(\theta-1) f_{e,t}} \left(\frac{\tilde{y}_{d,t+1}}{\tilde{z}_d} + \frac{N_{x,t+1}}{N_{d,t+1}} \frac{\tau_{t+1}}{\tilde{z}_{x,t+1}} \tilde{y}_{x,t+1} \right) \end{array} \right) \right]$$

- Job creation

$$1 = \beta E_t \left\{ \frac{C_{t+1}^{-\gamma_c}}{C_t^{-\gamma_c}} \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \left[(1-\lambda_j) \frac{q_{jt}}{q_{jt+1}} + \frac{q_{jt}}{\kappa_j} \left(\varphi_{t+1} Z_{jt+1} - w_{jt+1}(1+\tau_{jt+1}^f) \right) \right] \right\}$$

- Wage determination

$$\begin{aligned} w_{Ft} &= \frac{\eta}{1-\tau_{Ft}^w} \left(\frac{b}{(1+\tau_t^c)} - \vartheta \frac{e_{Ft}^{1+\varrho}}{1+\varrho} - \vartheta \frac{e_{It}^{1+\varrho}}{1+\varrho} \right) \\ &\quad + \frac{1-\eta}{1+\tau_{Ft}^f} \left(\varphi_t Z_{Ft} + + \frac{\kappa_F}{q_{Ft}} \left[(1-\lambda_F) - (1-\lambda_F-\iota_{Ft}) \frac{1+\tau_{Ft}^f}{1+\tau_{Ft+1}^f} \frac{1-\tau_{Ft+1}^w}{1-\tau_{Ft}^w} \right] \right) \\ w_{It} &= \eta \left(\frac{b}{(1+\tau_t^c)} - \vartheta \frac{e_{Ft}^{1+\varrho}}{1+\varrho} - \vartheta \frac{e_{It}^{1+\varrho}}{1+\varrho} \right) + (1-\eta) \left(\varphi_t Z_{It} + \kappa_I \frac{\iota_{It}}{q_{It}} \right) \end{aligned}$$

- Search intensity

$$\begin{aligned} \vartheta e_{Ft}^{\varrho} &= \left(\frac{1-\eta}{\eta}\right)\chi_F\left(\frac{V_{Ft}}{e_{Ft}U_t}\right)^{\epsilon}\left(\frac{1-\tau_{t+1}^{w}}{(1+\tau_{t+1}^{f})(1+\tau_{t+1}^{c})}\right)\frac{\kappa_F}{q_{Ft}} \\ \vartheta e_{It}^{\varrho} &= \left(\frac{1-\eta}{\eta}\right)\chi_I\left(\frac{V_{It}}{e_{It}U_t}\right)^{\epsilon}\left(\frac{1}{1+\tau_{t+1}^{c}}\right)\frac{\kappa_I}{q_{It}} \end{aligned}$$

- Euler equation for domestic bond holding

$$(1+\psi a_{t+1}) = (1+i_{t+1})\beta E_t\left(\frac{C_{at+1}^{-\gamma_c}}{C_{at}^{-\gamma_c}}\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\right)$$

- Euler equation for foreign bond holding

$$(1+\psi a_{t+1}^{*}) = (1+i_{t+1}^{*})\beta E_t\left(\frac{C_{at+1}^{-\gamma_c}}{C_{at}^{-\gamma_c}}\frac{Q_{t+1}}{Q_t}\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\right)$$

- Bond market clearing

$$a_{t+1} + a_{t+1}^{*} = 0$$

- Net foreign assets

$$(a_{t+1}-a_t) + Q_t(a_{t+1}^{*}-a_t^{*}) = i_t a_t + Q_t i_t^{*} a_t^{*} + Q_t N_{x,t}\tilde{\rho}_{x,t}\tilde{y}_{x,t} - N_{x,t}^{*}\tilde{\rho}_{x,t}^{*}\tilde{y}_{x,t}^{*}$$

- Law of motion for the stock of producing plants

$$N_{d,t+1} = (1-\delta)(N_{d,t}+N_{e,t})$$

- Share of exporting plants

$$N_{x,t} = \left(\frac{z_{\min}}{\tilde{z}_{x,t}}\right)^{k_p}\alpha^{\frac{k_p}{\theta-1}}N_{d,t}$$

