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# US EXPORTS AND EMPLOYMENT

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**ABSTRACT**

We examine the employment responses to import competition from China and to global export expansion from the United States, both of which have been expanding strongly during the past decades. We find that although Chinese imports reduce jobs, at both the industry level and the local commuting zone level, the global export expansion of US products also creates a considerable number of jobs. On balance over the entire 1991-2007 period, job gains due to changes in US global exports were slightly less than job losses due to Chinese imports. Using data at both the industry level and the commuting zone level, we find a net loss of around 0.2-0.3 million jobs. When we extend the analysis to 1991-2011, we find the net job effect of import and export exposure is roughly balanced at the commuting zone level.

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# 1 Introduction

Conventional wisdom in economics is that trade liberalization will have two effects on labor market outcomes. On the one hand, firms that face import competition may shrink or even exit and therefore displace workers. On the other hand, firms that gain access to foreign market should enter or expand, therefore generating new jobs. While such effects of job creation and destruction due to international trade are commonly accepted, empirical studies, particularly the recent growing literature on the 'China shock', focus on the job-reducing effect of surging imports from China or other low-wage countries on the US labor market (Autor, Dorn, and Hanson, 2013; Pierce and Schott, 2016; Acemoglu et al., 2016).[1] Much less explored is the job-creating effect of exports. Autor, Dorn, and Hanson (2013) begin to explore that issue by including *net* imports from China in their robustness analysis, but we do not feel that a bilateral trade balance with a single country is the right focus. Instead we shall consider *total* US exports as compared to imports from China.[2]

Specifically, this paper provides the first account of job creation due to the export expansion in the United States, at both the industry level and the local labor market (commuting zone) level. The United States is one of the leading exporting countries in the world trading system: in 2014, the value of its merchandise exports reached more than 1.6 trillion US dollars, second only after China. Figure 1 illustrates aggregate merchandise exports and manufacturing exports for the US over 1991 to 2011. It shows that prior to the global financial crisis, US exports grew strongly, from less than 600 billion (in 2007 US dollars) in 1991 to more than 1.2 trillion dollars.

[1]A notable exception is Dauth, Findeisen, and Suedekum (2014), who use the German trade and labor data to show that the rise of the East (Eastern Europe and China) caused substantial job losses in regions exposed to import competition, while it also led to strong employment gains in regions that are more export oriented. Their results are driven almost entirely by the rise in Eastern Europe, however, and not by China.

[2]For symmetry, it might be preferable to examine total US exports and total US imports. That is the approach taken by Feenstra and Sasahara (2017) who use a global input-output analysis and examine both US imports from China and imports from all countries. They find that the implied employment effect of US manufacturing imports from China is somewhat smaller than found in this paper, while the employment effect of US manufacturing imports from the world is somewhat larger. The implied employment effect of US manufacturing exports to the world is similar to that found here. See also note 5 and the paper by Wood (2017), who uses a global input-output analysis to focus on US imports and exports with developing countries.

No doubt such an expansion in export value generated increased demand for labor. The US export expansion was not evenly distributed across industries, however. Figure 2 lists the top industries that have experienced the largest increase in export value during 1991 - 2007. Among 392 revised SIC manufacturing sectors, semiconductors experienced the largest increase in export value during 1991-1999, while motor vehicles and petroleum refining have been the champion of export expansion in the period 1999-2007.[3] These top categories reflect America's comparative advantage and grew much faster than many other categories, some of which even saw reductions in exports, therefore creating large variation for our estimation.

[Figure 1 and Figure 2 here]

Empirically, however, it is not easy to obtain unbiased estimates of the effects of export expansion due to endogeneity. While increased access to foreign markets drives up demand for labor employment, domestic supply shocks such as new technology or TFP growth will also promote exports, and quite possibly reduce employment, causing difficulty in identification. Uncontrolled (often unobserved) domestic demand shocks, too, can be expected to affect export value and labor employment simultaneously. Lack of plausible instruments probably explains the lack of more balanced empirical evidence of the effect of both export and import shocks on employment.

To deal with endogeneity, we adopt two instruments. First, we follow the spirit of Autor, Dorn and Hanson (2013, henceforth ADH) to look at the export expansion of other high-income countries.[4] This is based on the assumption that these high-income countries face similar import demand shocks in foreign countries as does the United States in its exports to those countries. We will present evidence that these foreign demand shocks are not substantially correlated with US domestic demand shocks, so this instrument satisfies that exclusion restriction. The second instrument that we adopt in this paper relies on a more carefully modeling of US exports to

[3] As a comparison, Figure A.1 in the appendix presents the top import SIC categories that have experienced the largest increase in volume from China.

[4] ADH (2013) instrument the US import penetration from China using eight other high-income countries' import penetration from China.

each foreign market, based on a CES framework. The export equation that we obtain includes a term that captures the exports of other countries to that foreign market (similar to our first instrument), and in addition, it includes the tariffs faced by the United States and all other countries selling in that market. Thus, we construct a second instrument as the predicted US exports based on the foreign demand for imports (except from the US), tariffs that US faces, and the tariffs that other competing countries face in each foreign market.

