

# Value-Added Exports and U.S. Local Labor Markets: Does China Really Matter?\*

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## Abstract

In this paper, our main focus is the direct contribution of the Chinese economy to changes in U.S. labor market outcomes. Our results indicate that the effects of continuously rising value-added exports from China to the U.S. depend on the position of the Chinese exporting industry in the global value chain. In particular, we find that an increase in U.S. exposure to value-added exports from China in industries with high degree of downstreamness leads to negative effects on the share of manufacturing employment, while the same is not present in the case of industries with low degree of downstreamness. Moreover, our results also suggest that the effects of an increase in U.S. exposure to value-added exports from China on average wages and on unemployment levels depends on the position of the Chinese industry in the global value chain.

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*“What we call “Made in China” is indeed assembled in China, but what makes up the commercial value of the product comes from the numerous countries that preceded its assembly in China in the global value chain, from its design to the manufacture of the different components and the organization of the logistical support to the chain as a whole”*

Pascal Lamy, former WTO director

## 1 Introduction

The world media have dedicated significant attention to China’s return to the post of world’s largest manufacturing producer by the end of 2010, a position last occupied by the country in the first half of the 19<sup>th</sup> century.<sup>1</sup> This fact marks the phenomenal transition of the Chinese economy from a centrally planned economy by the end of the 1970s to a global trading partner, inclusive of its WTO membership accession process, during the first decade of the 2000s. The shift in the world manufacturing base towards China has been a source of jubilation and, at the same time, of apprehension among policy makers and scholars.<sup>2</sup> One of the most contentious issues has been the effects of economic growth in China on the U.S. economy. This is particularly important as China’s astonishing economic growth over the last decades coincides with a contraction in manufacturing employment in the U.S. economy and with the formation of a burgeoning trade deficit with the same economy of about \$273 billion in 2010.<sup>3</sup>

These facts have not been ignored by the economic literature. In an influential paper, Autor, Dorn and Hanson (ADH, 2013) conclude that the growing exposure of the U.S. economy to Chinese gross exports has had a negative effect on manufacturing and non-manufacturing employment levels, as well as on wages, across U.S. local labor markets (commuting zones). Their results suggest that increasing exposure to Chinese competition can explain 26 percent<sup>4</sup> of the decline in U.S. manufacturing employment for the years 2000 to 2007. The

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<sup>1</sup>For example, the British newspaper *Financial Times* published material related to this issue in “<http://www.ft.com/cms/s/0/002fd8f0-4d96-11e0-85e4-00144feab49a.html>”

<sup>2</sup>World Bank (2006) summarizes the opportunities and potential challenges faced by Latin American economies due to China’s emergence as an economic power.

<sup>3</sup>Information provided by the U.S. census bureau. The importance of the U.S. trade deficit with China can be gauged by the fact that it represents a substantial fraction of the \$500 billion trade deficit of the U.S. economy in that year.

<sup>4</sup>Moreover, ADH (2013) find that the increase in U.S. exposure to Chinese gross exports explains 21 percent of the decline in the share of manufacturing employment between the years 1990 and 2007.

literature has also shown that labor market effects of growing exposure to trade with China depends on the position of the exporting industry in the global value chain. For instance, Pierce and Schott (2016) find that the U.S. decision to grant normal trade relation status to China on a permanent basis (i.e., extending the most favored nation status to China) has generated negative effects on manufacturing employment, which they show was more intense in industries with greater degrees of downstreamness. Similarly, Acemoglu et al. (2016) show empirical evidence that an increase in industry-level exposure to competition from China can explain 10 percent of the decrease in manufacturing employment levels across U.S. industries. However, this effect can be magnified by 75 percent with the inclusion of the effects of import competition on a particular industry’s sellers, i.e., the effects of trade-related competition enlarges by considering the degree of downstreamness of a particular industry.<sup>5</sup>

However, the direct contribution of China to U.S. labor market outcomes has to be gauged with caution. This is particularly important as the world economy has become more integrated and access to imported materials and technologies has never been more important. In particular, Kee and Tang (2016) show that most Chinese exports emerge from the so-called “export processing firms”, which correspond to firms that can import materials free of duty for assembling and pure exporting. Their findings are in line with the statement made by former WTO’s director Pascal Lamy reported above. This information suggests that the direct contribution of China to changes in labor market outcomes overseas should take into account two important features. First, the value added by companies exporting from China may be significantly different from Chinese gross exports. Second, Chinese exported goods can be, in many cases, close to the bottom of the production chain, and thus be characterized as having a high degree of downstreamness.

In this paper, we consider the role played by value-added exports from China in the recent changes that have taken place in the U.S. local labor markets. By definition, the direct contribution of China to the international production of goods, as well as to labor market outcomes in the U.S. and other economies, is represented by the value-added exports from that country. Considering the role played by value-added exports rather than gross exports is important and is now more feasibly investigated than ever before. Notice that recent

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<sup>5</sup>Notice that Acemoglu et al. (2016) do not find statistically significant effects of trade-related competition on an industry’s buyers.

papers by Koopman, Wang and Wei (KWW, 2014) and by Johnson and Nogueira (2012) have compiled datasets on bilateral value added exports across sectors, enabling researchers to map the contributions of each country to the production processes of various goods.<sup>6</sup> A striking conclusion from these papers is that value-added exports can be very different from gross exports.<sup>7</sup> Second, they suggest that usual economic inference based on gross exports can be misleading. In the case of revealed comparative advantage, KWW (2014) show that the ranking of comparative advantage based on value-added exports supports very different conclusions from the ranking based on gross exports.

Our strategy follows the insights provided by a model of international trade with  $G$  regions, where  $N$  of these regions represent commuting zones in the U.S. economy, and where firms in a particular sector and country are assumed to have access to the same technology displaying increasing returns to scale. Following Halpern, Koren and Szeidl (2015), we assume that the production of final goods requires the use of intermediate goods which can be produced domestically (within a region) or abroad (in another region). Wage rates are allowed to be different across regions but are assumed to be fixed throughout the analysis. The model assists us in two main aspects. First, it allows us to precisely define several measures important for our paper, including the definition of the measure of value-added exports used in the empirical sections. Second, the model allows us to investigate the potential effects of an increase in value-added exports on labor market outcomes while considering the position of the exported good on the global value chain.

In essence, the results suggest that an increase in value-added exports in goods with high degree of downstreamness tends to decrease employment levels in the economy exposed to these trade flows, while the effect in the case of goods with low degree of downstreamness is inherently ambiguous. The intuition for the former case is simple. An increase in exposure to exports in goods with high downstreamness decreases the demand for labor in the sector directly competing with the imported products but also decreases domestic sales of that sector's sellers, causing a negative magnification effect on employment outcomes. However, in the latter case, imported goods tend to decrease the marginal cost of some firms, which

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<sup>6</sup>In another paper, Wang, Wei and Zhu (2014) extend the original KWW's (2014) analysis by incorporating additional measures of value-added exports based on backward linkages. Moreover, they provide a more detailed analysis of the different components that add to gross exports.

<sup>7</sup>In the case at hand, Johnson and Nogueira (2012) point out that the U.S. trade deficit with China measured by value-added exports is at least 30 percent lower than the deficit measured using gross exports.

tend to boost firms' production levels, while they also displace domestic production (e.g., inputs) involved with the production of goods for final consumption, for instance. This analysis is in line with the idea that offshoring may increase the productivity of firms as empirically verified by Goldberg et al. (2010) for firms in India.<sup>8</sup>

Our empirical analysis builds on the insights provided by our theoretical framework, as well as on the definitions used in the model, relating value added exports and employment levels, and on the empirical strategy used by ADH (2013). In particular, we use information on value-added exports across countries and products available in KWW (2014). Our main focus is the change in U.S. exposure to value-added exports from China between the years 2000 and 2007. This time interval corresponds to the peak of export growth from China to the U.S. economy.<sup>9</sup> During this time interval, gross exports from China to the U.S. grew by 303 percent while value-added exports grew by 256 percent. It is also important for our analysis to distinguish exporting sectors according to their degrees of downstreamness (low or high). Most of our analysis distinguishes between these groups according to the usage of exported products (final versus intermediate), which is based on the definition used in KWW (2014), and also distinguish these groups based on the distribution of the sectorial ratio between the foreign value-added content in exports and gross exports, which, instead, is based on arguments outlined in Wang, Wei and Zhu (2014). Importantly, the decomposition of the change in value-added exports from China to the U.S. suggests that most of the change depends on exports from sectors with high degree of downstreamness, which is the opposite of what is found by considering changes in U.S. exposure to exports from other groups of countries (middle income, high income and transition economies).

We calculate U.S. exposure to Chinese value-added exports across local labor markets following the approach suggested by our model, which is similar to the approach used in ADH (2013), while using sectorial value-added trade flows based on the 2-digit of the ISIC industry classification, and we instrument it using Chinese value-added exports to other developed countries.<sup>10</sup> The distribution of U.S. exposure to Chinese value-added exports

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<sup>8</sup>Most importantly, Goldberg et al. (2010) show that access to new imported inputs has increased the product scope of those firms.

<sup>9</sup>Autor, Dorn and Hanson (2013) employ a dataset covering the years from 1990 to 2007. However, Koopman, Wang and Wei (2014) provide information on value added exports from 1995 to 2009. Thus, we can not cover the years from 1990 to 2000 in our analysis.

<sup>10</sup>Section 3.2 explains the concordances in detail.

displays important characteristics that are in line with the discussion above. In particular, we find that the average increase in the U.S. local labor market exposure to Chinese value-added exports is significantly lower than the average measure used in ADH (2013), which is based on gross exports. Moreover, we also find that these measures are positively, but not strongly, correlated. Most importantly, while we conclude that most of the U.S. increase in exposure to Chinese value-added exports is due to value-added exports in sectors with high degree of downstreamness, we also find a significant increase in U.S. exposure to value-added exports from China in sectors with low degree of downstreamness. This is in line with the facts described in Wang, Wei and Zhu (2014) that lead to the conclusion that China has evolved from an economy that primarily assembles final goods to an economy that increasingly serves as a source for intermediate products, participating fully in the different stages of the (international) production of goods.<sup>11</sup>

Our econometric strategy considers these insights. The results provide a complementary picture to the results obtained by ADH (2013). We begin our analysis by exploring the average effect of an increase in U.S. exposure to value-added exports from China without focusing on the role played by the degrees of downstreamness of exported products. Our main specification suggests that an increase in U.S. exposure to Chinese value-added exports leads to a decrease in the share of manufacturing employment, albeit producing a smaller and less statistically robust economic effect relative to the result obtained using gross exports. Then, we explore the other key additional features of our model and dataset. In particular, the theoretical framework suggests that the effects of traded goods on labor market outcomes should depend on the degree of downstreamness of the exporting industry. This issue seems to be very relevant for China and U.S. trade relations. A comparison between the increase in U.S. exposure to Chinese value-added exports, with the U.S. exposure to other countries, reveals that, while the U.S. increase in exposure towards China is slightly biased towards exporting industries with high degree of downstreamness, for other groups of countries (high income, middle income and transition economies) the U.S. increase in exposure is biased towards industries with low degree of downstreamness.<sup>12</sup>

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<sup>11</sup>Their paper provides an important example related to U.S. exports of transportation equipment. In that case, Wang, Wei and Zhu (2014) provide evidence that China had emerged as the main source of foreign value added to that industry, surpassing even Japan, by the end of the first decade of the 21<sup>st</sup> century.

<sup>12</sup>Hummels, Ishii and Yi (2001) were pioneers in documenting the increasing importance of trade in intermediate goods, and, consequently, also in understanding the substantial increase in the degree of vertical

Our econometric results suggest that the role played by downstreamness is paramount in explaining the effects of Chinese exports on U.S. local labor markets. We find that an increase in U.S. exposure to exports from China in sectors with high degree of downstreamness leads to a strong and statistically robust decline in manufacturing employment across U.S. local labor markets, while the same does not apply to the case of an increase in exposure to value-added exports in sectors with low degree of downstreamness. Our results suggest that the U.S. average increase in exposure to value-added exports in sectors with high downstreamness levels explains between 38 and 44 percent of the decline in the share of manufacturing employment across U.S. local labor markets depending on the measure used. These effects are statistically robust to controlling for U.S. value-added exports to China albeit significantly lower in economic terms. Our results suggest that the contribution of China to changes in U.S. local labor markets depends intrinsically on the position of the exporting industry on the global value chain.

On the other hand, we find no statistical evidence that an increase in U.S. exposure to Chinese exports causes either an average decline of wages, or an increase in unemployment levels, across U.S. local labor markets. This finding is robust to either using measures of gross exports or value-added exports for the period between the years 2000 and 2007 and is very much in line with our theoretical framework that assumes the wage rates are constant. Moreover, we also find that the position of the exporting industry in the global value chain matters, a result that is also in line with our model. In this case, an increase in exposure to trade with China in industries with low degree of downstreamness increases average wages, while it decreases unemployment levels, across U.S. local labor markets. Moreover, we find that our results are robust to a variety of changes in the measure of exposure and in the measure used to define the degree of downstreamness.<sup>13</sup>

The rest of our paper proceeds as follows. Section 2 discusses the importance of distinguishing between economic exposure to value-added exports and to gross exports, and also specialization in world trade.

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<sup>13</sup>Costa, Garred and Pessoa (2016) find slower wage growth for manufacturing workers across Brazilian local labor markets that are more affected by Chinese import competition. Instead, Caliendo, Dvorkin and Parro (2015) develop a dynamic model to allow for labor mobility frictions, trade costs, and input-output linkages in determining equilibrium allocations across local markets. With labor mobility, an increase in import competition from China may generate greater manufacturing employment loss in U.S. local labor markets due to migration. They find that increasing exposure to Chinese exports accounts for 50 percent of the change in manufacturing employment share unexplained by a linear time trend.

provides a theoretical framework defining important terminology used to relate changes in value-added export to labor market outcomes. Section 3 presents our econometric strategy and the dataset used in our empirical analysis. Section 4 describes the econometric results while Section 5 concludes the paper.

## 2 Motivation and Model

### 2.1 Why Value-Added Trade

It is well-known that the U.S. economy is very competitive in high-tech industries, producing certain products that the rest of the world economy clearly craves. One of the best examples of U.S. economic successes has been products produced by Apple Inc., which has been considered as (one of) the most valuable company(ies) in the world based on the stock market valuations in recent years.<sup>14</sup> In many aspects, for instance, the iPhones produced by Apple Inc. have come to symbolize the meaning of a profitable and successful commercial product.<sup>15</sup> However, in spite of the economic success of Apple Inc. and of its admired iPhones, it is striking to find out that this product, clearly one of the best-selling U.S. technology products world-wide, added \$1.9 billion to the U.S. trade deficit with China in 2009 according to Dedrick, Kraemer and Linden (2009, 2011) and Xing and Detert (2010). How is this fact possible? And what conclusions should we derive about the effects of Chinese exports on U.S. labor market outcomes?

The traditional way of measuring international trade based on gross trade flows (exports and imports) produces the number above since it fails to reflect the complexities of the global supply chain where the design, manufacturing and assembly of products involve many countries. Traditional trade statistics from both U.S. and China consider the iPhone a Chinese export to the U.S., even though it is entirely designed and owned by a U.S. company (Apple Inc.), and is made largely of parts produced in several Asian and European countries. The role played by China in the global production chain of the iPhones is relegated mostly to

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<sup>14</sup>The U.S. firms have dominated the top 10 most valuable companies list for several years. In 2015, all top 10 companies were U.S. based corporations and the top 3 (Apple, Alphabet and Microsoft) were labeled as high-tech firms. See “<http://fortune.com/2016/02/04/most-valuable-companies-fortune-500-apple/>” for details.