- Export productivity cutoff

$$\tilde{z}_{x,t} = \alpha^{\frac{1}{\theta-1}}z_{x,t}$$

- Average price of a domestic variety

$$\tilde{\rho}_{d,t} = \frac{\phi}{\phi-1}\frac{\varphi_t}{\tilde{z}_d}$$

- Average price of an exported variety

$$\tilde{\rho}_{x,t} = \frac{\phi}{\phi-1}\frac{\tau_t}{Q_t}\frac{\varphi_t}{\tilde{z}_{x,t}}$$

- Average output of a domestic variety

$$\tilde{y}_{d,t} = \tilde{\rho}_{d,t}^{-\phi} N_{d,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^C$$

- Average output of an exported variety

$$\tilde{y}_{x,t} = \tilde{\rho}_{x,t}^{-\phi} N_{x,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^{C*}$$

- Aggregate demand

$$Y_t^C = \omega C_{at} + (1-\omega)(C_{Ft} + C_{It} + C_{ut}) + \kappa_F V_{Ft} + \kappa_I V_{It} + G_t$$

- Formal workers' consumption

$$C_{Ft} = w_{Ft} \;\; l_{Ft} \;\; \frac{1-\tau_t^w}{1+\tau_t^c}$$

- Unemployed agents' consumption

$$C_{ut} = \frac{b_t(1-l_t)}{1+\tau_t^c}$$

- Informal workers' consumption

$$C_{It} = w_{It} \;\; \frac{l_{It}}{1+\tau_t^c}$$

- Total consumption

$$C_t = \omega C_{at} + (1-\omega)(C_{Ft} + C_{It} + C_{ut})$$

- Unemployment

$$U_t = 1 - l_{Ft} - l_{It}$$

- Job filling rate

$$q_{jt} = \chi_j \left(\frac{e_{jt} U_t}{V_{jt}} \right)^{1-\varepsilon}$$

- Job finding rate

$$\iota_{jt} = \chi_j \left(\frac{V_{jt}}{e_{jt} U_t} \right)^{\varepsilon} e_{jt}$$

- Productivity shock

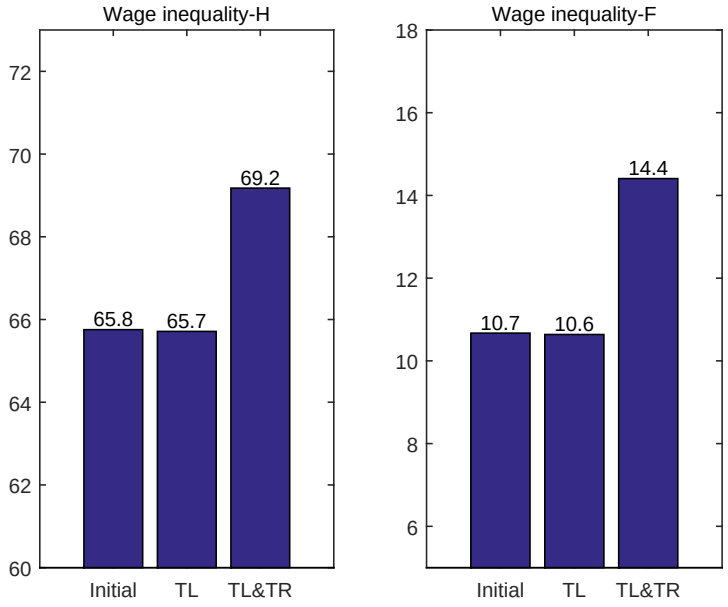
$$\log Z_{jt} = \phi^{Z1} \log Z_{jt-1} + \phi^{Z2} \log Z_{jt-1}^* + \epsilon_{jt}^Z$$

- Government spending

$$G_t = \tau_t^c [\omega C_{at} + (1-\omega)(C_{Ft} + C_{It} + C_{ut})] + (\tau_t^w + \tau_t^f) \;\; w_{Ft} \;\; l_{Ft} - b_t U_t$$