Our empirical results show important job gains due to US export expansion. Based on the industry level estimation, our results show that US export expansion *net of* China's import penetration actually led to a net gain of 324,000 jobs in the first period 1991-1999, while it led to a net loss of 642,000 jobs for the second period 1999-2007, or 697,000 job losses for 1999-2011. On balance over the entire 1991-2007 period or 1991-2011 periods, therefore, job gains due to changes in US global exports largely offset job losses due to China's imports, resulting in about 0.3-0.4 million job losses in net.

To account for effects of reallocation and local demand in general equilibrium, we also explore the variations across US commuting zones in their exposure to export and import. We find somewhat bigger effects of job creation due to rising US exports, while the net job loss from Chinese imports is consistently close to the results using industry level data. Quantitatively, accounting for local market effects implies that increased import exposure led to a loss of about 2.58 million manufacturing jobs in local labor market from 1999 to 2007, and another 0.97 million manufacturing job losses from 1991 to 1999 . On the other hand, increased export exposure implies a gain of 2.01 million manufacturing jobs from 1991 to 1999 and 1.34 million from 1999 to 2007. In net, however, export exposure significantly offsets the reduction in jobs caused by import penetration, resulting in about 0.2 million net job losses. If we extend the analysis to the period 1991-2011, then over the full 2 decades, import exposure led to about 4.22 million job losses, while export expansion generated about 4.24 million jobs. Thus, the net effect is roughly balanced over this longer period. We would not be surprised if a similar conclusion continued to hold if we expanded US imports to include all countries while also expanding imports and exports to include all merchandise and service trade.[5]

The rest of the paper is structured as follows: Section 2 presents the empirical strategy and describes our main datasets. Section 3 shows the main industry level estimations. Section 4 examines the impact of trade exposure at the commuting zone level. Section 5 concludes.

# 2 Empirical Strategy

We take an approach similar to Acemoglu et al. (2016), investigating the effect of export growth and import exposure on labor employment first at the industry level, and then at the local labor market level.

## 2.1 Measuring Trade Exposure

Acemoglu et al. (2016) measure the change in the industry level import penetration in the US from Chinese imports as

$$\Delta IP_{st} = \frac{\Delta M^{UC}_{s,t}}{Y_{s,t_0} + M_{s,t_0} - E_{s,t_0}}, \tag{1}$$

where $s$ denotes 392 manufacturing sectors in the SIC classification. $\Delta M^{UC}_{s,t}$ denotes the change in *US imports from China* (UC) in sector $s$ for the time period $t$ ($t$ is either 1991-1999, or 1999-2007, and in some cases 1999-2011). To normalize, $\Delta M^{UC}_{s,t}$ is divided by the initial domestic absorption, which consists the industrial real shipment, $Y_{s,t_0}$, plus industry real net imports, $M_{s,t_0} - E_{s,t_0}$, both at initial year $t_0 = 1991$ and deflated by the Personal Consumption Expenditures (PCE) price index. This variable therefore measures the actual increase in import exposure by each US manufacturing industry $s$. Such a change in import exposure from China

[5] As explained in note 2, Feenstra and Sasahara (2017) use a global input-output analysis to estimate the employment effects of US imports and exports. When focusing on manufacturing imports and exports from all countries, they obtain a net job loss over 1995-2011. But when including merchandise *and* service imports and exports with all countries, they obtain a substantial net job gain, due to the large job-creating effect of US service exports. Under the global input-output approach it is difficult to control for the endogeneity of imports and exports, however, and Feenstra and Sasahara make only limited progress towards that end. It would be likewise challenging to extend the approach of this paper to include all countries importing to the US, and to also include services trade, because of the need to find instruments for those imports and exports.

could be either due to a supply shock in its exports (e.g. productivity growth in China's export sectors), or caused by unobserved domestic shocks in the US demand. The latter component may affect sectoral imports and sectoral employment simultaneously and therefore contaminate trade flows. To address this endogeneity concern, ADH (2013) and Acemoglu et al. (2016) suggest using the change in import exposure from China in eight other high-income countries as an instrument:

$$\Delta IP_{st}^{OTH} = \frac{\Delta M_{s,t}^{OC}}{Y_{s,t_0} + M_{s,t_0} - E_{s,t_0}}, \tag{2}$$

where $\Delta M_{s,t}^{OC}$ measures the change in *other countries' imports from China* (OC) in sector $s$ during the period $t$ by these eight other nations,[6] which is then normalized by the initial domestic sectoral absorption in 1988 ($t_0 = 1988$). The validity of this instrument relies on the assumption that high-income countries are similarly exposed to import competition that is driven by the supply shock in China, while the industry import demand shocks are uncorrelated between these eight countries and the United States.

To capture the industrial export exposure, we start with an analogous measure to (1) as:

$$\Delta EP_{st} = \frac{\Delta X_{s,t}}{Y_{s,t_0}}, \tag{3}$$

where $\Delta EP_{st}$ measures changes in export exposure of sector $s$ between t and t+1, defined as changes in US sector exports $\Delta X_{s,t}$, divided by the initial sectoral shipments $Y_{s,t_0}$. Thus, $EP_{st}$ is a measure of export intensity, capturing the share of export value out of the total industrial output. Different from the measure of China-specific import shock, we are interested in measuring the total US export expansion to the entire rest of the world.[7]

To identify the effect of import and export exposure on the industrial employment, we adopt the following empirical specification:

$$\Delta ln(L_{st}) = \beta_t + \beta_1 \Delta IP_{st} + \beta_2 \Delta EP_{st} + \gamma X_{s0} + \epsilon_{st}, \tag{4}$$

[6] These countries are: Australia, Denmark, Finland, Germany, Japan, New Zealand, Spain, and Switzerland. An additional reason that we use these eight countries is that their disaggregated HS trade data are available since 1991.