<sup>15</sup>For an example see “<http://www.independent.co.uk/news/business/analysis-and-features/apples-iphone-the-most-profitable-product-in-history-10009741.html>”.

the assembly line and it adds very little value to this product. Therefore, the Chinese participation in this case in value-added terms seems modest albeit presenting a high degree of downstreamness since its contribution is related to activities at the bottom of the production chain. According to Dedrick, Kraemer and Linden (2011), the value added by Chinese workers represents 1.8 percent of the total retail value of the iPhones sold in the U.S. For comparison purposes, two major South Korean suppliers (LG and Samsung) add about 12 percent of the retail value, while Apple Corporation adds about fifty-eight percent of the iPhone's retail value.

These facts imply two main points related to our paper. First, measuring the Chinese contribution to labor (and any other) market outcome in the U.S. should take into account that gross exports may be very different from value added exports. In the case at hand, the Chinese value-added exports of the iPhones represents a small portion of the Chinese gross exports. Therefore, using gross exports guides us towards reaching the wrong conclusion that high-tech products do not increase the demand for U.S. workers. Additionally, Xing and Detert (2010) concludes that a value-added based approach would indicate that the iPhone generates a U.S. trade surplus of \$48 million with China based on the sales of iPhones in the U.S. and in China. Second, the iPhone example highlights that its production depends on the contribution of several countries and the contribution of China to labor market outcomes depends on its place in the global production chain. In the case at hand, other Asian countries, such as South Korea and Japan, are important contributors to iPhones exported by China to the U.S. economy. Thus, even if China appears as the official exporter of the iPhones to the U.S. economy according to national customs practices, the significant foreign value added contained in Chinese exports reveals that the Chinese contribution is smaller than suggested by official trade statistics albeit possibly representing a substantial challenge to U.S. import-competing industries given its high degree of downstreamness. Our analysis considers these important elements.

## 2.2 Model

We develop a partial equilibrium model that considers how increased import competition from China affects employment in a U.S. commuting zone. There are a total of  $G$  regions, which can be interpreted as having  $N$  regions representing commuting zones in the U.S.,

another region representing China, and  $G - N - 1$  other regions. Following Antràs and Helpman (2004), producers of traded goods face a perfectly elastic supply of labor in each of the regions. We denote the wage rate in region  $k$  by  $W^k$  and we assume it to be fixed.<sup>16</sup> Below we use the wording market and region interchangeably.

There are  $J$  traded-good sectors, indexed by  $j$ , where consumers allocate  $J$  share of spending on each. For each traded good sector, there are intermediate goods and final goods. In the case of final goods, the demand for product varieties is derived from a CES sub-utility function, such that total demand for a variety  $y_j^i$  is the sum over the demand in each destination market  $k$  ( $y_j^{ik}$ ) given by,

$$y_j^i = \sum_k y_j^{ik} = \sum_k \frac{(p_j^{ik})^{-\sigma_j} E^k}{(P_j^k)^{1-\sigma_j} J},$$

where  $p_j^{ik}$  is the delivered price in market  $k$  of a variety in sector  $j$  produced in region  $i$ , and  $E^k$  is the total expenditure in market  $k$ .  $P_j^k$  is the price index for final goods in sector  $j$  of market  $k$ , and captures the intensity of competition in a market;  $\sigma_j > 1$  is the elasticity of substitution between any pair of varieties in the final good sector  $j$ .

Similar to Halpern, Koren and Szeidl (2015) and Blaum, Lelarge, and Peters (2016), the production of final goods requires the use of intermediate goods,

$$y_j^i = \prod_k \prod_s (m_{sj}^{ki})^{\eta_{sj}^{ki}},$$

where  $m_{sj}^{ki}$  is the intermediate good produced in sector  $s$  in region  $k$  and used for sector  $j$  in region  $i$ , and  $\eta_{sj}^{ki}$  is the exogenous input-output linkages with  $\eta_{sj}^{ki} \in [0, 1]$  and  $\sum_k \sum_s \eta_{sj}^{ki} = 1$ . One unit of intermediate good ( $m_{sj}^{ki}$ ) requires one unit of labor in region  $k$  with wage  $W^k$ . Cost minimization yields the following demand for intermediate goods:

$$m_{sj}^{ki} = y_j^i \left( \frac{\eta_{sj}^{ki}}{W^k} \right)^{1-\eta_{sj}^{ki}} \prod_{k'} \prod_{s'} \left( \frac{W^{k'}}{\eta_{s'j}^{k'i}} \right)^{\eta_{s'j}^{k'i}}, \quad (1)$$

which can be used to obtain the following total cost ( $TC_j^i$ ) and marginal cost functions

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<sup>16</sup>The assumption of fixed wage rates can be justified in general equilibrium by assuming that  $W^k$  is the productivity of labor in producing the freely traded numeraire good in each region and that labor supply is large enough in every region so that all regions produce the numeraire.

$(MC_j^i)$ ,

$$TC_j^i = y_j^i \prod_k \prod_s \left( \frac{W^k}{\eta_{sj}^{ki}} \right)^{\eta_{sj}^{ki}} \quad MC_j^i = \prod_k \prod_s \left( \frac{W^k}{\eta_{sj}^{ki}} \right)^{\eta_{sj}^{ki}} \quad \text{for } \eta_{sj}^{ki} \neq 0.$$

To produce a final good variety  $y_j^i$ , there is a fixed labor cost  $\alpha_j^i$ . Under monopolistic competition, the price of each variety is a constant markup over marginal cost as described by  $p_j^{ik} = (\sigma_j / (\sigma_j - 1)) \tau_j^{ik} MC_j^i$ , where  $\tau_j^{ik} \geq 1$  is the iceberg transportation cost of delivering one unit of a final good in sector  $j$  from region  $i$  to region  $k$ . Let  $L_T^i$  denote the labor used in region  $i$  to produce final goods and intermediate goods. This implies that  $L_T^i = \sum_j M_j^i \alpha_j^i + \sum_j \sum_s \sum_k m_{js}^{ik}$  where  $M_j^i$  is the number of final good varieties produced by sector  $j$  in region  $i$ .

We can now consider the contribution of the degree of downstreamness in determining labor market outcomes. In the empirical section of the paper, we measure the level of downstreamness using different approaches. In this section, we mostly consider a good to display either high or low degree of downstreamness depending on its usage as a final good or intermediate good, respectively. We also offer comments related to the definition of downstreamness using the foreign value-added content in gross exports. Our strategy at first disregards the presence of trade in intermediate goods in the status quo situation, and then allows for an external shock to either lead to more trade in final goods or to some marginal trade in intermediate goods. Next, we consider a more general case where the trade in intermediate goods is present in the status quo situation and this step requires a substantial extension of the notation used in the model.

Let us first consider a situation where the production of the final good variety ( $y_j^i$ ) requires all intermediate inputs to be produced in region  $i$  (i.e.,  $\sum_s \eta_{sj}^{ki} = 1$  for  $k = i$ ). The price of each final good variety depends only on the wage in region  $i$ , on the iceberg transportation cost  $\tau_j^{ik}$  and on exogenous parameters  $\sigma_j$  and  $\eta_{sj}^{ki}$ . In this case, free entry in each sector drives profits to zero for a given production technology in sector  $j$  region  $i$ , implying that the level of output for each final good variety is fixed,  $y_j^i = \alpha_j^i (\sigma_j - 1) / \left( \sigma_j \prod_s (1 / \eta_{sj}^{ii})^{\eta_{sj}^{ii}} \right)$ . Therefore, any adjustment in sectorial output and employment occurs at the extensive margin, through changes in the number of final good varieties (i.e.  $\Delta y_j^i / y_j^i = 0$  and adjustment occurs through  $\Delta M_j^i / M_j^i$ ). In this case, an increase in import competition from China, which represents an

exposure to import competition in goods with high degree of downstreamness, leads to an increase in the number of final goods varieties produced in China for each market served by region  $i$ . This effect then lowers the labor demand in the traded-good sector in region  $i$ . In essence, this result corresponds to ADH's (2013) main result.

In the second case, suppose intermediate inputs can suddenly be sourced from China (represented by superscript  $c$ ) in sector  $s$  due to trade liberalization, such that  $\eta_{sj}^{ci} \neq 0$  for some region  $i$ . This assumption represents an increase in exposure to Chinese exports in goods with low degree of downstreamness. This lowers the marginal cost of production ( $MC_j^i$ ) implying that final good producers can earn a positive profit. Thus, new final good producers can enter the market in region  $i$ , leading to an ambiguous total effect on employment in region  $i$  since imports of intermediate goods from region  $c$  may lower total employment ( $L_T^i$ ) in region  $i$  while the increase in demand for this variety from all markets may lead to an increase in total employment in that region.

In the third case, we consider an external shock from China (e.g. a reduction in  $W^C$ ) with existing trade in intermediate and final goods. Gross output of sector  $s$  in region  $i$  is the sum of intermediate goods produced plus the sum in final goods produced,

$$x_s^i = \sum_k \sum_j m_{sj}^{ik} + M_s^i \sum_k y_s^{ik}$$

This can be re-written in block matrix notation following KWW (2014) as

$$\begin{bmatrix} X^1 \\ X^2 \\ \vdots \\ X^G \end{bmatrix} = \begin{bmatrix} A^{11} & A^{12} & \dots & A^{1G} \\ A^{21} & A^{22} & \dots & A^{2G} \\ \vdots & & & \\ A^{G1} & A^{G2} & \dots & A^{GG} \end{bmatrix} \begin{bmatrix} X^1 \\ X^2 \\ \vdots \\ X^G \end{bmatrix} + \begin{bmatrix} \sum_k^G Y^{1k} \\ \sum_k^G Y^{2k} \\ \vdots \\ \sum_k^G Y^{Gk} \end{bmatrix}$$

where  $X^i$  is a  $J \times 1$  vector  $[x_1^i, \dots, x_s^i, \dots, x_J^i]^T$  that gives region  $i$ 's gross output.  $A^{ik}$  is a  $J \times J$  block input-output coefficient matrix, where  $a_{sj}^{ik}$  is an element in the  $A^{ik}$  matrix and is the direct input-output coefficient that gives units of the intermediate goods produced in sector  $s$  of region  $i$  that are used in the production of one unit of gross output in sector  $j$  of region  $k$  (i.e.,  $a_{sj}^{ik} = m_{sj}^{ik}/x_s^i$ ).  $Y^{ik}$  is a  $J \times 1$  vector that gives final goods produced in region  $i$  and

that are consumed in region  $k$ .  $Y^i = \sum_k^G Y^{ik}$  is also a  $J \times 1$  vector that gives the global use of region  $i$ 's final goods.

The above matrix can be re-arranged and written as follows:

$$\begin{bmatrix} X^1 \\ X^2 \\ \vdots \\ X^G \end{bmatrix} = \begin{bmatrix} B^{11} & B^{12} & \dots & B^{1G} \\ B^{21} & B^{22} & \dots & B^{2G} \\ \vdots & \vdots & \ddots & \vdots \\ B^{G1} & B^{G2} & \dots & B^{GG} \end{bmatrix} \begin{bmatrix} \sum_k^G Y^{1k} \\ \sum_k^G Y^{2k} \\ \vdots \\ \sum_k^G Y^{Gk} \end{bmatrix},$$

where  $B^{ik}$  is the  $J \times J$  block Leontief inverse matrix. An element in  $B^{ik}$  ( $b_{sj}^{ik}$ ) is referred to as the total requirement coefficient in the input-output literature. Specifically,  $b_{sj}^{ik}$  gives the total amount of gross output in sector  $s$  in region  $i$  needed to produce an extra unit of final goods in sector  $j$  in region  $k$ , which is for consumption in region  $i$  as well as other regions. Note that  $b_{sj}^{ik} \cdot y_j^{kr}$  gives the total amount of gross output in sector  $s$  in region  $i$  needed to produce final goods in sector  $j$  in region  $k$  for consumption in region  $r$ .  $B$  matrix is  $GJ \times GJ$ . Notice that  $X^i$  may be re-written in terms of matrices  $X^{ik}$ , which corresponds to  $J \times 1$  gross output vector that gives gross output produced in region  $i$  and absorbed in region  $k$ .

The direct value-added coefficient  $v_s^i$  is defined by  $1 - \sum_k \sum_j a_{js}^{ki}$  while country  $i$ 's direct value-added vector can be written in matrix form as  $V^i = [v_1^i \quad v_2^i \quad \dots \quad v_J^i]$  which corresponds to a  $1 \times J$  row vector of direct-value-added coefficients. Then, the total value-added multiplier, or the total value-added coefficient matrix ( $VB$ ) is defines as follows:

$$VB = \begin{bmatrix} V^1 B^{11} & V^1 B^{12} & \dots & V^1 B^{1G} \\ V^2 B^{21} & V^2 B^{22} & \dots & V^2 B^{2G} \\ \vdots & \vdots & \ddots & \vdots \\ V^G B^{G1} & V^G B^{G2} & \dots & V^G B^{GG} \end{bmatrix},$$

where  $VB$  is a  $G \times GJ$  matrix. Let  $\hat{V}^i$  be a  $J \times J$  diagonal matrix with direct value-added coefficients  $v_s^i$  along the diagonal. We can define a  $GJ \times GJ$  diagonal matrix  $\hat{V}$  where each element of its diagonal is formed by a matrix  $\hat{V}^i$ . Then, we can define the domestic value-added matrix in a region's gross output  $\hat{V}X$ , which equals the  $GJ \times G$  matrix  $\hat{V}BY$ , as follows:

$$\begin{bmatrix} \hat{V}^1 \sum_g B^{1g} Y^{g1} & \hat{V}^1 \sum_g B^{1g} Y^{g2} & \dots & \hat{V}^1 \sum_g B^{1g} Y^{gG} \\ \hat{V}^2 \sum_g B^{2g} Y^{g1} & \hat{V}^2 \sum_g B^{2g} Y^{g2} & \dots & \hat{V}^2 \sum_g B^{2g} Y^{gG} \\ \vdots & & & \\ \hat{V}^G \sum_g B^{Gg} Y^{g1} & \hat{V}^G \sum_g B^{Gg} Y^{g2} & \dots & \hat{V}^G \sum_g B^{Gg} Y^{gG} \end{bmatrix},$$

where elements in the diagonal give each region's production of value added absorbed at home. The off-diagonal elements of the  $\hat{V}BY$  matrix gives each region  $i$ 's production of value added that is absorbed in region  $k$ , or the value-added exports ( $VAX^{ik}$ ),

$$VAX^{ik} = \hat{V}^i X^{ik} = \hat{V}^i \sum_g B^{ig} Y^{gk} = \hat{V}^i B^{ii} Y^{ik} + \hat{V}^i B^{ik} Y^{kk} + \hat{V}^i \sum_{g \neq k, i} B^{ig} Y^{gk}, \quad (2)$$

where  $\hat{V}^i B^{ii} Y^{ik}$  is value-added exports in final goods produced in  $i$  and absorbed in  $k$ . Similarly,  $\hat{V}^i B^{ik} Y^{kk}$  is value-added exports in intermediate goods produced in  $i$  and absorbed in  $k$ . Lastly,  $\hat{V}^i \sum_{g \neq k, i} B^{ig} Y^{gk}$  is the value-added exports in intermediates that are first exported to region  $g$  and eventually absorbed in region  $k$ . Note also that  $VAX^{ik}$  is a  $J \times 1$  vector.