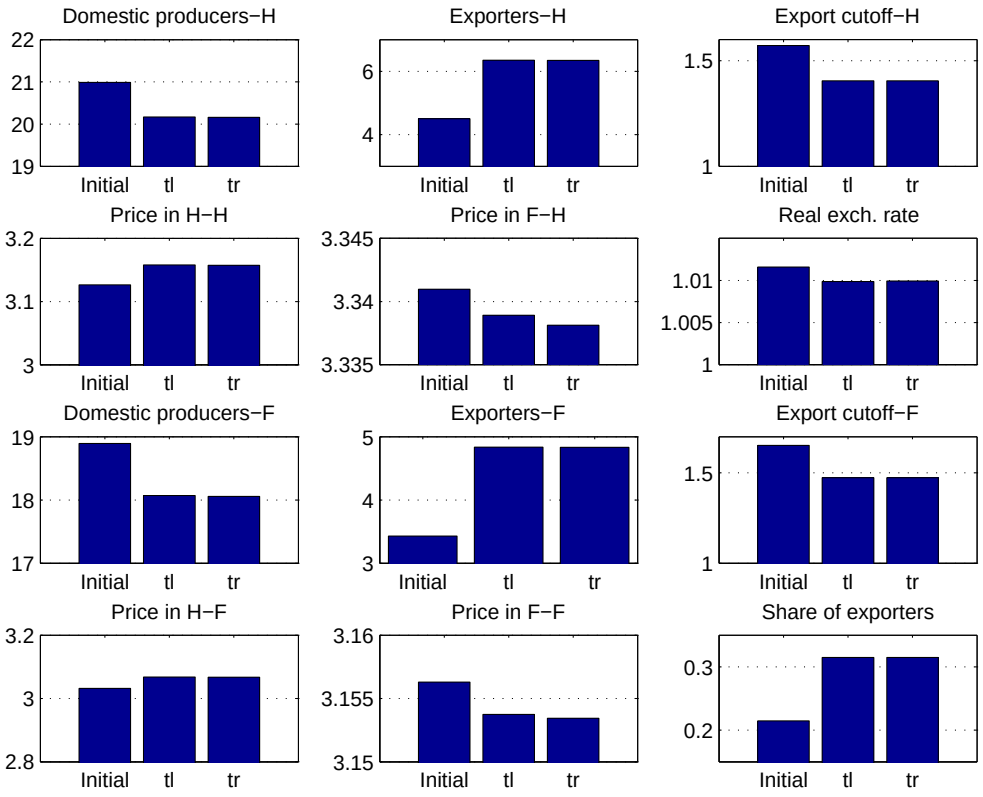
B Steady states

Figure 4: Wage inequality



Note: H and F indicate respectively the "Home" country (i.e. the developed country) and the "Foreign" country (i.e. the emerging country). Wage inequality is defined by $w_{Ft}/w_{It} - 1$.

Figure 5: Goods markets



Note: H and F indicate respectively the "Home" country (i.e. the developed country) and the "Foreign" country (i.e. the emerging country).