[7] See notes 2 and 5.

where $\Delta ln(L_{st})$ is the annual log change in employment in sector $s$ over time period $t$, $X_{s0}$ is a set of start-of-period sectoral controls, and $\Delta IP_{st}$ and $\Delta EP_{st}$ measure the annual change in import exposure from China and the annual change in export exposure, respectively. Following Acemoglu et al. (2016), we fit this equation for stacked first differences covering two subperiods 1991-1999 and 1999-2007, where in some cases we also extend the latter subperiod to 1999-2011. All variables in changes are annualized.

As described above, equation (4) is subject to endogeneity of the trade exposure measures. We should use instrumental variables that are not correlated with US shocks, since those shocks (on the demand or supply side) lead to endogenous changes in employment, imports and exports. In ADH (2013) and Acemoglu et al. (2016), identification is achieved via the 'China shock', which is a supply-shock in China. To avoid having that shock correlated with US shocks, they use the import exposure from China in other eight high-income economies ($\Delta IP_{st}^{OTH}$) as instrument, which is intended to reflect China's rising comparative advantage (e.g., productivity shock) and falling trade costs in these sectors that are common to high-income importing countries. Admittedly, this IV will also reflect demand conditions in those eight countries, but provided that those demand conditions are not correlated with those in the US, that should not present a problem for the IV.[8]

In our paper, the IV should also be uncorrelated with US shocks. Since we are modeling exports, we aim to identify their impact on US employment from foreign demand shocks: those shocks would lead to a rise in exports and employment that is not contaminated by other shocks in the US market. Our first instrumental variable for export exposure uses the export expansion

[8] Specifically, an unobserved common demand shock raises demand for the US domestic products, and therefore promotes employment, and will likely understate the impact of import shock. We present evidence in section 3 that foreign demand shocks are correlated with US import demand only through a common macroeconomic shock (equal across sectors), which is controlled for in our specification; see note 13. ADH (2013) further adopt a gravity equation and use the inferred change in China's comparative advantage and market access vis-a-vis the United States. In that case, the common demand shocks in high-income countries are differenced out by importer and product fixed effects.

of eight other high-income economies to the world (except for the United States):

$$\Delta EP_{st}^{OTH} = \frac{\Delta X_{s,t}^{OTH}}{Y_{s,t_0}}. \tag{5}$$

Using other advanced nations' exports to instrument for the US exports closely follows the idea of ADH (2013) and is intended to reflect common foreign demand shocks that drive exports of both the US and the eight high-income countries. The identification relies on the exogenous component of United States export growth that stems from the world's rising demand for goods in these sectors. This could be due to income growth of emerging economies since the 1980s, when many countries experienced fast growth and move from low income to middle-income countries, notably China and India. Income growth from emerging economies drives demand for high-quality consumption goods from high-income countries (Costa, Garred and Pessoa, 2016). Furthermore, emerging economies (China and other newly industrialized economies) are increasingly involved in global supply chains due to the disintegration of the production process (Feenstra, 1998). Increasing production capacity drives up their demand for capital goods, which are largely supplied by high-income countries (Eaton and Kortum, 2002).

These observations motivate the idea of foreign demand shocks that are correlated between US exports and those of other high-income countries selling in the same foreign markets. We will need to confirm that these demand shocks are not correlated with demand in the United States itself, however, as we shall do with an equation for US exports. It is possible that export expansion may also reflect supply-side shocks in the United States. That potential correlation with supply-side shocks will be apparent in our derivation of the export equation, below. In terms of estimation, a US supply shock that is labor saving will reduce US employment but raise exports, resulting in an under-estimated OLS coefficient of exports on employment. On the other hand, a US supply shock that expands product variety tends to *increase* both exports and employment, therefore resulting in an over-estimated OLS coefficient of exports on employment. We will propose a method of correcting for such supply shocks in the export equation, by using fixed effects to absorb them.

In the following subsections, we develop a careful specification of US exports in a constant-elasticity, monopolistic competition framework. That export equation will provide a method to test and control for US demand and supply shocks, and from which we obtain a second instrumental variable.

## 2.2 Predicting US Exports

To understand the driving forces underlying the US export growth, Caliendo et al. (2015) show that from 1990 until 2011 both MFN tariffs and the preferential tariffs have fallen by nearly nine percent, most of which was driven by substantial trade liberalization in emerging and developing economies. Notable examples include China's accession into the WTO in 2001, which lowered its average import tariff from above 15 percent to below 9 percent within just a few years; and the North American Free Trade Agreement (NAFTA), which integrated production chains and the flow of consumer goods across the continent of North America. Romalis (2007) find a substantial increase in the trade volume and output among the United State, Canada and Mexico, particularly in the products that were previously highly protected.