We can now proceed with a three-country example in order to highlight the role of downstreamness in explaining labor market outcome changes. Consider that the global economy can be divided into 3 regions namely: region  $i$  (commuting zone  $i$  in U.S.), region  $k$  (rest of commuting zones in the U.S.), and region  $c$  (China). Moreover, let us assume the presence of 2 sectors denoted by subscripts 1 and 2. An increase in exposure from China affects the labor market in U.S. commuting zone  $i$  by changing the demand for labor (i.e., value added) used in producing goods in  $i$  exported to all regions for either final consumption or as an intermediate product. In this case, value-added exports from region  $i$  to region  $k$  can be defined according to expression 2 as  $VAX^{ik} = \hat{V}^i \sum_g B^{ig} Y^{gk} = \hat{V}^i B^{ii} Y^{ik} + \hat{V}^i B^{ik} Y^{kk} + \hat{V}^i B^{ic} Y^{ck}$ . This expression can be rewritten using matrix notation as follows,

$$\begin{bmatrix} v_1^i b_{11}^{ii} Y_1^{ik} + v_1^i b_{12}^{ii} Y_2^{ik} \\ v_2^i b_{21}^{ii} Y_1^{ik} + v_2^i b_{22}^{ii} Y_2^{ik} \end{bmatrix} + \begin{bmatrix} v_1^i b_{11}^{ik} Y_1^{kk} + v_1^i b_{12}^{ik} Y_2^{kk} \\ v_2^i b_{21}^{ik} Y_1^{kk} + v_2^i b_{22}^{ik} Y_2^{kk} \end{bmatrix} + \begin{bmatrix} v_1^i b_{11}^{ic} Y_1^{ck} + v_1^i b_{12}^{ic} Y_2^{ck} \\ v_2^i b_{21}^{ic} Y_1^{ck} + v_2^i b_{22}^{ic} Y_2^{ck} \end{bmatrix}.$$

For instance,  $v_1^i b_{11}^{ii} Y_1^{ik}$  is value added created in region  $i$  sector 1 used by region  $i$ 's sector 1 in the production of final goods exported to (absorbed in) region  $k$ . Likewise,  $v_1^i b_{11}^{ik} Y_1^{kk}$  is

value added created in region  $i$ 's sector 1 used by region  $k$ 's sector 1 to produce final goods absorbed in region  $k$ . The other terms can be similarly defined. As said above, the effects on the labor market in region  $i$  from an increase in its exposure to region  $c$  (China) depends on its labor demand across markets, which can be expressed by

$$\begin{aligned} \sum_k^G VAX^{ik} &= \hat{V}^i \sum_k^G \sum_g^G B^{ig} Y^{gk} = \hat{V}^i \sum_g^G B^{ig} Y^g \\ &= \begin{bmatrix} v_1^i b_{11}^{ii} Y_1^i + v_1^i b_{12}^{ii} Y_2^i \\ v_2^i b_{21}^{ii} Y_1^i + v_2^i b_{22}^{ii} Y_2^i \end{bmatrix} + \begin{bmatrix} v_1^i b_{11}^{ik} Y_1^k + v_1^i b_{12}^{ik} Y_2^k \\ v_2^i b_{21}^{ik} Y_1^k + v_2^i b_{22}^{ik} Y_2^k \end{bmatrix} + \begin{bmatrix} v_1^i b_{11}^{ic} Y_1^c + v_1^i b_{12}^{ic} Y_2^c \\ v_2^i b_{21}^{ic} Y_1^c + v_2^i b_{22}^{ic} Y_2^c \end{bmatrix} \end{aligned}$$

where  $Y_1^g$  denotes  $Y_1^{gi} + Y_1^{gk} + Y_1^{gc}$  for every  $g = \{i, c, g\}$ .

Importantly, the value of production of final goods produced by sector 1 in region  $i$  has to equal the value added in the production of inputs from all regions used in its production. Following Wang, Wei and Zhu (2014), this implies that the following tautology applies

$$(v_1^i b_{11}^{ii} + v_2^i b_{21}^{ii} + v_1^k b_{11}^{ki} + v_2^k b_{21}^{ki} + v_1^c b_{11}^{ci} + v_2^c b_{21}^{ci}) Y_1^i = Y_1^i,$$

or, equivalently that

$$v_1^i b_{11}^{ii} + v_2^i b_{21}^{ii} + v_1^k b_{11}^{ki} + v_2^k b_{21}^{ki} + v_1^c b_{11}^{ci} + v_2^c b_{21}^{ci} = 1. \quad (3)$$

Expression (3) is important since it will assist us in considering an increase in region  $i$ 's exposure to exports in goods with low downstreamness (intermediate goods) from region  $c$ . To consider the case of exposure to final goods exported by  $c$ , we consider an equivalent expression relating the value of production of final goods by sector 1 based in region  $c$  to the value-added contributions from all regions:

$$v_1^i b_{11}^{ic} + v_2^i b_{21}^{ic} + v_1^k b_{11}^{kc} + v_2^k b_{21}^{kc} + v_1^c b_{11}^{cc} + v_2^c b_{21}^{cc} = 1. \quad (4)$$

We can now proceed with the consideration of an increase in value-added exports from China (region  $c$ ) in low downstreamness products, which is represented by an increase in intermediate goods, with the assistance of expression (3). In this case, an increase in value-added exports from China to region  $i$  in intermediate goods produced by sector 1 implies

$\uparrow v_1^c b_{11}^{ci}$  in expression (3), leading to three alternative situations:

1. There is a decrease in intermediates used from region  $k$  in sector 1 or 2, represented by  $\downarrow v_1^k b_{11}^{ki}$  or  $\downarrow v_2^k b_{21}^{ki}$ .

2. There is a decrease in intermediates used from region  $c$  in sector 2,  $\downarrow v_2^c b_{21}^{ci}$ .

3. There is a decrease in value added from region  $i$  in sector 1 or 2,  $\downarrow v_1^i b_{11}^{ii}$  or  $\downarrow v_2^i b_{21}^{ii}$ .

In alternatives 1 and 2, the value-added shares in region  $i$  are not directly affected. However, import competing intermediate inputs from China in sector 1 could lower marginal costs, and, according to expression (1), could lead to an increase in  $Y_1^i$  and  $Y_2^i$ , which would then increase the demand for labor region  $i$ . In alternative 3, the domestic value-added shares in final goods are reduced, which could lead to a decrease in employment in region  $i$ , depending on whether or not the increase in the production of final goods increase in  $Y_1^i$  and  $Y_2^i$  sufficiently according to expression (1). In this particular case then the net effect on the demand for labor in region  $i$  is unclear.

Alternatively, we can consider an increase in region  $i$ 's exposure to value added exports from China (region  $c$ ) in products with high degree of downstreamness. We focus on an example involving the increase in value-added exports of final goods by industry 1, which can be expressed as  $\uparrow v_1^c b_{11}^{cc}$  in our model. In this case, expression (4) suggests three possible alternatives, namely:

1.  $\downarrow v_1^k b_{11}^{kc}$  or  $\downarrow v_1^k b_{21}^{kc}$  in region  $k$ .

2.  $\downarrow v_2^c b_{21}^{cc}$  in region  $c$

3.  $\downarrow v_1^i b_{11}^{ic}$  or  $\downarrow v_2^i b_{21}^{ic}$  in region  $i$ .

In alternative 1, we have the substitution of intermediate inputs originating in region  $k$  for inputs originating in region  $c$ , and in alternative 2, we have the substitution of intermediate inputs originating in region  $c$  sector 1 for inputs originating in region  $c$  sector 2, with no direct effect on the shares of value added originating in region  $i$ . However, final goods production in region  $i$  declines, and, therefore, the application of expression (1) leads to a decline in the demand for labor in region  $i$ . In alternative 3, we have both a negative direct effect on the demand for labor, through decreases in  $v_1^i b_{11}^{ic}$  and/or  $v_2^i b_{21}^{ic}$ , and an indirect effect through lower production of final goods. Thus, an increase in value-added exports from China in goods with high degree of downstreamness leads to a decrease in employment in region  $i$ .

Our empirical strategy also characterizes the degree of downstreamness by using the

share of foreign value-added content in gross exports. Defining the foreign value content in region  $c$ 's gross exports of good  $j$  to region  $i$ , represented by  $FVA_j^{ci}$ , requires us to extend our notation since gross exports may not be fully absorbed in the destination country. In this case, foreign value added in final goods can be represented by  $(\sum_{g \neq c} \sum_{m=1}^2 v_m^g b_{mj}^{gc})Y_j^{ci}$ , while foreign value added in intermediate goods can be described by  $(\sum_{g \neq c} \sum_{m=1}^2 v_m^g b_{mj}^{gc})M_j^{ci}$ . As such, total foreign value added can be represented by

$$\begin{aligned} FVA_j^{ci} &= \left( \sum_{g \neq c} \sum_{m=1}^2 v_m^g b_{mj}^{gc} \right) Y_j^{ci} + \left( \sum_{g \neq c} \sum_{m=1}^2 v_m^g b_{mj}^{gc} \right) M_j^{ci} \\ &= \left( \sum_{g \neq c} \sum_{m=1}^2 v_m^g b_{mj}^{gc} \right) E_j^{ci} , \end{aligned} \quad (5)$$

where  $E_j^{ci}$  stands for region  $c$ 's gross exports to region  $i$  in sector. Expression (5) clearly shows that the foreign value-added content is lower than growth exports since expression  $\sum_{g \neq c} \sum_{m=1}^2 v_m^g b_{mj}^{gc}$  is less than one as explained above.

As explained in KWW (2014) and Wang, Wei and Zhu (2014), higher  $FVA_j^{ci}$  implies a greater degree of downstreamness for sector  $j$  in country  $c$ . In addition, higher  $FVA_j^{ci}$  may increase (or decrease)  $v_m^i b_{mj}^{ic}$  for  $m = 1, 2$ , and lead to an increase (or decrease) in value-added exports from region  $i$  in sector  $j$ . Instead, a decrease in  $v_m^i b_{mj}^{ic}$  may occur if region  $i$  does not have a comparative advantage in producing inputs for downstream sector  $j$ . Thus, the effect on labor demand in region  $i$  is negative if higher  $FVA_j^{ci}$  leads to less intermediate inputs imported by region  $c$  from region  $i$  to use in region  $c$ 's export to region  $i$ .

**Proposition 1** *The effect of an increase in Chinese value-added exports depends on the degree of downstreamness of the exported goods. An increase in value-added exports in sectors with high degree of downstreamness has a negative effect on employment in the US. On the other hand, an increase in value-added exports in sectors with low degree of downstreamness has an ambiguous effect on employment in the US. Therefore, the overall effect from value-added exports across sectors is ambiguous.*

Our empirical analysis relies on how changes in exposure to value-added exports affects changes in local labor market outcomes.<sup>17</sup> As described below, we are particularly interested

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<sup>17</sup>Notice that Proposition 1 focuses on value-added exports from China since the focus of this paper is

in the relationship between changes in exposure and in the share of employment in this tradable (e.g., manufacturing) sector. Notice that, by definition, total employment equals the value added in gross output,  $L_T^i = \sum_j v_j^i X_j^i$ . In this case,  $X_j^i$  is sector  $j$ 's gross output in region  $i$ . Thus, log differentiation yields the following expression:

$$\tilde{L}_T^i = \sum_j \frac{1}{L_T^i} \Delta v_j^i X_j^i, \quad (6)$$

where  $\tilde{L}_T^i$  stands for  $\Delta L_T^i / L_T^i$ . This expression indicates that the total percent change in employment in region  $i$  is directly related to changes in value added in gross output. Moreover, total value added can be directly related to value added generated and absorbed in region  $i$ , and to domestic value added in region  $i$  that is absorbed in other regions, by the following expression as discussed above:

$$v_j^i X_j^i = \sum_g \hat{V}^i B^{ig} Y^g = \hat{V}^i B^{ii} Y^i + \hat{V}^i B^{ik} Y^k + \sum_{g \neq i, k} \hat{V}^i B^{ig} Y^g$$

This expression allows us to relate changes in total value-added output in region  $i$ 's sector  $j$  to changes in value-added exports from region  $c$  (China) to region  $i$  as discussed above in the following way:

$$\begin{aligned} \Delta v_j^i X_j^i &\propto \pm \Delta V A X^{C,i} \\ \Delta v_j^i X_j^i &\propto -\Delta V A X^{C,i}_{final} \\ \Delta v_j^i X_j^i &\propto \pm \Delta V A X^{C,i}_{intermediates}. \end{aligned}$$

We can then approximate the effects of changes in labor demand due to changes in value-added exports from region  $c$  (China) to region  $i$  (commuting zone in the U.S.) using expression (6) according to the following expression:

$$\tilde{L}_T^i = \sum_j \frac{1}{L_T^i} \Delta V A X_j^{c,i},$$

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China's contribution to the production of traded goods. Notice that the same value of gross exports may contain X percent of value-added in China or represent instead 10 times X percent of value-added in China. They represent the same amount in gross terms but very different contributions. Similarly, the same amount in gross exports from China could have completely different effects if contained no inputs originating in the U.S. or only inputs originating in the U.S.

where the total effect is ambiguous as discussed above.<sup>18</sup> However, we do not observe China's value-added exports to region  $i$ , but only China's value-added exports to the U.S. Thus, our empirical strategy weights each region  $i$  in the U.S. by its own value-added share, or labor share of region  $i$  in the U.S. ( $L_j^i/L_j^{US}$ ) in sector  $j$  as follows:

$$\Delta EXP\_VAX_i = \sum_j \frac{L_j^i}{L_j^{US}} \frac{1}{L_T^i} \Delta VAX_j^{C,US}, \quad (7)$$

which can also be defined using changes in value-added exports in final and in intermediate goods

$$\begin{aligned} \Delta EXP\_VAX_{i\_final} &= \sum_j \frac{L_j^i}{L_T^i} \frac{1}{L_j^{US}} \Delta VAX_j^{C,US\_final} \\ \Delta EXP\_VAX_{i\_interm} &= \sum_j \frac{L_j^i}{L_T^i} \frac{1}{L_j^{US}} \Delta VAX_j^{C,US\_intermediates}. \end{aligned} \quad (8)$$

### 3 Empirical Strategy

This section has two main objectives. First, we describe the econometric model used to investigate the effects of trade flows between the U.S. and China on the former economy's local labor markets. Our analysis focuses on changes in trade flows between these two economies between the years 2000 and 2007. Essentially, our econometric strategy builds on the strategy used by ADH (2013), while it extends their analysis to the investigation of the role played by value-added exports, as well as the role played by the position of Chinese exports in the global value chains, on labor market effects. On one hand, we allow for different effects due to changes in gross exports and in value-added exports, while, on the other, we explore the potentially different effects generated by exports with varying degrees of downstreamness.

Second, we describe the dataset used in this paper, which relies on data made available by ADH (2013), KWW (2014) and by other sources described below. In this case, we elaborate

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<sup>18</sup>Our analysis also reveals that an increase in U.S. exposure to Chinese value added exports in indirect form may have an ambiguous effect on U.S. labor market outcomes. However, indirect exports from China are relatively small and represent Chinese exports of intermediate goods that promote indirect exports of final goods to the U.S. economy. For this reason, our analysis does not focus on value-added exports in indirect form when controlling for the degree of downstreamness which is clearly less well defined in this case.

on the definition of value-added exports used in KWW (2014) and on the differences between the U.S.-China measures of trade flows using gross and value-added exports. We also provide a comparison between the measures of change in the U.S. local labor market exposure to trade with China using gross and value-added exports. Notice that we use below the words sector and industry interchangeably.

### 3.1 Econometric Model

The key variable in our empirical exercises is the measure of U.S. local market exposure to value-added exports from China. This variable captures the direct contribution of the Chinese economy to the (international) production of goods exported by China and sold in the U.S. economy. Our model described in Section 2.2 suggests that we can approximate the effects of an increase in value-added exports from China on U.S. local labor markets on a per-worker basis by applying expression (7). In this case, the importance of sectorial trade in a particular labor market is weighted by the share of national sectorial employment for a particular labor market, which is similar to the approach used in ADH (2013). Our basic measure of U.S. local labor market exposure can be described as follows:

$$\Delta LEXP\_VAX^i = \sum_j \frac{L_j^i}{L_j^{US}} \frac{\Delta VAX_j^{C,US}}{L_T^i}, \quad (9)$$

where  $\Delta VAX_j^{C,US}$  stands for the change in value-added exports from China to the U.S. in industry (sector)  $j$  between the years 2000 and 2007. The definition of value-added exports is provided by expression (2) in Section 2.2. For this reason, we refer to the year 2000 as the base year. Consistent with the notation used in our model, the variable  $L_T^i$  represents employment in local market  $i$  for the base year, while  $L_j^{US}$  represents U.S. employment in industry  $j$  for the base year.