Figure 6: Labor markets

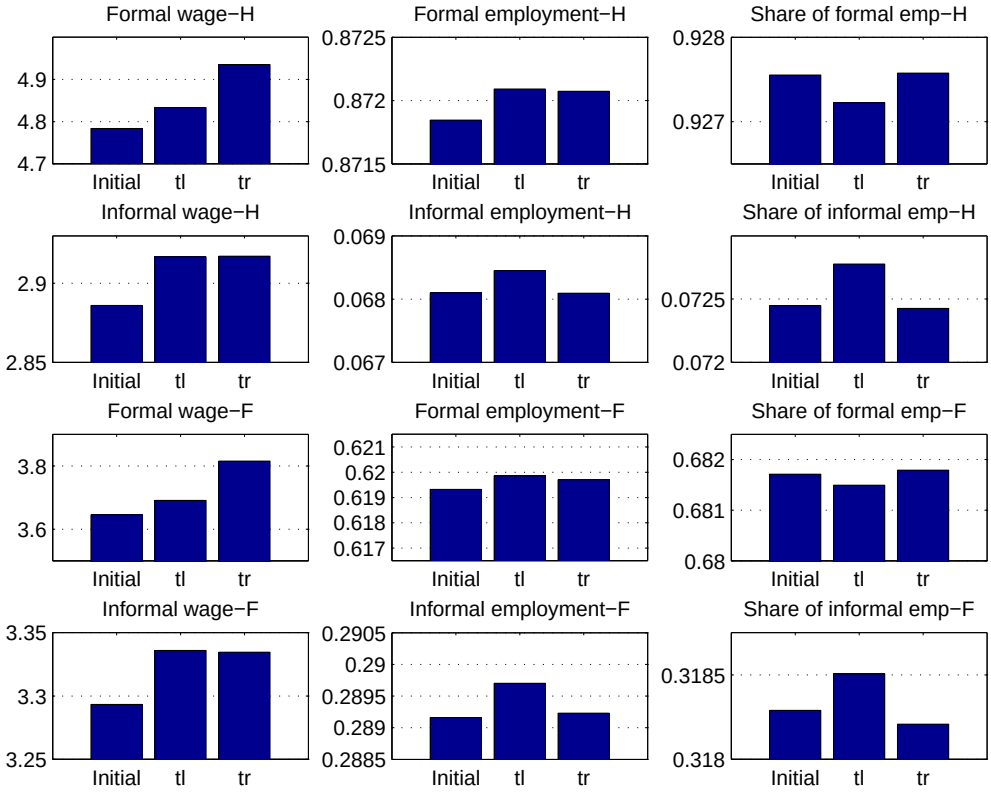
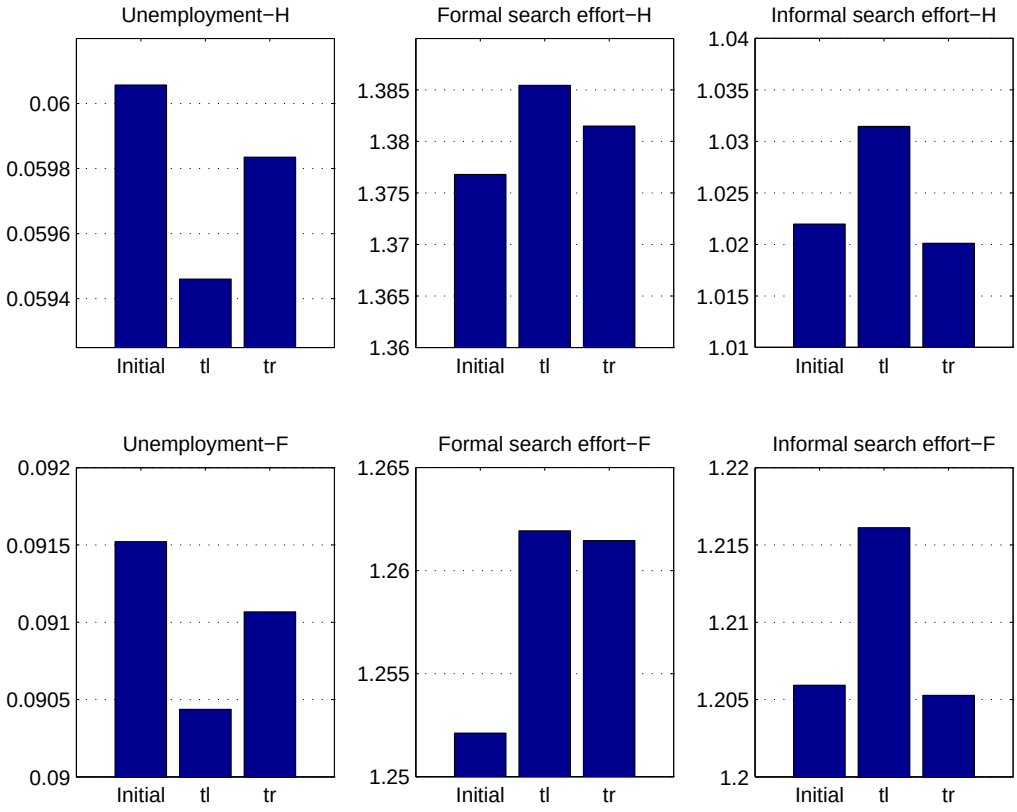


Figure 7: Unemployment



Note: H and F indicate respectively the "Home" country (i.e. the developed country) and the "Foreign" country (i.e. the emerging country).