Inspired by these observations, our second instrument for the US export expansion, denoted by $\Delta EP_{st}^{PRE}$, is constructed as the *predicted* US exports due to reductions in import tariffs faced by the US exporters and their competitors selling in foreign countries. Similar to the first instrument, predicted US exports $\Delta EP_{st}^{PRE}$ will also reflect the sales of other countries (besides the US) selling in those foreign markets. To derive this instrument, we start from a simple symmetric CES equation as in Romalis (2007),

$$\frac{X_{svt}^{us,j}}{X_{svt}^{i,j}} = \left(\frac{w_{st}^{us} d^{us,j} \tau_{st}^{us,j}}{w_{st}^{i} d^{i,j} \tau_{st}^{i,j}}\right)^{1-\sigma}, \tag{6}$$

where: $X_{svt}^{us,j}$ is the US exports to country $j$ in variety $v$ of sector $s$; $X_{svt}^{i,j}$ is the exports from country $i$; $w_{st}^{us}$ and $w_{st}^{i}$ are the relative marginal costs of producing varieties of sector $s$ in the United States and country $i$; $\tau_{st}^{us,j}$ and $\tau_{st}^{i,j}$ are *ad valorem* import tariffs imposed by importer $j$ on exports from the United States or from country $i$; and $d^{us,j}$ and $d^{i,j}$ are the bilateral distance or transport costs from the United States or exporting country $i$ to importing country $j$. Finally, $\sigma$ denotes the elasticity of substitution.

Suppose that there are $M^i_{st}$ identical product varieties in sector $s$ produced and exported by country $i$. We can re-arrange the above equation by multiplying both sides by $M^i_{st}$ and summing over all countries $i \neq us$:

$$X^{us,j}_{svt} \sum_{i \neq us} M^i_{st} \left(w^i_{st} d^{i,j}\right)^{1-\sigma} = \left(w^{us}_{st} d^{us,j} \tau^{us,j}_{st}\right)^{1-\sigma} \sum_{i \neq us} M^i_{st} X^{i,j}_{svt} \left(\tau^{i,j}_{st}\right)^{\sigma-1}. \tag{7}$$

Multiply this equation by $M^{us}_{st}$, and denote the total sectoral exports from the United States and country $i$ to country $j$ as $X^{us,j}_{st} = M^{us}_{st} X^{us,j}_{svt}$ and $X^{i,j}_{st} = M^i_{st} X^{i,j}_{svt}$, respectively. After a few re-arrangements, we can get:

$$X^{us,j}_{st} = \frac{M^{us}_{st} \left(w^{us}_{st} d^{us,j} \tau^{us,j}_{st}\right)^{1-\sigma}}{\sum_{k \neq us} M^k_{st} \left(w^k_{st} d^{k,j}\right)^{1-\sigma}} \left(\sum_{k \neq us} X^{k,j}_{st}\right) \sum_{i \neq us} \frac{X^{i,j}_{st}}{\sum_{k \neq us} X^{k,j}_{st}} \left(\tau^{i,j}_{st}\right)^{\sigma-1}, \tag{8}$$

where we multiply and divide by $\sum_{k \neq us} X^{k,j}_{st}$ for convenience.

Taking logs of the above equation, we obtain:

$$\ln X^{us,j}_{st} = \beta^{us}_{st} + \ln\left(d^{us,j}\right)^{1-\sigma} + \ln(\tau^{us,j}_{st})^{1-\sigma} + \ln\left(\sum_{k \neq US} X^{k,j}_{st}\right) + \ln\left[\sum_{i \neq us} \frac{X^{i,j}_{st}}{\sum_{k \neq us} X^{k,j}_{st}} \left(\tau^{i,j}_{st}\right)^{\sigma-1}\right] + \epsilon^j_{st},$$

where $\beta^{us}_{st} = ln\left(M^{us}_{st} \left(w^{us}_{st}\right)^{1-\sigma}\right)$, which includes the US export variety and marginal costs of production. This term reflects a US supply shock and can be proxied by a set of sector and year fixed effects or their interactions.[9] The term $\epsilon^j_{st} = -ln\left(\sum_{k \neq us} M^k_{st} \left(w^k_{st} d^{k,j}\right)^{1-\sigma}\right)$ is an unobserved error term, reflecting the supply shocks in all other source countries.

Empirically, we can therefore use the following specification:

$$\ln X^{us,j}_{st} = \beta^{us}_{st} + \beta_1 \ln(\tau^{us,j}_{st}) + \beta_2 \ln\left(\sum_{k \neq US} X^{k,j}_{st}\right) + \beta_3 \ln(T^j_{st}) + \beta_4 \ln\left(d^{us,j}\right) + \epsilon^j_{st}. \tag{9}$$

So from the demand side, the US exports of good $s$ to country $j$ are determined by four items: the first is the import tariffs imposed by $j$ on US exporters ($\tau^{us,j}_{st}$); and the second is the total

[9] A reduction in $w^{us}_{st}$ reflects an improvement in productivity (a supply shock) that may increase exports and decrease labor employment simultaneously. An increase in $M^{us}_{st}$ reflects an expansion in US product variety that may increase both exports and labor employment simultaneously. We especially want to control for the latter product variety effect, since it would overstate the OLS coefficient of US exports on employment.

imports by $j$ from all other exporters $\left(\sum_{k\neq US} X_{st}^{k,j}\right)$, which we refer to as country $j$'s *multilateral* import demand from the rest of world except the United States. Note that our first instrument for US exports, $\Delta EP_{st}^{OTH}$, uses the export expansion of eight other high-income economies to the world except the United States, and is therefore similar to this multilateral demand variable.