We explore variations in the manner in which we measure the exposure of local labor markets to international trade flows. For comparison purposes, we also use the measures of exposure based on changes in gross exports from China originally calculated by ADH (2013). This strategy allows us to consider whether the effects of changes in value-added exports from China to the U.S. differ from the effects of changes in gross exports. Moreover, we also calculate the exposure measure (9) separately for value added exports according to their

degree of downstreamness and we adopt two main approaches in considering this question. First, we consider value-added exports in terms of their usage where value-added exports in final goods reflect greater downstreamness relative to value-added exports in intermediate goods.<sup>19</sup> In this case, we replace  $\Delta VAX_j^{C,US}$  in expression (9) by the change in value added exports in final goods and by the change in value-added exports in intermediate goods as described in expressions (8) of the model outlined in the last section.

Second, we use data on trade flows to identify the sectorial exports from China that display greater and lower degrees of downstreamness. According to Wang, Wei and Zhu (2014), it is clear that the increasing degree of economic integration among national economies has led to the lengthening of the international production chain. This fact indicates that bilateral trade flows may be significantly affected by the presence of foreign value added originating in third countries.<sup>20</sup> In the case in question, trade flows between China and the U.S. are prone to be affected by the significant presence of foreign value-added content in Chinese exported goods due (for example) to the presence of “export processing zones” in China as discussed in Kee and Tang (2016).

Following the insights outlined in Wang, Wei and Zhu (2014), we use the distribution of the sectorial ratio between the foreign value added contained in Chinese exports and the gross exports from China in identifying sectors with greater and lower downstreamness.<sup>21</sup> In this approach, sectors with relative high ratio values are deemed to have high degree of downstreamness, or, equivalently, are closer to be bottom of the global value chain, while sectors with low ratio values display lower degree of downstreamness. The next section describes in more detail the data and assumptions used in determining each case. In practical terms, we construct a variable  $I_j^d$  which equals 1 if a sector  $j$  is deemed to have high degree of downstreamness and equals 0 otherwise. We can then recalculate expression (9) separately

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<sup>19</sup>According to expression (2), value-added exports can be divided into final, intermediate and indirect exports. In the case of indirect value-added exports, these flows correspond to intermediate products sold by China to a third country before being sold in the U.S. economy as a final product. Thus, it is unclear how we should classify these exported goods in terms of their degree of downstreamness as indicated by footnote 17 in Section 2.2.

<sup>20</sup>Please see expression (5) in our model for a precise definition of the foreign value-added content in gross exports.

<sup>21</sup>We are also grateful to a referee for suggesting this approach to us. Please see page 31 in Wang, Wei and Zhu (2014).

for sectors where  $I_j^d$  equals 0 and 1 as follows,

$$\begin{aligned}\Delta LEXP\_VAX_{high}^i &= \sum_j \frac{L_j^i}{L_j^{US}} \frac{\Delta VAX_j^{C,US}}{L_T^i} I_j^d, \\ \Delta LEXP\_VAX_{low}^i &= \sum_j \frac{L_j^i}{L_j^{US}} \frac{\Delta VAX_j^{C,US}}{L_T^i} (1 - I_j^d),\end{aligned}\tag{10}$$

where the expression shown in the top (bottom) of (10) describes the change in U.S. exposure to value-added exports from China in sectors with high (low) degree of downstreamness.

We also consider the role played by net value-added trade between U.S. and China in determining U.S. labor market outcomes. The latter measure controls for the effects of economic growth in China in promoting employment and in raising wages across U.S. local labor markets through the increase of U.S. value-added exports to China. For robustness purposes, we consider three alternative definitions of downstreamness, we also replace the change in value-added exports per worker ( $\Delta VAX_j^{C,US}/L_T^i$ ) in expression (9) by a measure based on the import penetration ratio ( $(\Delta VAX_j^{C,US}/X_j^i)$ , where  $X_j^i$  represents the value of shipments (output)), and, additionally, consider measures of changes in U.S. exposure to trade with high income and middle income countries separately.

Our econometric specification considers the effects of changes in U.S. local labor market exposure to trade with China on changes in employment, unemployment and in wage levels. More specifically, our basic model is represented by the following econometric specification:

$$\Delta \frac{L_m^i}{WP^i} = \alpha + \gamma_1 \Delta LEXP\_VAE^i + \gamma_2' \mathbf{X}^i,\tag{11}$$

where  $\Delta \frac{L_m^i}{WP^i}$  represents the change in the manufacturing employment share of the working age population in local market  $i$ . In this specification, the direct contribution of China, in terms of value added originating and exported by that country, to changes in U.S. labor market outcomes is captured by parameter  $\gamma_1$ . As is clear from expression (11), we also include a set of local market controls described by the matrix  $\mathbf{X}^i$ . These controls include possibly relevant characteristics of local labor markets, measured during the base year, such as the percentage of employment in manufacturing, the percentage of college-educated population, the percentage of foreign-born population, among others. The idea is that, controlling for

these local market characteristics, we can capture the effects of changes in market exposure on the manufacturing employment share. A similar strategy is used to gauge the effects of local labor market exposure to trade on average wage levels and on unemployment levels. In addition, all estimated versions of expression (11) weight observations by the local labor market's share of national employment at year 2000 and standard errors are clustered at the state level.

The key remaining problem is that there may be variables missing from expression (11) that are correlated with the measure of change in local market exposure to Chinese value-added exports, possibly generating biases in the econometric results from the estimation of this expression. To address this issue, we follow the strategy proposed by ADH (2013) and use the following variable to instrument the change in local labor market exposure to value-added exports from China ( $\Delta LEXP\_VAE^i$ )

$$\Delta IVEXP\_VAE^i = \sum_j \frac{L_{jt-1}^i}{L_{jt-1}^{US}} \frac{\Delta VAE_j^{rich}}{L_{Tt-1}^i}. \quad (12)$$

The variable  $\Delta VAE_j^{rich}$  represents the change in value-added exports from China to other selected developed countries in industry  $j$  between 2000 and 2007.<sup>22</sup> The instrumental variable described by expression (12) uses employment-based variables measured in 1990, ten years prior to the base year. This explains the application of subscript  $t - 1$  in expression (12). In this case, the objective is to mitigate possible simultaneity bias generated by the employment-based variables used to calculate the instrumental variable. Our strategy is to estimate expression (11) using a 2-stage least square approach where expression (12) instruments our measure of change in labor market exposure described by expression (9). Our strategy also provides information about the quality of the instrumental variables, including a statistical test for weak instruments.

An additional component of the empirical strategy is to investigate the effects of traded products on labor market outcomes controlling for their degree of downstreamness. In these cases, we calculate the instrumental variable described by (12) in line with our strategy. For instance, if we measure the change in exposure described by expression (9) using value-added exports from China to the U.S. in final goods, then we also use value-added exports in

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<sup>22</sup>The list of developed countries used in this case can be found below.

final goods from China to selected developed countries in order to construct our instrumental variable. A similar approach is used to relate changes in value-added exports in sectors where the binary variable  $I_j^d$  equals one (high downstreamness) and zero (low downstreamness). In addition, our analysis also considers the effects of net trade flows between China and the U.S. on labor market outcomes. In this particular case, we calculate an additional instrumental variable, based on expression (12), using data on U.S. gross and value-added exports to middle income and transition economies.

### 3.2 Dataset and Basic Statistics

The key variable for estimating expression (11) is the measure of change in local labor market exposure to value-added exports from China described by (9). Moreover, we need to instrument this variable as explained above, which requires value-added exports from China to other developed countries' markets. For this reason, we use information on bilateral value-added exports provided by KWW (2014). Their dataset is organized at the sectorial level using the 2-digit of the International Standard Industrial Classification (ISIC) and it provides sectorial value-added exports among 40 countries constructed from World Input-Output Tables (Timmer et al., 2015). The employment information for the years 1990 and 2000 are provided by ADH (2013) and they are organized at the 4-digit of the Standard Industrial Classification (SIC). We proceed by applying a concordance to the employment information from the 4-digit of the SIC to the 2-digit ISIC since the latter classification is more aggregated, allowing us to relate several SIC codes to a particular code of the 2-digit ISIC.<sup>23</sup> We are then able to calculate the change in exposure to value-added exports by using information on value-added exports and on employment according to expression (9). A similar approach is used to calculate the instrumental variable described by (12) and for the other variables that consider value-added exports according to their degree of downstreamness as exemplified by expressions (10).<sup>24</sup>

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<sup>23</sup>We have also applied the concordance to the value-added export measures from the 2-digit ISIC to the 4-digit of the SIC. Most of the econometric results are robust to this approach as well. However, this approach forces us to disaggregate value-added exports measured at the 2-digit ISIC level into various SIC codes, which requires an assumption about how this should be done. For this reason, we proceeded by aggregating the employment-related variables to the 2-digit ISIC since this does not require additional assumptions to concord the data.

<sup>24</sup>The instrumental variable uses information about Chinese value-added exports to eight developed countries, namely: Australia, Denmark, Finland, Germany, Japan, New Zealand, Spain and Switzerland.

Notice that sectorial value-added exports provided by KWW (2014) measure the domestic value added that originates from a particular industry, and is either exported directly to a particular country by that industry or is exported via forward linkages to ultimately be absorbed abroad.<sup>25</sup> A similar definition is also used in Johnson and Noguera (2012). Importantly, this information implies that our data on sectorial value-added exports are not bound by sectorial gross exports since value added generated by a particular sector can be exported by downstream sectors as well.<sup>26</sup>

Panel A of Table 1 provides information related to the change in U.S.-China trade flows measured between the years 2000 and 2007. First, we note that aggregate Chinese gross exports to the U.S. tend to be greater than aggregate Chinese value-added exports, while the inverse may happen for Chinese imports from the U.S. Second, gross trade flows between the U.S. and China have grown at a faster pace than value-added trade flows. These two points lead to the result that the U.S. trade deficit with China measured using gross exports in 2007 (about \$223 billion) is about 26 percent greater than the U.S. trade deficit measured using value-added exports (about \$177 billion). The fact that the U.S. trade deficit with China is smaller in value-added terms is corroborated by other trade flow measures, such as the ones provided by Johnson and Noguera (2012), which tend to yield numbers of a similar magnitude.

An important part of our econometric exercise is dedicated to assessing the effects of changes in U.S. exposure to Chinese value-added exports while controlling for their degree of downstreamness. As described above, one of the ways in which we measure the degree of downstreamness relies on the ratio between the sectorial foreign value-added content in Chinese gross exports and the sectorial gross exports from that country. Information on foreign value-added content was provided by Wang, Wei and Zhu (2014) and is also organized using the 2-digit ISIC aggregation level. In Panel B of Table 1, we provide aggregate figures for

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<sup>25</sup>Wang, Wei and Zhu (2014) explain in detail the differences between measuring value-added exports using forward linkages and using backward linkages. The former focuses on the contribution of a sector to value added, while the later focuses on the contribution of upstream sectors to the exports of a particular sector. The former is not bound by sectorial gross exports, while the latter is bound by it. This is why (like us) Wang, Wei and Zhu (2014) focus on value-added exports via forward linkages in measuring revealed comparative advantage across countries.

<sup>26</sup>This point is made clear by considering the information described by Table A1 in the online appendix. In this case, we have a list of the top 5 industries in terms of value-added exports greater than gross exports and the top 5 industries in terms of gross exports greater than value-added exports.

the foreign value-added content on trade flows between the U.S. and China. These figures indicate that foreign value added content has grown faster than the bilateral trade flows between these two economies using either value-added or gross exports. This fact corroborates the idea that the international production chain has become longer. Furthermore, this information confirms the greater reliance of Chinese gross exports relative to U.S. gross exports to foreign-made intermediate products. Using information for the year 2007, one can conclude that 24 percent of Chinese gross exports to the U.S. correspond to value added in third countries (about \$72 billion over \$301 billion) in comparison to 11 percent of U.S. gross exports to China (about \$8 billion over \$78 billion). In addition, the data provided by Wang, Wei and Zhu (2014) indicate that sixty-five percent of the foreign value added contained in Chinese exports is used in final goods exported by that country, rather than used in intermediate exported goods, the second highest margin present in the exports of any country in their dataset. This information suggests that many goods exported by China are indeed characterized by great downstreamness levels.<sup>27</sup>

Panel C of Table 1 shows a comparison between the changes in the measure of local labor market exposure to trade flows using gross and value-added exports. This information suggests that the change in the average local labor market exposure using gross exports tends to be significantly higher than the change in the average exposure using value-added exports. This is in line with the discussion involving the pace at which gross exports from China to the U.S. have grown relative to value-added exports. The numbers suggest average increases in exposure to gross Chinese exports of \$2.64 thousand per worker during the years 2000 and 2007, while the average change in exposure based on value-added exports suggests increases of \$1.76 thousand per worker. It is also clear that the dispersion of the distribution of changes in exposure based on gross exports is greater than the dispersion of the distribution using value added, as suggested by the ratio between the standard deviation and the average change in exposure. Notice that the data indicate that the correlation between the U.S. measures of exposure based on gross and value exports from China is 0.23.<sup>28</sup> This suggests

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<sup>27</sup>Expression (5) in our model defines the foreign value added contained in gross exports. In our context, the foreign value added in Chinese exports also includes value added in the U.S. that is embodied in Chinese imports of intermediate products used to produce goods exported by China. The dataset made available by Wan, Wei and Zhu (2014) does not allow us to identify the origin of foreign value added in gross exports, though.

<sup>28</sup>We show in Table A2 in the online appendix that the top 3 U.S. local labor markets in terms of greatest increases in exposure based on gross exports from China differ from the top 3 markets based on value-added

that they are positively albeit not strongly correlated.<sup>29</sup>

The information discussed in Panel C of Table 1 reveals the average differences between value-added exports and gross exports. Still, it may be beneficial to have a visual description of the differences between these two measures of trade flows across U.S. local labor markets (our sample). Moreover, our main goal in the econometric strategy is to relate information about these measures of trade flows to labor market outcomes. These are the reasons why we have decided to compile information on these variables graphically using Figures 1 and 2. In Figure 1, we consider the difference between the changes in U.S. exposure using gross exports and value-added exports across local labor markets between years 2000 and 2007. This figure makes it clear that the main differences in exposure are concentrated in the Southeastern part of the U.S., followed by areas located in the rust belt (e.g. Ohio and Pennsylvania). Differently, Figure 2 focuses on the percentage change in the share of manufacturing employment across U.S. local labor markets. This figure indicates that the main losses in the share of manufacturing employment also took place in the Southeastern part of the U.S. economy. This implies that the measures displayed in Figures 1 and 2 are negatively correlated, implying that the higher the difference between the two exposure measures, the higher tends to be the loss in the share of manufacturing employment.<sup>30</sup> Thus, we can confirm that results using measures based on gross exports may be very different from results using value-added exports and we explore some of these differences below.<sup>31</sup>

Table 2 provides information about the relationship between the average increase in exposure across U.S. local labor markets to value-added exports from China, as well as the change in U.S. exposure to exported goods from other groups of countries, and the degree

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exports from that country. The same applies to the bottom 3 local labor markets.