The third determinant of exports is a measure of country j's average import tariffs on all non-US imports of good s, $T_{st}^{j} = \sum_{i\neq us} \frac{X_{st_0}^{ij}}{\sum_{k\neq us} X_{st_0}^{k,j}} \left(\tau_{st}^{i,j}\right)^{\sigma-1}$. Empirically we use exports in the base year $t_0$ to construct weights. This term captures the substitution between US export products and their competitors: higher levels in $T_{st}^{j}$ raises more demand for the US export. Note that the difference between the tariffs on US imports and the multilateral tariff term comes from from the deviation from MFN tariffs (i.e. preferential tariffs due to free trade agreements, for example). The final variable in the export equation is distance $\ln\left(d^{us,j}\right)$, and expect to find $\beta_1 < 0$, $\beta_2 > 0$, $\beta_3 > 0$, and $\beta_4 < 0$ in the estimates. In our benchmark results, we use $\sigma = 7$ but we have also experimented with sigmas ranging from 1 to 6 to make sure that our results are robust to different degree of substitutions.

Our second instrument for US exports, $\Delta EP_{st}^{PRE}$, is constructed as the predicted US exports due to changes in tariffs and multilateral import demand as specified by equation (9). Crucially, we *do not* include the fixed effects $\beta_{st}^{us}$ when constructing this prediction, so that it is not contaminated by US supply shocks. In the following subsection, we introduce the data used for prediction, and then discuss the estimation as well as other identification issues.

## 2.3 Tariff and Trade Data

Equation (9) guides our estimation of US total exports using data on global trade flow and tariffs. To be more specific, we collect global trade flow data from the UN-Comtrade Database, which provides trade value by 6-digit HS and 5-digit SITC products. Tariff schedules are collected from the TRAINS and IDB databases accessed via the World Bank's WITS website, which have been complemented by manually collected tariff schedules published by the International Customs Tariff Bureau (BITD) and made available by Feenstra and Romalis (2014) and Caliendo et al.

(2015). Putting these together, our empirical work is built on a comprehensive, disaggregated, annual database with trade flow and tariff schedules which are consistently matched at 5-digit SITC product classification for more than 150 countries over the period 1984 to 2011.

To facilitate the comparison with the effect of import exposure and employment changes, we construct our export exposure and the instrumental variables at the revised SIC (standard industrial classification) level which was adopted by ADH (2013) and Acemoglu et al. (2016). The US export data at 6-digit HS product level could be readily converted to the revised SIC product level by adopting the crosswalk (with weights) in Acemoglu et al. (2016). We then take similar steps to construct the export value at the revised SIC level for the other eight advanced economies, obtaining our first instrument for US exports, $\Delta EP_{st}^{OTH}$.

For the second instrument, there are several steps from converting US exports at 5-digit SITC products across importing countries to measuring export exposure at the revised SIC product level. First, we estimate equation (9) using the above-mentioned datasets provided by Feenstra and Romalis (2014) and Caliendo et al (2016) for US exports of product $g$ (at SITC 5-digit) across importing countries $j$, which are then aggregated across export destination markets to get the US industrial exports, denoted as $\hat{X}_{gt}^{SITC}$. Second, we construct a crosswalk between SITC to SIC, following Feenstra, Romalis and Schott (2002). In the cases where one SITC code is matched to multiple SIC codes, we use the initial year export value to construct weights.[10] Thirdly, we use the crosswalk provided by Acemoglu et al (2016) to convert the 1987 SIC industry code to the revised SIC code, ending up with export values for 392 revised 4-digit SIC codes, covering each year from 1991 to 2011, which we denote accordingly as $\hat{X}_{st}^{SIC} = \sum_{g\in s} \omega_{gs,t_0} \hat{X}_{gt}^{SITC}$, where $s$ denotes the SIC sector, while $\omega_{gs,t_0}$ is the start-of-period weights used in matching SITC product $g$ to SIC sector $s$.

The estimation results from regressing US exports at the 4-digit SITC industry level on

[10] Here we adopt the 1987 SIC classification. We use US export data in 1990 to construct weights when one SITC product is matched to multiple SIC product for years between 1990 and 2000, and similarly US exports in 2000 to construct weights for years between 2000 and 2011. Details about the structure of US export data is provided in Feenstra, Romalis and Schott (2002).

tariffs and multilateral import demand of destination markets are provided in Table 1, where we experiment with various fixed effects. The odd columns report the benchmark results: column (1) uses SITC fixed effects, column (3) further adds year dummies, while column (5) uses SITC×year fixed effects. All regression coefficient estimates have the expected signs and reasonable values.