<sup>29</sup>Notice that the correlation between the sectorial change in Chinese value added exports and gross exports to the U.S. economy between years 2000 and 2007 is 0.77. Thus, this correlation clearly does not control for how different local labor markets are affected, which depends on the employment shares as described by expression (9). The graphical description of the differences in exposure measures is also made obvious with the assistance of Figure 1 as discussed below.

<sup>30</sup>Figure B1 in the online appendix confirms this information by showing graphically the relationship between the two measures. In particular, it shows that the correlation is negative (-0.358) and displays a high t-value (-12.03).

<sup>31</sup>It may be important to provide examples in order to link Figures 1 and 2 to economic reality. According to the newspaper *USAToday* “about 650 textile plants closed between 1997 and 2009, draining thousands of jobs and depressing communities” in U.S. southern states. As described in Table A1 found in the online appendix, the sector related to Textiles and its products is one of the sectors where the gap between Chinese gross and value added exports is the highest, clearly raising the question about the degree to which China has contributed to these negative effects across several Southern communities in the United States. See report at “<https://www.usatoday.com/story/news/nation/2014/02/05/stateline-textile-industry-south/5223287/>”.

of downstreamness of these exported goods. As discussed above, we define the degree of downstreamness according to the use of traded goods (final versus intermediate) as well as using the distribution of the ratio between a country's (or group of countries' according to income level) sectorial foreign value added contained in its exports and its sectorial gross exports. In the latter case, our main results rely on the median, as well as on the 75th percentile, of the distribution of this ratio in defining the variable  $I_j^d$ , which is a key variable in calculating expressions (10). Thus, we define the sectors with the value for this ratio above the median (75th percentile) as being part of the high downstreamness group ( $I_j^d$  equal to one) while sectors with ratio below the median (75th percentile) as being part of the low downstreamness group ( $I_j^d$  equal to zero).

It is clear from Table 2 that, using the definition of downstreamness based on usage, most of the average change in the U.S. exposure to Chinese value added exports is due to an increase in exports from high downstreamness sectors. The same conclusion is obtained using the median of the distribution of the ratio between foreign value added and gross exports.<sup>3233</sup> In this case, the theoretical framework discussed in Section 2.2 suggests that most of the increase in value-added exports from China represents direct competition to U.S. sectors with high downstreamness, possibly causing negative direct effects to manufacturing employment in these sectors and also causing indirect negative effects to their upstream sellers.<sup>34</sup> On the contrary, for all other groups of countries, most of the increase in U.S. exposure is due to increases in value-added exports in low downstreamness sectors. This fact is in line with the idea that trade in intermediate products has become more important because the production chain has become longer. This dichotomy between the value-added exports from China and from other countries may be part of the explanation related to the concern that exists in many policy circles regarding the increase in exports from China to the U.S. In this case,

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<sup>32</sup>By definition, using the 75th percentile of the distribution leads to many more sectors allocated into the low degree of downstreamness group. As such, it is more appropriate to compare average changes in exposure across countries using the 75th percentile of the distribution.

<sup>33</sup>Note that the summation of the change in U.S. exposure to Chinese value added exports in final and in intermediate forms do not add up to the total change in U.S. exposure reported in Panel C of Table 1. The difference corresponds to value-added exports in indirect forms.

<sup>34</sup>Wang, Wei and Zhu (2014) suggest that the importance of Chinese value exports in intermediate goods has substantially increased over the years. Moreover, the sophistication of Chinese exports to the U.S. market has also increased. An important example involves Chinese exports of automobile parts and accessories. By the end of the 2000s, China was exporting to the U.S. transmission electro-hydraulic control modules and control resistors, on top of more simple auto parts such as knobs, rear-view mirrors and etc. More information can be found at <https://www.fas.org/sgp/crs/row/R43071.pdf>.

it is clear that an increase in U.S. exposure to value-added exports from China may have different effects on labor markets from an increase in exposure to value-added exports from other countries.<sup>35</sup>

The dependent variable and the controls for local labor market characteristics used to estimate (11) were provided by ADH (2013). As explained above, we also consider other definitions of exposure, such as exposure defined by net trade flows where we use imports and exports. We also consider exposure depending on the degree of downstreamness and test the robustness of our results to alternative measures of the degree of downstreamness discussed above. Notice that all measures of degree of downstreamness used in our econometric exercises are positively correlated with China's revealed comparative advantage index. Finally, we consider a traditional measure of exposure based on the import penetration ratio, which is defined as the ratio between the value of imports and the value of shipments at the sectorial level. In this case, information on the value of shipments was made available by the U.S. Bureau of Census for the years of 2002 and 2007 and these data are organized according to the 6-digit of the North American Industrial Classification System (NAICS). We use a concordance between the 6-digit of the NAICS and the 4-digit of the SIC made available by David Dorn, and, we can then aggregate the data on the value of shipments from the 4-digit of the SIC to the 2-digit of the ISIC following the same strategy used for employment-related variables as detailed above. Our results are robust to these different measures of exposure as we discuss in the next Section.<sup>36</sup>

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<sup>35</sup>We can relate this discussion about downstreamness to the example described above related to the presence of Textiles and Textile products industry in U.S. Southern states. In our data, Textiles and Textile products figure among industries characterized as having high degree of downstreamness. Thus, despite the fact that Chinese value-added exports are significantly lower than gross exports, the increase in U.S. exposure to Chinese value added in this sector may have significant direct effects on this industry as well as on upstream sectors selling inputs to this industry. Thus, the location of this industry in the production chain can clearly magnify the effects of increased exposure in this case.

<sup>36</sup>The instrumental variable used to control for the endogeneity of the change in U.S. exposure based on the import penetration ratio uses the change in the ratio between the sectorial Chinese exports to the selected developed countries indicated above divided by the U.S. value of shipments, weighted by labor shares as described in expression (12).

## 4 Econometric Results

### 4.1 Basic Results

We can now proceed to the description of our econometric results. Our benchmark model corresponds to the estimation of expression (11) using a 2-stage least square strategy where we instrument the measure of exposure described by (9) using the variable represented by (12). Our basic results are shown in Table 3. In this case, columns (1)-(3) show the results that use gross exports from China to the U.S. in order to measure the change in trade exposure across U.S. local labor markets. Instead, columns (4)-(6) show results that use value-added exports. The sample used in each column of Table 3 covers information on 722 U.S. local labor markets (commuting zones) and covers the changes in exposure between the years 2000 and 2007.

The results displayed in columns (1)-(3) are in line with the results found in ADH (2013) where the contribution of China to changes in U.S. local labor market outcomes is measured using gross exports rather than value-added exports. In essence, these results suggest that an increase in exposure to gross exports from China between the years 2000 and 2007 tends to decrease the share of manufacturing employment in U.S. local labor markets. The results seem robust to the presence of local labor market controls as is evident from a comparison between the parsimonious model used in column (1) relative to the more comprehensive model used in column (3). Moreover, the estimated results show that the instrumental variable is highly correlated with the measure of changes in trade exposure, and that it also passes the weak instrumental variable test found at the bottom of the Table. It is also apparent that the other labor market controls have the same expected signs as obtained by ADH (2013).<sup>37</sup>

These results can be used to gauge the relative importance of changes in trade exposure based on gross exports. Table 2 indicates that the average increase in trade exposure based on gross exports is \$2.64 thousand dollars per worker. This information can be used to conclude that, if we were to use gross exports to measure the contributions of China to

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<sup>37</sup>We have decided to include estimates of the effect of changes in exposure to gross exports from China since we focus on the changes between the years 2000 and 2007, while ADH (2013) focus on the discussion of the results using data from 1990 to 2007. This is the case since we do not have information on value-added exports for the first half of the 1990s.

changes in U.S. local labor market outcomes, the increase in exposure to gross exports from China would have decreased (on average) the share of manufacturing employment across local labor markets by 1.24 percentage points.<sup>38</sup> This is a significant result given that the average decrease in the share of manufacturing employment across local labor markets during this time frame was 2.3 percentage points. In a nutshell, the model suggests that using gross exports from China to measure trade exposure allows us to explain 54 percent of the average decline in the share of manufacturing employment across U.S. local labor markets.

However, as explained in ADH (2013), this measured effect would overstate the effect of the supply shock resulting from economic growth in China over the last decade. In particular, this total effect combines changes in supply related to economic growth in China and changes in relative demand for products in which China has become an important exporter. To disentangle the two effects, and more properly measure the contribution related to Chinese economic growth, we follow ADH's (2013) strategy that relies on an interplay between OLS and the IV estimations without using controls for commuting zone characteristics.<sup>39</sup> This procedure allows us to conclude that about 59 percent of the change in U.S. exposure to gross exports from China is due to supply changes related to economic growth in China. As such, if we were to use gross exports to measure exposure, a more appropriate measure is that the increase in exposure to Chinese gross exports would be responsible for 32 percent of the average decline in the share of manufacturing employment across U.S. labor markets.

A slightly different picture emerges when considering the role played by value-added exports from China on the share of manufacturing employment across U.S. local labor markets. In this case, the results are presented in columns (4)-(6) of Table 3. Notice that the coefficient of our measure of changes in exposure based on value-added exports is also negative, suggesting that increases in exposure to value-added exports from China have also led to a decrease in the share of manufacturing employment across U.S. local labor markets. The

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<sup>38</sup>This effect is the result of the product of the average increase in exposure (2.64) and the coefficient of the change in exposure (-0.469).

<sup>39</sup>The OLS version of column (1) of Table 4 yields a coefficient equal to -0.436. The regression of the dependent variable on the difference between the variable measuring exposure and its instrumental variable yields a coefficient equal to -0.03. Using the coefficient for column (1) of Table 4 and these two coefficients, yields an estimated effect of Chinese growth on the total exposure to Chinese gross exports equal to 0.59. Instead, ADH (2013) suggest a contribution of Chinese growth of 0.48. The difference between our results is due to using data between the years 1990 to 2007 in their case, and our using a sample covering the year 2000 to 2007. See the appendix in ADH (2013) for more details.

point estimates suggest that the average effect of changes in exposure to value-added exports from China is significantly smaller than the effect obtained measuring exposure using gross exports as a comparison between the results in columns (3) and (6) seem to indicate.<sup>40</sup> Moreover, this result is less statistically robust, since, as we move from the parsimonious model described in column (4) to the results described in columns (5) and (6), it is clear that the degree of statistical significance of the coefficient of changes in trade exposure declines.

The presence of differences between the effects of changes in U.S. exposure based on gross exports and value added exports from China is not entirely surprising. First, notice that Figures 1 and 2 suggest that the difference between the changes in U.S. exposure based on gross exports and value-added exports from China is negatively correlated with the change in the share of manufacturing employment across U.S. local labor markets. This result provides strong indications that these changes in exposure can have different effects on the share of manufacturing employment. Second, our model as well as the literature suggest that the effects of an increase in Chinese value-added exports could also depend on the degree of downstreamness of the exported goods. In this case, an increase in value-added exports from sectors with high degree of downstreamness should have a negative effect on the share of manufacturing employment in the U.S.. On the contrary, Chinese value-added exports in sectors with low degree of downstreamness could have an ambiguous effect on the share of manufacturing employment as U.S. manufacturing firms could become more competitive by having greater access to foreign-produced inputs, and these traded products tend to affect less the demand for goods and services provided by upstream sellers. Notice that Table 2 suggests that the increase in U.S. exposure to Chinese value-added exports in sectors with low degree of downstreamness is significant.<sup>41</sup>

We then proceed to investigate the effects of the changes in U.S. exposure to Chinese value-added exports taking into account the degree of downstreamness of traded goods. Table

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<sup>40</sup>This fact can be verified by taking the product between the average increase in exposure based on value-added exports of 1.76 in Table 2, the coefficient of the measure of change in exposure found in column (6) of Table 4, and also multiplying by 0.59 given that we are concerned with the supply side effects related to Chinese growth. This yields an average decline in the share of manufacturing employment of 0.37 percentage points, which corresponds to about 16 percent of the observed change in the share of manufacturing employment.

<sup>41</sup>For instance, focusing on the degree of downstreamness determined by the median of the ratio between foreign value added contained in exports and gross exports, suggests that 48 percent of the U.S. increase in exposure to Chinese value-added exports is related to exports from Chinese sectors displaying low degree of downstreamness (ratio of \$0.85 per worker and \$1.76 per worker).

4 shows the results using value-added exports according to their degree of downstreamness using the measures discussed in Section 3.2. In this case, every specification controls for all labor market characteristics available in our dataset, the same ones used in columns 3 and 6 of Table 3. The specifications used in columns (1) - (3) control for changes in exposure to value-added exports from China in sectors with high degrees of downstreamness, while the specifications in columns (4)-(6) control for changes in exposure to value-added exports from China in sectors with low degrees of downstreamness. In this case, the specifications in columns (1) and (4) define the degree of downstreamness based on the usage of exported goods; the specifications in columns (2) and (5) measure the degree of downstreamness based on the median of the distribution of the ratio between the foreign value added contained in sectorial Chinese exports and the sectorial gross exports, while the specifications in columns (3) and (6) use the 75th percentile of the distribution of this ratio in defining the degree of downstreamness.

The results in columns (1)-(3) of Table 4 confirm that an increase in value added exports from China in sectors with high downstreamness tends to decrease the share of manufacturing employment across U.S. local markets. This is true regardless of whether or not local labor market characteristics are controlled for, although we report the specifications controlling for all labor market characteristics we have available to us. Notice that this effect is highly statistically significant across all measures used in specifications (1)-(3). Moreover, it is also economically important. Table 3 indicates that the average increase in U.S. exposure to value-added exports from China in final goods was \$0.93 thousand per worker, while it also suggests an average change in U.S. exposure to value-added exports with high degree of downstreamness using the median of the distribution of \$0.91 thousand per worker. Keeping in mind that only 59 percent of the changes in U.S. exposure to exports from China is due to economic growth in that country as discussed above, we can conclude that the U.S. increase in exposure to value-added exports in high downstreamness sectors can (on average) explain between 38 and 44 percent of the decline in the share of manufacturing employment across local labor markets.<sup>42</sup>

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<sup>42</sup>This result can be obtained by first multiplying the coefficients of the change in U.S. exposure (-1.588, -1.881), by the average changes in U.S. exposure (\$0.93 thousand and \$0.91 thousand) across local labor markets from Table 2, and by the contribution of economic growth in China of 0.59. Then, we divide the product of these numbers by the average decrease in the share of manufacturing employment across local labor markets (2.3).

The results in columns (4)-(6) of Table 4 are also very much in line with the intuition discussed above related to the role played by the degree of downstreamness of exported goods. In these specifications, an increase in U.S. exposure to value-added exports from China in sectors with low degree of downstreamness leads to an increase in the share of manufacturing employment. However, the results do not seem statistically significant, and, economically speaking, they yield significantly smaller changes in the share of manufacturing employment than the results obtained in columns (1)-(3).<sup>43</sup> Thus, the expected dichotomy between the effects of an increase in U.S. exposure to exports in sectors with low degrees of downstreamness versus sectors with high degrees of downstreamness is confirmed by our results. In general, these results are in line with our intuition, as well as with conclusions of the theoretical model discussed in Section 2.2, that suggests distinct effects on labor markets depending on the degree of downstreamness of exported goods.<sup>44</sup>

We notice from Table 1 that U.S. value-added exports to China grew by more than 200 percent between the years 2000 and 2007, certainly a substantial rate of growth although smaller than the growth rate of value-added exports from China to the U.S. The question is whether or not our main conclusions related to the average role played by value-added exports on the U.S. economy changes by taking into account the substantial growth of U.S. value added exports to China. Table 5 investigates this issue and considers the effect of U.S. net trade exposure with China in terms of gross exports and in terms of value-added exports. In this case, column (1) considers the effects of U.S. net trade exposure based on gross exports and we find that increases in gross exports from China have deleterious effects on the share of manufacturing employment in U.S. local labor markets. The estimates described in column (1) suggest that the increase in the U.S. net exposure to trade with China has decreased the U.S. share of manufacturing employment across labor markets by 0.42 percentage points, which corresponds to 19 percent of the actual average decrease in the share of manufacturing employment.<sup>45</sup> Needless to say, the effects of U.S. exposure to trade

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<sup>43</sup>For instance, the results in column 4 suggest that an increase in U.S. exposure to Chinese value-added exports in intermediate goods tends to increase the share of manufacturing employment by 7 percent.

<sup>44</sup>As indicated previously, we do not include results for changes in U.S. exposure to value-added exports from China in indirect form separately. However, the results involving value-added exports in indirect form are similar to the direction of the results shown in Tables 4-9 for value-added exports in intermediate goods and they are available upon request.

<sup>45</sup>This result can be obtained by multiplying the coefficient of the change in U.S. net exposure (0.33) by the average change in U.S. net exposure (\$2.2 thousand) across local labor markets, and by the contribution

with China based on gross exports decreases significantly by considering the contribution of U.S. exports to China.

Next, we focus on the effects of U.S. net exposure to trade with China using value-added exports. Column (2) makes it clear that, even taking into account the effects of U.S. value-added exports, our results suggest that changes in the U.S. net exposure to value-added trade with China may have led to negative effects on the share of manufacturing employment across U.S. local labor markets. However, we find that this result is not very statistically robust. In this case, the results described in Column (6) of Table 3 are re-enforced since the effects of U.S. value added exports to China may have the opposite effect of Chinese value-added exports to the U.S. However, as we consider the effects of value-added trade controlling for the degree of downstreamness of exported goods, an even clearer picture of the different effects emerge. Columns (3)-(5) confirm that the net effect of changes in U.S. exposure to value-added trade in sectors with high degree of downstreamness on the share of manufacturing employment is negative and statistically significant, while the results described in columns (6)-(8) indicate that the effect of changes in net value-added exposure in sectors with low degree of downstreamness is positive albeit not statistically significant. The bottom line is that the net effect of changes in value-added trade with China on U.S. manufacturing employment seems to depend on the position of the industry exporting to the U.S. economy in the global value chain. These results are also in line with our theoretical framework.

## 4.2 Other Labor Market Outcomes

One important issue that we have yet to address is how changes in U.S. exposure to international trade affect other important labor outcomes and whether or not the effects vary depending on the level of downstreamness of traded goods. In particular, we consider the effects of changes in U.S. exposure to Chinese exports on average wages and on the share of unemployed workers across U.S. local labor markets.<sup>46</sup> Our initial strategy consists in

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of economic growth in China of 0.59.

<sup>46</sup>Hummels et al. (2014) find that offshoring has also lead to increases in within-group and across-group inequality. Our results are not in contradiction with their results, as we are measuring the effects of value added exports that may or may not represent offshoring activities. Moreover, we measure the effects of trade on average wages for workers whose exposure to trade will vary at the firm-level, job status and skill set.

replacing the dependent variable in expression (11) by the change in average wages for U.S. local labor markets, while we calculate changes in U.S. exposure to trade using gross exports and value-added exports from China as we did for Tables 3 and 4. A similar approach is used to consider the effects of exposure on the share of unemployed workers.

The literature has not only considered the average effects of trade across all workers but has also considered the heterogeneity of trade effects across groups of workers. In particular, Hummels et al. (2014) consider the different effects of offshoring on workers with high and low skills, while Ebenstein et al. (2014) investigates the effects of greater exposure to trade flows and offshoring activities on workers controlling for the degree of routineness of their occupations. In both cases, an increase in exposure to trade flows and offshoring seems to have heterogeneous effects across groups of workers. In the former case, low-skilled workers tend (on average) to be more negatively effected by offshore activities than high-skilled workers, while, in the latter case, greater import competition tends to have negative affects on workers involved with occupations displaying high levels of routineness while workers involved with occupations displaying low and middle levels of routineness are not negatively affected.

We consider the heterogeneous effects of changes in U.S. exposure to exports from China by investigating its effects on college educated workers and non-college educated workers following an approach similar to ADH (2013). In this case, we replace the dependent variable used in expression (11) by the average change in weekly wages measured in log points, as well as by the change in the share of unemployed workers, across local labor markets. The average of these variables across local labor markets indicate that average wages have increased by 3.84 log points between years 2000 and 2007, while the unemployed share has increased by 3.42 percent during the same time frame. However, there seems to exist considerable heterogeneity across groups of workers. In particular, the wage of college educated workers tends to increase more than three times as much as the wages of non-college educated workers, while the unemployment rate among non-college educated workers grows more than three times as much as the unemployment rate of college educated workers.

These correlations certainly reveal significant heterogeneity across groups of workers but our main interest is to relate changes in U.S. exposure to changes in these labor market outcomes. The results of our econometric approach can be found in Tables 6 and 7. The

results shown on columns (1) and (2) of Table 6 suggest that changes in exposure, either using gross exports or using value-added exports from China, are not statistically significant in explaining changes in wage levels across U.S. local labor markets. However, the results clearly depend on the degree of downstreamness of exported goods. A comparison between the results shown in columns (3) and (4) with the results shown in columns (5) and (6) strongly suggests that increased U.S. exposure to exports from sectors with low degree of downstreamness has a positive and statistically significant effect on wages, while greater exposure to goods exported by sectors with high degree of downstreamness do not have a statistically significant effect. Notice that these results are economically important since, for instance, they suggest that the average increase in the U.S. exposure to value-added exported by China in low downstreamness sectors tends to increase average wages by 0.62 log points according to column (6) of Table 6, which accounts for 16.1 percent of the increase in wages between 2000 and 2007.<sup>47</sup> It is important to highlight that these effects tend to be stronger for non-college educated workers both in economic and in statistical terms.

Table 7 describes the econometric results exploring the causal relationship between U.S. exposure to Chinese exports and the unemployment rate across U.S. local labor markets. Again, the results shown in columns (1) and (2) of Table 7 suggest that changes in exposure, either using gross exports or using value-added exports from China, are not very statistically significant in explaining changes in the unemployment rate across U.S. local labor markets. However, the results clearly depend on the degree of downstreamness of exported goods. It is clear from the results in columns (5) and (6) that an increase in exposure to Chinese exported goods in low downstreamness sectors decreases the unemployment rate and this result is robust to using the sample including all employed workers, as well as using the different samples of workers controlling for their educational level. Moreover, the results in column (6) also show that this effect tends to be stronger in economic and in statistical

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<sup>47</sup>This result can be obtained by multiplying the coefficient of column 6 (1.234) by the average increase in U.S. exposure to low downstreamness sectors using the median of the distribution found in Table 3 (0.85), and by share of the increase in U.S. exposure to China due to supply side effects (0.59). Then, we divide the product among these components by the average increase in wages (3.84).

terms for the sub-sample of non-college educated workers.<sup>4849</sup>

### 4.3 Robustness Tests

We establish above that the average effect of an increase in exposure to value-added exports from China on the U.S. share of manufacturing employment depends on the position of the exporting industry on the global value chain. In particular, we found that the effect of value-added exports in sectors with high degree of downstreamness differs from the effect of value-added exports in sectors with low degree of downstreamness. These results readily extend to other labor market outcomes (e.g., average wages and unemployed rates) where we show that the effect on an increase in U.S. exposure to Chinese value-added exports also depends on the degree of downstreamness of the exporting industry. We can now explore other results related to trade flows between the U.S. and China.

Tables 4-7 rely on two specific measures of downstreamness and we can now consider the robustness of our results to changes in these measures. In particular, we consider three additional measures in constructing the dummy  $I_j^d$  used to identify sectors with high and low degrees of downstreamness. In addition, we investigate the effects of changes in U.S. exposure to gross exports from China while controlling for the degree of downstreamness of the Chinese exporting industry. First, Panel A of Table 8 examines our results using the ratio between Chinese sectorial foreign value added used in exports of final goods and sectorial Chinese gross exports. Second, Panel B of the same table considers the same results using the ratio between Chinese sectorial foreign value added used in exports and the summation between sectorial foreign value added and sectorial value added exports from China. Third, Panel C of Table 8 identifies sectors with low and high degrees of downstreamness based on the downstreamness index used in Antràs et al. (2012), while Panel D investigates the effects of changes in U.S. exposure to Chinese gross exports depending on the degree of

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<sup>48</sup>Notice that the lack of statistical significance for the coefficients on value-added exports from China in columns (3) and (4) of Table 8 can be explained as follows. An increase in U.S. exposure to Chinese value-added exports in sectors with high degree of downstreamness decreases the share of manufacturing employment as made evident by Table 4, while it increases the share of non-manufacturing employment. These two forces tend to offset each other and that explains the results found in columns (3) and (4). The results related to the effects of changes in exposure on the share of non-manufacturing employment are available upon request.

<sup>49</sup>Notice that we can find the results described in ADH (2013) on wages and on unemployment, using information on gross exports from China to the U.S., if we incorporate changes from 1990-2000 into the dataset. However, this result may be sensitive to the time frame used as made evident by Tables 6 and 7.

downstreamness.<sup>50</sup>

The additional measures of downstreamness used in Panels A-C of Table 8 are strongly correlated with the revealed Chinese comparative advantage index. In all cases, the results provide ample support to our previous findings. In particular, the results indicate that an increase in U.S. exposure to Chinese value-added exports in sectors with high degree of downstreamness tends to decrease the share of manufacturing employment (see results in columns (1)-(2)) while the opposite may happen in the case of an increase in exposure to exports from sectors with low degree of downstreamness (see results in columns (3)-(4)). Our paper primarily focuses on the direct contributions of the Chinese economy to labor market outcomes which is better captured by its value-added exports. However, Panel D of Table 8 considers the effects of changes in U.S. exposure to gross exports from China controlling for the degree of downstreamness of the exporting industry. In this case, we measure the identifier dummy  $I_j^d$  using the distribution of the ratio between sectorial foreign value added in Chinese exports and sectorial gross exports from China. This is the same methodology employed in Tables 4-7. The results in Panel D confirm the previous results regarding the relationship between the degree of downstreamness and labor market outcomes. In sum, these results are very in line with our previous ones.

So far we have measured changes in U.S. exposure to trade flows with China using changes in gross exports or changes in value-added exports. However, it is apparent that many strands of this literature refer to exposure of an industry to foreign competition by relying on measures of import penetration. This is the case of Ebenstein et al. (2014) and Acemoglu et al. (2014) that measure the exposure of an industry to globalization using import penetration ratios. A similar argument can be found in most of the literature on the political economy of trade (Grossman and Helpman (1994)). In Table 9, we investigate the effects of changes in the U.S. exposure to trade with China using changes in import penetration instead of the changes in trade flows per worker used in previous results.

The results described in Table 9 are very much in line with the results found in Tables 4-5.

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<sup>50</sup>Panel C focuses on the upstreamness measure proposed by Antràs et al. (2012) which relies on information provided by the OECD STAN database. The main idea of their index is that the degree of upstreamness for a sector should be directly related to its average distance from final use. Thus, industries selling most of their output to relatively upstream industries should be relatively upstream themselves. We construct our dummy  $I_j^d$  used in expressions (10) taking into account that lower values of their index implies higher levels of downstreamness.

Column (1) of Table 9 indicates that an increase in U.S. exposure to trade with China based on gross import penetration leads, on average, to a decrease in the share of manufacturing employment across local labor markets. In column (2), we calculate import penetration using value-added exports from China to the U.S., and the results suggest that an increase in exposure to trade with China based on value-added import penetration does not lead to a statistically significant change in the share of manufacturing employment. The results in columns (3)-(6) explain these different results, namely: an increase in U.S. exposure to import penetration measured using value-added exports from China in sectors with high degree of downstreamness has a negative effect on the share of manufacturing employment, while an increase in U.S. exposure to import penetration in sectors with low degree of downstreamness has a positive effect on the share of manufacturing employment. These results are clearly in line with the results from previous tables.

It is also important to consider whether the effects of changes in U.S. exposure to trade with China differ from the effects of changes in exposure to trade with other countries. For instance, Ebenstein et al. (2014) find that an increase in U.S. offshoring activities to low income countries decreases the real wages of professions that perform routine tasks, while the opposite is found for an increase in U.S. offshoring activities to high income countries. Table 2 provides strong evidence that the profile of the change in the U.S. exposure to value-added exports from China differs from the profile of the change in exposure to other groups of countries. This is the case since the change in U.S. exposure to China is biased towards sectors with high degree of downstreamness while for all other groups it is biased towards sectors with low degree of downstreamness. As pointed out by our theoretical model, we should expect that these two different profiles could yield different effects on labor market outcomes.

The dataset made available by KWW (2014) allows us to calculate changes in exposure following expression (9) using gross and value added exports from middle income and high income countries. Likewise, the dataset made available by Wang, Wei and Zhu (2014) provides information on sectorial foreign value added used in gross exports that we use in identifying sectors with low and high degrees of downstreamness for these different groups of countries. The division of countries into the middle and high income country groups follows

the criteria used by the World Bank to define countries according to their national income.<sup>51</sup> We eliminate from both groups the transition economies since these were economies that for decades have been subject to a substantial degree of central planning, and, therefore, differ in their economic structure from most other members of both groups. Moreover, the change in U.S. exposure to exports from transition economies is quite petite as the numbers in Table 2 clearly indicate. Table 10 shows the results of changes in U.S. trade exposure to exports from each group of countries on the share of manufacturing employment across U.S. local labor markets.

It is clear that there is a dichotomy in the results for these two groups. A comparison between results shown in column (1) indicates that an increase in U.S. exposure to gross exports from middle income countries leads to a decline in the share of U.S. manufacturing employment, while the predicted effect of an increase in exposure to gross exports from high income countries is positive but this effect is not statistically significant. This dichotomy is in line with those obtained by Ebenstein et al. (2014). Instead, column (2) uses value-added exports to the U.S. to calculate the measure of exposure. The results shown in this column suggest that an increase in U.S. exposure to value-added exports from high income countries has a positive and statistically significant effect on the share of manufacturing employment, while the effect is not statistically significant for middle income countries. The results shown in columns (3) and (4) suggest that an increase in U.S. exposure to value-added exports in sectors with high downstreamness is negative for exports from middle income countries and is positive for exports from high income countries. However, in the case of exposure to exports in low downstream sectors, the results in columns (5) and (6) suggest that an increase in exposure can have a positive effect on the share of manufacturing employment. Thus, the results for middle income countries resemble well the results described above for China.<sup>52</sup>

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<sup>51</sup>According to the World Bank's criteria, the only low income country in the KWW's (2014) dataset is India. Thus, we include India as part of the group of middle income countries. Notice that we exclude exports from China to the U.S. from both groups of countries.

<sup>52</sup>In the online appendix, we show that our results are robust to relying on different measures of value added exports. In particular, Table A3 in the appendix shows the results using value added exports made available by Johnson and Noguera (2012). These results confirm that an increase in U.S. exposure to value-added exports tends (on average) to decrease the share of manufacturing employment across local labor markets but this result is not very statistically robust.

## 5 Conclusion

This paper highlights that the direct contribution of China to U.S. local labor market outcomes has to be gauged with caution for two main reasons. First, Chinese exports contain a significant degree of content that originates in other trading partners including the U.S. economy. This implies that Chinese gross exports to the U.S. are significantly different from Chinese exports measured in value-added terms. Second, Chinese exports vary in their position in the global value chain with a significant share consisting of exports from sectors with low degree of downstreamness (i.e., not close to the bottom of the production chain). Recent results by ADH (2013) find strong negative effects of the growth of Chinese gross exports to the U.S. in terms of manufacturing employment and wages across U.S. commuting zones.