[Table 1 about here]

As we discussed above, one concern with these estimates is that demand may be correlated across countries, so that import growth of other countries may also reflect import growth of the United States. To address this concern, we experiment with a set of auxiliary regressions to test for correlations between the year-to-year changes in US demand (measured by the change in total US imports from all sources) and the foreign demand for US goods, as measured by the US exports (i.e., the dependent variable in our regression).[11] The results are shown in Table 1. Column (2) shows that US import growth has a significant effect on US exports, confirming that some correlation exists. However, once we include SITC and year fixed effects, as in column (4), the US import growth loses its significance.[12] These results show that the correlation of import demand across countries is a macroeconomic phenomena that can be controlled for by using sector and time fixed effects. Therefore, by taking a decadal difference and including a decade period dummy, as we do in our employment regressions, any effects of correlated demand shocks are eliminated.[13]

[11] We use the *change* in US imports because the level of US imports is found to have a unit root. Specifically, using the Im–Pesaran–Shin test (for large N and fixed T), and including a time trend, the null hypothesis of a unit-root in the panel of US imports by SITC industry cannot be rejected.

[12] A comparison of the odd columns with their corresponding even columns shows that the number of observations is reduced. This is because the US import variable is not available for all SITC products that the US is exporting. Moreover, the reduction in the number of observations accounts for nearly all of the change in the coefficient estimates of other variables (such as tariffs) in the regression.

[13] In Appendix Table A.1, we explore the relationship between exports of each of the eight high-income countries and the change in US imports. When SITC and year fixed effects are included, the change in US imports is insignificant in 5 out of 8 cases, positive and significant at the 1% level in two cases (Japan and Finland), and negative and significant at 10% level in one case (New Zealand). This further indicates that there is little systematic evidence for a correlation between the country's exports to third markets and US import demand, provided that sector and time fixed effects are controlled for.

The other threat to our identification is that the supply shock originated in the United States may be correlated with the supply shocks from other exporting countries. As shown in equation (9), $\beta_{st}^{us}$ includes the US export variety and production marginal costs, and reflects a US supply shock (such as an expansion in product variety). Thus, in column (5) we further include SITC×year fixed effects, which absorb the supply shock. This is our preferred specification, and the second instrument is constructed from the predicted values in column (5), but excluding the SITC×year fixed effects. Using these predictions, we construct the second instrument as,

$$\Delta EP_{st}^{PRE} = \frac{(\hat{X}_{st}^{SIC} - \hat{X}_{st_0}^{SIC})}{Y_{s,t_0}}, \tag{10}$$

which is at the revised SIC industry level and is used as the instrument for the actual US export expansion.

After the above steps, we end up with measures of the change in US import penetration from China and its instrument, as well as the change in US export expansion to the world and two instruments, for 392 revised SIC manufacturing sectors.

## 2.4 US Employment

For US employment changes we use the County Business Patterns (CBP) for the years 1991, 1999, 2007, and 2011. We use the same data coverage as Acemoglu et al (2016) and follow their steps to merge the data into 392 manufacturing sectors and 87 non-manufacturing sectors by 722 commuting zones. For additional sectoral level information within the manufacturing sector (such as the number of production workers and nonproduction workers, and a number of sectoral controls which we will discuss in detail in later sections), we use the NBER-CES Manufacturing Industry Database for the same years 1991, 1999, 2007.[14]

Table 2 summarizes our main variables of interests, including the measures of import and export exposure, changes in labor employment, and instrumental variables.

[Table 2 about here]

[14]The NBER-CES database ends at the year 2009.

# 3 Exports Create Jobs in Manufacturing

## 3.1 Benchmark Industry Estimation

Table 3 takes a first look at the impact of US exports to the world, in addition to its import exposure from China. Following Acemoglu et al. (2016), we adopt a stacked first-difference model for the two time periods 1991-1999 and 1999-2007. Column (1) starts with an OLS regression, where import exposure from China has a significantly negative impact on the industrial employment growth, while export expansion creates a positive and significant effect on employment. More specifically, a one percentage point rise in industry import penetration reduces domestic industry employment by 0.74 percentage points, while a one percentage point rise in export expansion increases industrial employment by 0.39 percentage points.

As noted above, both estimates for the import exposure and export exposure could be biased due to simultaneous changes in domestic demand and supply. Thus, starting from column (2) we present results that use 2SLS. Recall that we have two instruments for export expansion, thus we clarify at the top of each column which instrument(s) are used for exports. Column (2) presents the results with the first instrument for US exports (i.e., contemporaneous changes in export from other eight countries to the rest of world except the United States, $\Delta EP_{st}^{OTH}$), for period 1991-2007. It shows that, after correcting the simultaneity bias, we obtain larger estimates than the OLS estimates, for both import and export expansion. This is consistent with a US product demand shock that increases imports, decreases exports, while reducing employment and therefore biasing the OLS coefficients on both imports and exports towards zero. On the other hand, a US supply shock that is labor saving will reduce employment, raise output and likely reduce imports, but raise exports, which will also bias the OLS coefficients towards zero.