We investigate the effects of trade between the U.S. and China on the former country's labor market outcomes using the recent dataset organized by KWW (2014). Their dataset provides information on Chinese value-added exports to the U.S. and also decomposes them according to the usage of traded goods. Our results suggest that the direct contribution of China to U.S. labor market outcomes depends on the position of the exported goods from China on the global value chain. In this case, we find that the increase in U.S. exposure to Chinese value-added exports in sectors with high degree of downstreamness has led to a decrease in the share of manufacturing employment, while the opposite is found for value-added exports in sectors with low degree of downstreamness. These findings are robust in relation to controlling for U.S. value-added exports to China, and they are also in line with our theoretical framework which relies on the presence of economies of scale and firm homogeneity in terms of technology (within a country).

Finally, we do not find any average effect on wages, as well as none on the share of unemployed workers, due to an increase in U.S. exposure to Chinese exports during this time frame, except when controlling for the degree of downstreamness of exported goods. In this case, a positive effect is found for value-added exports in sectors with low degree of downstreamness, in particular for non-college educated workers. The results also make it clear that the effects of U.S. exposure to China are different from U.S. exposure to high income countries, and this is also due to the position of exported goods in the global value

chain.

## References

- [1] Acemoglu, Daron, David Autor, David Dorn, Gordon Hanson and Brendan Price (2016) “Import Competition and the Great U.S. Employment Sag of the 2000s”, *Journal of Labor Economics*, vol. 34(51), pp. S141-S198.
- [2] Antràs, P, Davin Chor, Thibault Fally, and Russell Hillberry (2012) “Measuring the Upstreamness of Production and Trade Flows”, *American Economic Review*, vol. 102, pp. 112-116.
- [3] Antràs, P. and E. Helpman. 2004. ”Global Sourcing,” *Journal of Political Economy*, vol. 112 (3), pp. 552–580.
- [4] Autor, David H., David Dorn and Gordon H. Hanson (2013) “The China Syndrome: Local Labor Market Effects of Import Competition in the United States”, *American Economic Review*, vol. 103, pp. 1553-1597.
- [5] Blaum, J., C. Lelarge, and M. Peters. 2016. ”The Gains from Input Trade in Firm-Based Models of Importing,” Working paper.
- [6] Costa, Francisco, Jason Garred and João Paulo Pessoa (2016) “Winners and losers from a commodities-for-manufactures trade boom”, *Journal of International Economics*, vol. 102, pp. 50-69.
- [7] Dedrick, Jason, Kenneth L. Kraemer, and Greg Linden (2009) “Who Captures Value in a Global Innovation Network? The Case of Apple’s iPod,” *Communications of the ACM*, vol. 52 (3), pp. 140-144.
- [8] Dedrick, Jason, Kenneth L. Kraemer, and Greg Linden (2011) “Capturing Value in Global Networks: Apple’s iPad and iPhone,” University of California, Berkeley, mimeo.
- [9] Ebenstein, Avraham, Ann Harrison, Margaret McMillan, and Shannon Philips (2014) “Estimating the Impact of Trade and Offshoring on American Workers Using the Current Population Surveys”, *Review of Economics and Statistics*, vol. 96, pp. 581-595.
- [10] Goldberg, Pinelopi, Amit Kumar Khandelwal, Nina Pavcnik and Petia Topalova (2010) “Imported Intermediate Inputs and domestic Product Growth: Evidence from India”, *Quarterly Journal of Economics*, vol. 125, pp. 1727-1767.
- [11] Grossman, Gene and Elhanan Helpman (1994) “Protection for Sale”, *American Economic Review*, vol. 84, pp. 833-850.
- [12] Halpern, L., M. Koren, and A. Szeidl. 2015. ”Imported Inputs and Productivity,” *American Economic Review*, vol. 105 (12), pp. 3660–3703.
- [13] Hummels, David, Rasmus Jorgensen, Jakob Munch and Chong Xiang (2014) “The Wage Effects of Offshoring: Evidence from Danish Matched Worker-Firm Data”, *American Economic Review*, vol. 104, pp. 1597-1629.
- [14] Hummels, David, J. Ishii and Kei-Mu Yi (2001) “The Nature and Growth of Vertical Specialization in World Trade” *Journal of International Economics*, vol. 54 (1), pp. 75-96.

- [15] Johnson, Noguera and Guillermo Noguera (2012) “Accounting for intermediates: Production sharing and trade in value added”, *Journal of International Economics*, vol. 86, pp. 224-236.
- [16] Kee, Hiau Looi and Heiwai Tang (2016) “Domestic Value Added in Exports: Theory and Firm Evidence from China”, *American Economic Review*, vol. 106 (6), pp. 1402-1436.
- [17] Koopman, Robert, Zhi Wang and Shang-Jin Wei (2014) “Tracing Value-Added and Double Counting in Gross Exports”, *American Economic Review*, vol. 104, pp. 459-494.
- [18] “Latin America and the Caribbean’s Response to the Growth of China and India: Overview of Research Findings and Policy Implications”, World Bank 2006.
- [19] Pierce, Justin R. and Peter K. Schott (2016) “The Surprisingly Swift Decline of U.S. Manufacturing Employment”, *American Economic Review*, vol. 106 (7), pp. 1632-1662.
- [20] Timmer, Marcel P., Erik Dietzenbacher, Bart Los, Robert Stehre and Gaaitzen J. de Vries. (2015). “An Illustrated User Guide to the World Input-Output Database: the Case of Global Automotive Production”, *Review of International Economics*, vol. 23, pp. 575-605.
- [21] Wang, Zhi, Shang-Jin Wei and Kufu Zhu (2014) “Quantifying International Production Sharing at the Bilateral and Sector Levels”, NBER working paper 19677.
- [22] Xing, Yuqing and Neal Detert (2010) “How the iPhone Widens the United States Trade Deficit with the People’s Republic of China”, ADBI working paper 257.s

Figure 1. Difference between Gross and Value-Added Trade Exposure from China

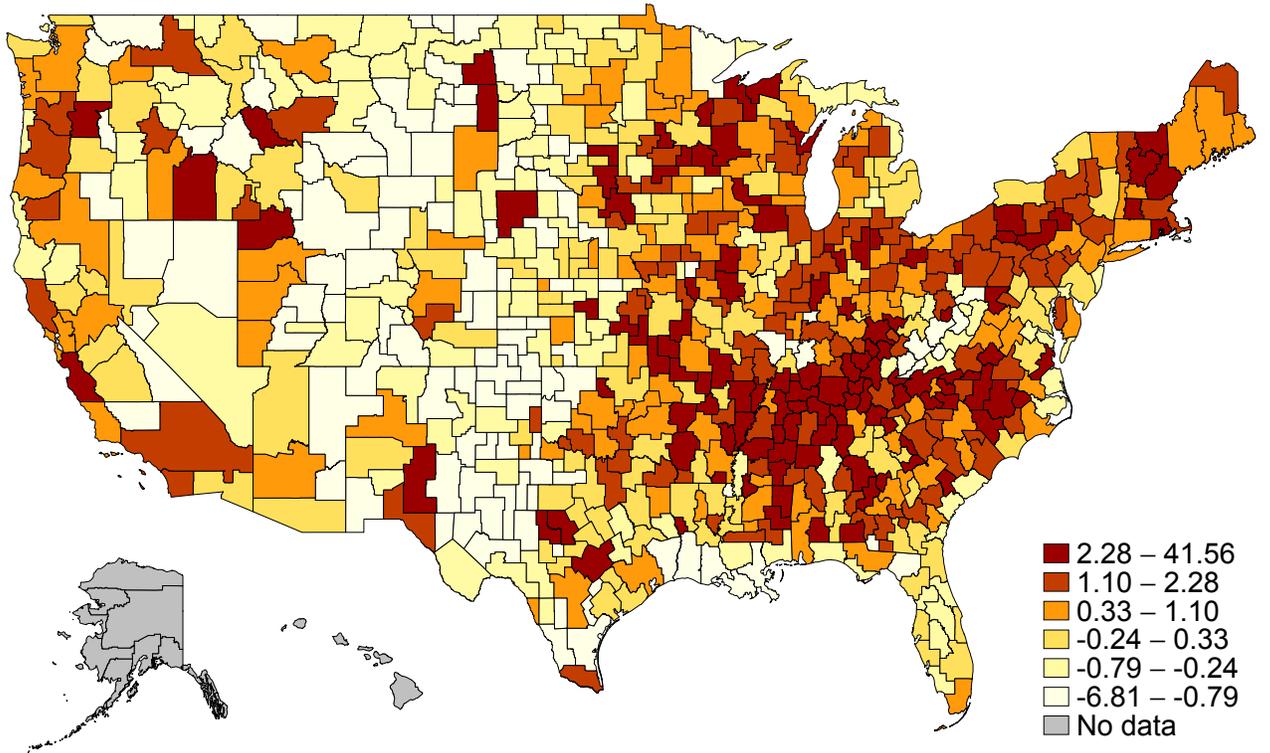


Figure 2. Change in Share of Manufacturing Employment

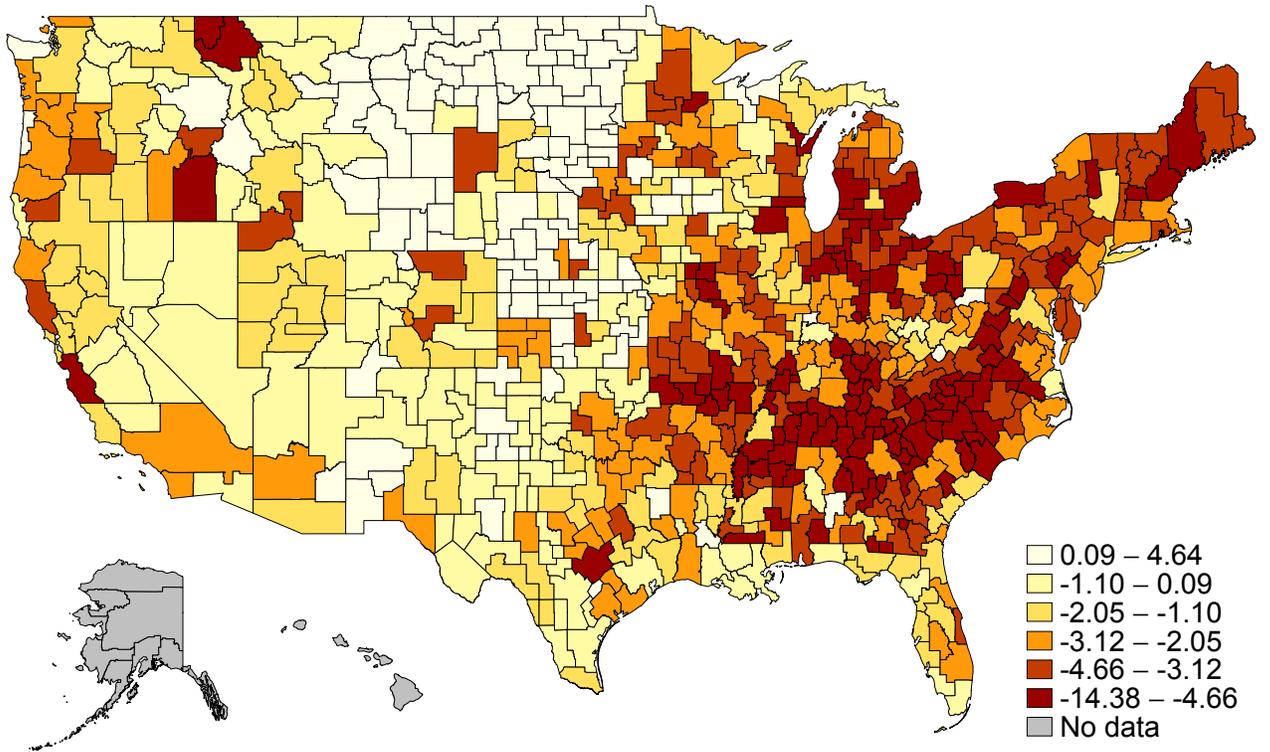


Table 1: U.S.-China Trade Flows<sup>a</sup>

Panel A - US-China Trade Flows					
Year	Chinese Gross Exports	Chinese Gross Imports	US Gross Trade Deficit		
2000	74524	19167	55357		
2007	300791	77931	222860		
Percent Change	303.6	306.6	303		
Year	Chinese Value-Added Exports	Chinese Value-Added Imports	US Value -Added Trade Deficit		
2000	68818	21845	46973		
2007	245564	68749	176815		
Percent Change	256.8	214.7	276		
Panel B - FVA in US-China Trade Flows					
Year	FVA in Chinese Gross Exports	FVA in Chinese Gross Imports	US FVA Trade Deficit		
2000	13217	2050	11167		
2007	71952	8300	63652		
Percent Change	444.4	304.9	470		
Panel C - Basic Exposure Figures					
	U.S. exposure in gross exports	U.S. exposure in value-added exports			
	Change (2000 - 2007) - average	2.64	1.76		
	Change (2000 - 2007) - std. dev.	3.02	0.76		

<sup>a</sup> Trade flows defined in millions of US dollars. FVA stands for foreign value-added content in gross exports

Table 2: Downstreamness and the Average Change in U.S. Exposure<sup>a</sup>

Mean (std dev)	Final goods	Above median	Above 75th	Intermediate goods	Below median	Below 75th
China						
High downstreamness ( $\Delta$ value-added exports from China to US) / worker	0.93 (0.40)	0.91 (0.61)	0.57 (0.49)			
Low downstreamness ( $\Delta$ value-added exports from China to US) / worker				0.65 (0.29)	0.85 (0.69)	1.18 (0.65)
High Income						
High downstreamness ( $\Delta$ value-added exports from China to US) / worker	0.40 (0.34)	0.64 (0.61)	0.47 (0.59)			
Low downstreamness ( $\Delta$ value-added exports from China to US) / worker				1.53 (1.63)	1.73 (2.05)	1.90 (2.02)
Middle Income						
High downstreamness ( $\Delta$ value-added exports from China to US) / worker	1.10 (0.43)	1.07 (0.74)	0.64 (0.52)			
Low downstreamness ( $\Delta$ value-added exports from China to US) / worker				1.59 (1.74)	1.89 (2.35)	2.32 (2.32)
Transition						
High downstreamness ( $\Delta$ value-added exports from China to US) / worker	0.02 (0.01)	0.08 (0.10)	0.05 (0.09)			
Low downstreamness ( $\Delta$ value-added exports from China to US) / worker				0.26 (0.32)	0.33 (0.44)	0.36 (0.45)

<sup>a</sup>Exposure is measured in thousands of dollars per worker. The list of high income countries includes Australia, Austria, Belgium, Canada, Cyprus, Germany, Denmark, Spain, Finland, France, Great Britain, Greece, Ireland, Italy, Japan, Korea, Luxemburg, Malta, Netherlands Portugal, Sweden and Taiwan. The list of middle income countries includes Brazil, China, Indonesia, India, Mexico and Turkey. The list of transition economies includes Bulgaria, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Russia, Slovakia and Slovenia.

Table 3: Value-Added Exports from China and Change in U.S. Manufacturing Employment<sup>a</sup>

	(1)	(2)	(3)	(4)	(5)	(6)
I. 2000-2007 2SLS						
( $\Delta$ gross exports from China to US) / worker	-0.718*** (0.064)	-0.426*** (0.116)	-0.469*** (0.123)			
( $\Delta$ value-added exports from China to US) / worker				-1.391*** (0.501)	-0.382 (0.273)	-0.354 (0.324)
Percentage of employment in manufacturing <sub>-1</sub>		-0.100*** (0.027)	-0.083*** (0.025)		-0.162*** (0.019)	-0.162*** (0.021)
Percentage of college-educated population <sub>-1</sub>			0.000 (0.021)			-0.015 (0.019)
Percentage of foreign-born population <sub>-1</sub>			0.057*** (0.013)			0.045*** (0.011)
Percentage of employment among women <sub>-1</sub>			0.064* (0.039)			0.065* (0.035)
Percentage of employment in routine occupations <sub>-1</sub>		-0.111 (0.105)	-0.143 (0.093)		-0.055 (0.094)	-0.078 (0.084)
Average offshorability index of occupations <sub>-1</sub>		0.036 (0.368)	-0.670* (0.344)		-0.601 (0.396)	-1.129*** (0.353)
Census division dummies	No	Yes	Yes	No	Yes	Yes
R <sup>2</sup>	0.14	0.52	0.53	0.19	0.57	0.60
II. 2SLS first stage estimates						
( $\Delta$ value-added exports from China to OTH) / worker	0.767*** (0.085)	0.536*** (0.097)	0.528*** (0.099)	0.935*** (0.046)	0.799*** (0.035)	0.799*** (0.037)
Adjusted R <sup>2</sup>	0.45	0.52	0.52	0.75	0.85	0.85
Kleibergen-Paap's Weak IV Test	80.715	20.522	27.821	404.813	512.089	466.397
(pass 5 percent critical value?)	Y	Y	Y	Y	Y	Y

<sup>a</sup>Dependent variable: Annual changes in manufacturing emp/working-age pop (in percentage points). Information on trade exposure available using thousands of US dollars per worker. VAX stands for value-added exports from China. Sample size in all columns is 722, which corresponds to the number of commuting zones available in the dataset. Superscripts “\*\*\*”, “\*\*” and “\*” represent statistical significance at the 1, 5 and 10 percent levels, respectively. Standard errors are clustered at state level.

Table 4: The Role of Downstreamness and the Share of Manufacturing Employment<sup>a</sup>

	I. 2000-2007 2SLS					
	(1)	(2)	(3)	(4)	(5)	(6)
	Final goods	Above median	Above 75th	Intermediates	Below median	Below 75th
High downstreamness ( $\Delta$ value-added exports from China to US) / worker	-1.558** (0.706)	-1.881*** (0.563)	-2.698*** (0.427)			
Low downstreamness ( $\Delta$ value-added exports from China to US) / worker				0.423 (0.655)	0.429 (0.277)	0.519 (0.334)
Percentage of employment in manufacturing <sub>-1</sub>	-0.139*** (0.020)	-0.077** (0.033)	-0.066*** (0.022)	-0.179*** (0.022)	-0.169*** (0.024)	-0.173*** (0.022)
Percentage of college-educated population <sub>-1</sub>	-0.021 (0.019)	-0.004 (0.018)	0.000 (0.018)	-0.010 (0.019)	-0.006 (0.019)	-0.004 (0.018)
Percentage of foreign-born population <sub>-1</sub>	0.045*** (0.011)	0.045*** (0.011)	0.049*** (0.012)	0.046*** (0.011)	0.047*** (0.011)	0.048*** (0.011)
Percentage of employment among women <sub>-1</sub>	0.059* (0.036)	0.053 (0.034)	0.049 (0.037)	0.071** (0.034)	0.071** (0.033)	0.072** (0.033)
Percentage of employment in routine occupations <sub>-1</sub>	-0.094 (0.081)	-0.054 (0.074)	-0.086 (0.063)	-0.061 (0.087)	-0.049 (0.088)	-0.053 (0.087)
Average offshorability index of occupations <sub>-1</sub>	-1.022*** (0.342)	-0.913*** (0.298)	-0.824*** (0.237)	-1.228*** (0.367)	-1.218*** (0.361)	-1.229*** (0.357)
Census division dummies	Yes	Yes	Yes	Yes	Yes	Yes
R <sup>2</sup>	0.60	0.61	0.59	0.59	0.59	0.59
	II. 2SLS first stage estimates					
( $\Delta$ value-added exports from China to OTH) / worker	0.777*** (0.040)	0.575*** (0.055)	0.709*** (0.061)	0.815*** (0.049)	0.783*** (0.054)	0.626*** (0.054)
Adjusted R <sup>2</sup>	0.85	0.86	0.74	0.82	0.80	0.69
Kleibergen-Paap's Weak IV Test	442.95	114.59	0.74	304	230.19	174.80
(pass 5 percent critical value?)	Y	Y	Y	Y	Y	Y

<sup>a</sup>Dependent variable: Annual changes in manufacturing emp/working-age pop (in percentage points). Columns 1-3 do not use controls for local labor market characteristics, while columns 4-6 use the same local labor market controls used in column 6 of Table 4. Superscripts \*\*\*, \*\*, and \* represent statistical significance at the 1, 5 and 10 percent levels, respectively. Standard errors are clustered at state level.

Table 5: The Effects of Net Trade Exposure on the Share of Manufacturing Employment<sup>a</sup>

	I. 2000-2007 2SLS							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			Final goods	Above median	Above 75th	Intermediate goods	Below median	Below 75th
( $\Delta$ net gross exports from China to US) / worker	-0.336*** (0.107)							
( $\Delta$ net value-added exports from China to US) / worker		-0.491 (0.394)						
High downstreamness								
( $\Delta$ net value-added exports from China to US) / worker			-1.658** (0.725)	-1.687** (0.725)	-2.769*** (0.586)			
Low downstreamness								
( $\Delta$ net value-added exports from China to US) / worker						1.077 (0.959)	0.211 (0.250)	0.392 (0.361)
$R^2$	0.57	0.60	0.62	0.61	0.60	0.59	0.60	0.60
	II. 2SLS first stage estimates							
( $\Delta$ value-added exports from China to OTH) / worker	0.616*** (0.113)	0.705*** (0.062)	0.782*** (0.055)	0.295*** (0.058)	0.474*** (0.072)	0.287*** (0.050)	0.195*** (0.060)	0.227*** (0.049)
$\Delta$ value-added exports from USA to OTH) / worker	-0.335*** (0.095)	-0.465 (0.581)	-1.756 (1.731)	2.669*** (0.750)	3.356*** (1.203)	1.367*** (0.438)	8.557*** (0.899)	5.219*** (1.339)
Adjusted $R^2$	0.48	0.84	0.84	0.85	0.68	0.82	0.87	0.69
Kleibergen-Paap's Weak IV Test	19.941	182.63	239.01	51.34	98.57	140.95	622.22	92.65
(pass 5 percent critical value?)	Y	Y	Y	Y	Y	Y	Y	Y

<sup>a</sup>Dependent variable: Annual changes in manufacturing emp/working-age pop (in percentage points). We use the same controls applied in column (6) of Table 4 in all columns of this Table. Superscripts “\*\*\*”, “\*\*” and “\*” represent statistical significance at the 1, 5 and 10 percent levels, respectively. Standard errors are clustered at state level.

Table 6: Value-Added Trade with China and the Effects on Wages  
across U.S. Local Labor Markets<sup>a</sup>

	(1)	(2)	(3)	(4)	(5)	(6)
			Final goods	Above median	Intermediate goods	Below median
	All					
( $\Delta$ gross exports from China to US) / worker	-0.135 (0.359)					
( $\Delta$ value-added exports from China to US) / worker		0.970 (0.780)				
High downstreamness ( $\Delta$ value-added exports from China to US) / worker			1.240 (1.799)	0.323 (1.843)		
Low downstreamness ( $\Delta$ value-added exports from China to US) / worker					3.024** (1.507)	1.234* (0.715)
	College					
( $\Delta$ gross exports from China to US) / worker	-0.205 (0.399)					
( $\Delta$ value-added exports from China to US) / worker		0.877 (0.933)				
High downstreamness ( $\Delta$ value-added exports from China to US) / worker			0.927 (1.917)	0.842 (2.182)		
Low downstreamness ( $\Delta$ value-added exports from China to US) / worker					3.047 (2.152)	0.840 (0.735)
	Non-college					
( $\Delta$ gross exports from China to US) / worker	0.142 (0.383)					
( $\Delta$ value-added exports from China to US) / worker		1.738* (0.914)				
High downstreamness ( $\Delta$ value-added exports from China to US) / worker			2.542 (2.133)	0.438 (1.854)		
Low downstreamness ( $\Delta$ value-added exports from China to US) / worker					4.953*** (1.747)	2.279*** (0.835)

<sup>a</sup>Dependent variable: Ten-year equivalent changes in average log weekly wage (in log pts). We use the same controls applied in column (6) of Table 4 in all columns of this Table. Superscripts “\*\*\*”, “\*\*” and “\*” represent statistical significance at the 1, 5 and 10 percent levels, respectively. Standard errors are clustered at state level.

Table 7: Value-Added Trade with China and the Effects on Unemployment across U.S. Local Labor Markets<sup>a</sup>

	(1)	(2)	(3)	(4)	(5)	(6)
			Final goods	Above median	Intermediate goods	Below median
	All					
( $\Delta$ gross exports from China to US) / worker	0.109 (0.099)					
( $\Delta$ value-added exports from China to US) / worker		-0.353 (0.250)				
High downstreamness ( $\Delta$ value-added exports from China to US) / worker			-0.525 (0.506)	0.246 (0.421)		
Low downstreamness ( $\Delta$ value-added exports from China to US) / worker					-0.975* (0.572)	-0.630** (0.299)
	College					
( $\Delta$ gross exports from China to US) / worker	0.059 (0.063)					
( $\Delta$ value-added exports from China to US) / worker		-0.352* (0.191)				
High downstreamness ( $\Delta$ value-added exports from China to US) / worker			-0.560 (0.377)	-0.014 (0.368)		
Low downstreamness ( $\Delta$ value-added exports from China to US) / worker					-0.932** (0.451)	-0.499** (0.217)
	Non-college					
( $\Delta$ gross exports from China to US) / worker	0.115 (0.137)					
( $\Delta$ value-added exports from China to US) / worker		-0.516 (0.336)				
High downstreamness ( $\Delta$ value-added exports from China to US) / worker			-0.827 (0.675)	0.322 (0.566)		
Low downstreamness ( $\Delta$ value-added exports from China to US) / worker					-1.342* (0.771)	-0.901** (0.379)

<sup>a</sup>Dependent variable: We use the Ten-Year equivalent change in the unemployed share (in percentage points). We use the same controls applied in column (6) of Table 4 in all columns of this Table. Superscripts “\*\*\*”, “\*\*” and “\*” represent statistical significance at the 1, 5 and 10 percent levels, respectively. Standard errors are clustered at state level.

Table 8: Robustness of Downstreamness<sup>a</sup>

	I. 2000-2007 2SLS			
	(1)	(2)	(3)	(4)
	Above median	Above 75th	Below median	Below 75th
Panel A – Downstreamness measured by FVA in final goods / gross exports				
$\Delta$ value-added exports from China to US / worker	-2.003*** (0.678)	-2.539*** (0.419)	0.366 (0.249)	0.433* (0.258)
	2SLS first stage estimates			
$\Delta$ value-added exports from China to OTH / worker	0.523*** (0.047)	0.754*** (0.061)	0.776*** (0.047)	0.751*** (0.039)
KP statistics	132.14	167.54	283.25	440.08
Panel B – Downstreamness measured by FVA / (FVA+VAX)				
$\Delta$ value-added exports from China to US / worker	-2.071*** (0.586)	-2.545*** (0.421)	0.419 (0.281)	0.434* (0.259)
$R^2$	0.60	0.60	0.59	0.60
	2SLS first stage estimates			
$\Delta$ value-added exports from China to OTH / worker	0.555*** (0.049)	0.752*** (0.060)	0.781*** (0.051)	0.749*** (0.039)
KP statistics	122.52	168.46	258.97	439.34
Panel C – Downstreamness measured by ACFH				
$\Delta$ value-added exports from China to US / worker	-1.589** (0.701)	-2.223*** (0.786)	-0.043 (0.228)	0.058 (0.250)
	2SLS first stage estimates			
$\Delta$ value-added exports from China to OTH / worker	0.616*** (0.070)	0.824*** (0.067)	0.801*** (0.035)	0.795*** (0.030)
KP statistics	88.46	188.06	522.70	717.29
Panel D - Downstreamness measured by FVA / gross exports				
$\Delta$ gross exports from China to US / worker	-1.220*** (0.157)	-0.958*** (0.157)	-48.781 (36.748)	0.015 (0.582)
	2SLS first stage estimates			
$\Delta$ gross exports from China to OTH / worker	0.627*** (0.035)	0.673*** (0.034)	-0.154** (0.069)	0.405*** (0.056)
KP statistics	521.68	563.48	5.78	49.84

<sup>a</sup> Dependent variable: Annual changes in manufacturing emp/working-age pop (in percentage points). We use the same controls applied in column (6) of Table 4 in all columns of this Table. Superscripts “\*\*\*”, “\*\*” and “\*” represent statistical significance at the 1, 5 and 10 percent levels, respectively. All first stage regressions pass the Kleibergen-Paap Weak IV test at 5% critical value. Standard errors are clustered at state level.

Table 9: The Effects of Import Penetration on the Share of Manufacturing Employment<sup>a</sup>

	I. 2000-2007 2SLS					
	(1)	(2)	(3)	(4)	(5)	(6)
			Final goods	Above median	Intermediate goods	Below median
( $\Delta$ U.S. gross import penetration from China) / worker	-0.463*** (0.166)					
( $\Delta$ U.S. value-added import penetration from China) / worker		-0.050 (0.063)				
High downstreamness						
( $\Delta$ U.S. value-added import penetration from China) / worker			-0.517** (0.264)	-2.673 (3.269)		
Low downstreamness						
( $\Delta$ U.S. value-added import penetration from China) / worker					0.196*** (0.065)	0.231*** (0.058)
II. 2SLS first stage estimates						
Instrument	1.24** (0.51)	6.93*** (2.41)	2.31** (1.02)	0.64 (0.81)	24.1*** (6.12)	12.6*** (2.63)
Kleibergen-Paap Weak IV test (pass 5% critical value?)	4.51 Yes	11.28 Yes	5.50 Yes	0.42 No	25.81 Yes	33.96 Yes

<sup>a</sup> Dependent variable: Annual changes in manufacturing emp/working-age pop (in percentage points). We use the same controls applied in column (6) of Table 4 in all columns of this Table. Superscripts “\*\*\*”, “\*\*” and “\*” represent statistical significance at the 1, 5 and 10 percent levels, respectively. Standard errors are clustered at state level.

Table 10: The Effects of Changes in Value-Added Exports from Middle and High Income Countries<sup>a</sup>

	(1)	(2)	(3)	(4)	(5)	(6)
			Final goods	Above median goods	Intermediate goods	Below median
	High income countries					
( $\Delta$ gross exports from specified exporter to US) / worker	0.096 (0.068)					
( $\Delta$ value-added exports from specified exporter to US) / worker		0.193* (0.105)				
High downstreamness			1.004 (0.687)	0.395* (0.233)		
( $\Delta$ value-added exports from specified exporter to US) / worker					0.221* (0.120)	0.038 (0.062)
Low downstreamness						
( $\Delta$ value-added exports from specified exporter to US) / worker						
	Middle income countries					
( $\Delta$ gross exports from specified exporter to US) / worker	-0.207** (0.085)					
( $\Delta$ value-added exports from specified exporter to US) / worker		0.008 (0.080)				
High downstreamness			-1.059 (0.692)	-0.594** (0.287)		
( $\Delta$ value-added exports in final goods from specified exporter to US) / worker					0.471 (0.104)	0.022 (0.055)
Low downstreamness						
( $\Delta$ value-added exports in final goods from specified exporter to US) / worker						

<sup>a</sup> Dependent variable: Annual changes in manufacturing emp/working-age pop (in percentage points). We use the same controls applied in column (6) of Table 4 in all columns of this Table. Superscripts “\*\*\*\*”, “\*\*\*”, “\*\*” and “\*” represent statistical significance at the 1, 5 and 10 percent levels, respectively. Standard errors are clustered at state level.