In a third scenario, a US supply shock that results in the expansion of product variety will increase exports and employment, resulting in an over-estimated OLS coefficient on the export variable. This possibility calls for a careful derivation of a gravity-type prediction of US exports, which we have provided in section 2. The predicted US export (i.e., $\Delta EP_{st}^{PRE}$) is used as an IV in column (3). In this case, the estimated effect of exports on employment is lower than that implied by column (2) but is still significant, resulting in lower implied job gains. However, as we show later in the commuting zone level regressions, using predicted US exports as an instrument generates stronger effect while using other eight countries' exports as instruments will give a weaker result, so both the export instruments are of interest.

In column (4), we include both instruments for US exports. As shown in equation (9), $\Delta EP_{st}^{PRE}$ — our second instrument — contains different information from the first instrument: it includes the tariff terms and gives a careful specification of the multilateral demand term. We use both instruments as our preferred specification because it makes full use of the information.[15] Based on the results in column (4), a one percentage point rise in industry import penetration reduces domestic industry employment by 1.3 percentage points, while a one percentage point rise in export expansion increases industrial employment by 0.69 percentage points. Columns (5)-(7) further extend the sample period to 2011, and the results are similar qualitatively: import exposure reduces jobs while export expansion creates them. In the bottom panels, we report the first stage regression results for the two endogenous variables. In most cases the F-statistics for the excluded instruments are well above the Stock-Yogo weak IV test critical value at 10% level.

[Table 3 about here]

Relying on the preferred estimation results in column (4) of Table 3, we can evaluate the economic magnitude of trade shocks on labor employment. From equation (4), and following Acemoglu et al. (2016), changes in industrial employment brought about by the increase in

[15] In the Appendix Table A.2, we investigate what extra information the second instrument adds. We find that the results from using both instruments are very similar to the results from using the first IV and the tariff component of the second IV (though the tariff component does not always have the expected sign in the first stage). But when we instead use the tariff and the non-tariff components of the second IV separately, the export variable has a smaller coefficient.

imports and export can be expressed as:[16]

$$\Delta L_t = \sum_s \left( L_{s,t}(1 - e^{(\hat{\beta}_1 \Delta IP_{st} + \hat{\beta}_2 \Delta EP_{st})}) \right), \tag{11}$$

where $\hat{\beta}_1$ and $\hat{\beta}_2$ are the 2SLS coefficient estimates. Hypothetically, this equation calculates the difference between the actual and counterfactual manufacturing employment in year t if there are no changes in import and export exposure. Applying the actual changes in import penetration ($\Delta IP_{st}$) and export expansion ($\Delta EP_{st}$), we calculate the net employment changes due to trade shocks. Export expansion *net of* China import penetration actually led to a net gain of 324,000 jobs in the first period 1991-1999, while it led to a net loss of 642,000 jobs for the second period 1999-2007, and 697,000 job losses for 1999-2011.[17]

Given that the observed changes in manufacturing employment over these time periods were a slight increase of 200,000 jobs in 1991-1999, and a large reduction of 3.34 million jobs in 1999-2007 (and another 2.48 million job losses from 2007 to 2011), import penetration contributed a substantial share of job losses, particularly in the second period when imports from China grew much faster. However, export expansion also created a considerable number of jobs at the same time, without which employment in US manufacturing would have been experienced a much worse contraction. On balance over the entire 1991-2007 period, therefore, job gains due to changes in US global exports largely offset job losses due to imports competition from China, resulting in about 0.32 million job losses in net. And, when we extend the time period to 2011, in net there are about 0.4 million job losses.[18]

[16] We are assuming that when $\Delta IP_{st} = \Delta EP_{st} = 0$, then the China shock and export opportunities have zero impacts on the *level* of employment, and not just on its difference. In other words, we are assuming that import penetration and export expansion do not create a common employment effect across industries that we are omitting in the diff-in-diff specification.

[17] If we focus on the export channel while shutting down the other (e.g. import exposure from China), then export expansion brought about 805,000 jobs in 1991-1999, and about 514,000 jobs in 1999-2007. On the other hand, if we focus on import shocks from China, the import competition led to 521,000 job losses in 1991-1999, and 1.24 million job losses in 1999-2007.

[18] In the bottom rows of Table 3, we present the implied net job change during different periods, for each specification.

## 3.2 Robustness with Additional Controls

As we have discussed above, industries subject to greater trade shocks may also be exposed to other economic fluctuations that are correlated with import and export growth. In Table 4, we add as robustness checks additional controls to address this concern. Following Acemoglu et al. (2016), we consider three groups of controls. In all regressions, we use both $\Delta EP_{st}^{OTH}$ and $\Delta EP_{st}^{PRE}$ to instrument for export expansion, and the same ADH-type instrument $\Delta IP_{st}^{OTH}$ for import shocks. First, column (1) includes a set of dummies for 10 one-digit broad manufacturing categories, which allows for differential trends across these one-digit sectors given our first differences specification. Column (2) considers a set of sectoral controls drawn from the NBER-CES database, including the share of production workers in sectoral employment, the log of the industrial average wage, the ratio of capital to value added (all measured in 1991), and computer and high tech equipment investment and pretrend variables in 1990 as a share of total 1990 investment. Column (3) captures the secular trends that US manufacturing has been declining since the 1950s and that manufacturing employment has been falling since the 1980s. Such a long-standing trend predates the recent rise in trade shocks and may overstate the impact of trade exposure in the current period. Thus, column (3) adds the change in the industry's share of total US employment and the change in the log of the industry average wage, both measured over 1976-1991. Then in column (4), we include all three sets of controls simultaneously.

[Table 4 about here]

Throughout columns (1) to (4), the coefficient estimates for export exposure are significant and stable in magnitude. With the full sets of controls, a one percentage point rise in industry import penetration reduces domestic industry employment by 0.81 percentage points, while a one percentage point rise in export expansion increases industrial employment by 0.63 percentage points. Finally in column (5) we include a full set of dummies for the 392 four-digit manufacturing industries. Using this full set of industry dummies in the stacked first-difference specification, the effect of trade shocks is identified by *changes* in the growth rates of industry employment and the trade exposure measures in the second period (1999-2007) relative to the first period (1991-1999). The coefficient estimates in this very demanding specification are noticeably reduced for both import and export exposure.

The last two columns (6)-(7) extend the coverage of the sample to 1991-2011. Column (6) uses full sets of industrial controls and obtains similar results, confirming the robustness of the job creating effect of export expansion. Column (7) uses the full set of industry dummies. In both cases, the impact of export expansion remains similar to column (5) for 1991-2007, while the significance and magnitude of the import coefficient is reduced further.

## 3.3 Impact on Other Industrial Outcomes

Next we explore the impact of trade exposure on other outcomes. Columns (1) to (5) of Table 5 use CBP data while columns (6)-(10) use NBER-CES database. Increasing import exposure reduces employment (col. 1), the number of establishment (col. 2), average employment per establishment (col. 3), the total wage bill (col. 4), and it also reduces employment of both production workers (col. 6) and non-production workers (col. 7). Interestingly, increasing import exposure increases the workers' real wage (col. 5), and has no significant effect on real wages of production and nonproduction workers separately (col. 8 and col. 9).

Export expansion, on the other hand, substantially increases employment (col. 1), the number of establishment (col. 2), employment per establishment (col. 3), and the real wage bill (col. 4), but has no significant impact on real wage (col. 5); it also increases employment in both production workers (col. 6) and non-production workers (col. 7), and the real wages of both types of workers (col. 8 and col. 9), though the wage effects on non-production workers are not significant. Finally column (10) shows that export expansion substantially increases real industrial output while import competition has no significant effect.

[Table 5 about here]

## 3.4 Accounting for Input-Output Linkages

Trade impacts may go beyond the industry boundary and propagate upstream and downstream. Note this effect is not limited to within the manufacturing sector (e.g. an automobile producer may be exposed to trade shocks in upstream steel industry, or vice versa), and trade shocks in manufacturing will also affect services and other nontradable sectors. Wang et al. (2017), for example, focus on China's position as a supplier of intermediate inputs for US sectors and argue that the net effect from trading with China on US employment is modestly positive.

To make our results closely comparable to ADH (2013) and Acemoglu et al. (2016), we apply the same input-output table for 1992 from the BEA to study the interindustry linkages. First, the *upstream effect* of export and import exposure measures the impact of downstream sectors' trade exposure on upstream suppliers. That is:

$$\Delta IP_{st}^{up} = \sum_{g} \omega_{gs}^{u} \Delta IP_{gt}, \qquad and \qquad \Delta EP_{st}^{up} = \sum_{g} \omega_{gs}^{u} \Delta EP_{gt}, \tag{12}$$

where $\omega_{gs}^{up}$ is the use coefficient which tells the share of product $s$ used as input in industry g, which is derived from the 1992 BEA input-output matrix. Thus $\Delta IP_{st}^{up}$ is a weighted average of the trade shocks faced by downstream buyers of products from sector $s$. When a downstream sector $g$ experiences an export expansion, it may also increase its demand for intermediate inputs from its upstream sector $s$.

We could similarly compute the *downstream effect* of export and import exposure, which measures the impact of upstream sectors' trade exposure on downstream buyers. When an upstream sector $g$ experiences an export expansion, it may drive up the domestic price for $g$, which creates a negative impact on domestic downstream users in sector $s$. On the other hand, export expansion may improve the productivity of upstream sector $g$, and therefore generate positive downstream effects on sector $s$. The downstream measures are:

$$\Delta IP_{st}^{down} = \sum_{g} \omega_{sg}^{d} \Delta IP_{gt}, \qquad and \qquad \Delta EP_{st}^{down} = \sum_{g} \omega_{sg}^{d} \Delta EP_{gt}, \tag{13}$$

where $\omega_{sg}^{d}$ measures the input share of product $g$ used as input in industry $s$.

Using equations (12) and (13), we can generate instruments for both the upstream and downstream exposure measures. Table 6 presents the 2SLS estimation results, for period 1991-2011. Column (1) focuses on the effect of import shocks, augmented with upstream and downstream import exposure, for 392 manufacturing sectors. Besides the significant direct effect of import exposure, upstream import exposure also exerts a negative impact on industrial employment, while downstream import exposure has a positive but not significant effect. Column (2) further incorporates changes in export exposure. In this case, the direct within-sector effect of export exposure is positive and significant. Furthermore, buyers' export exposure also creates significant and positive effect on the employment of upstream suppliers (as shown by the coefficient for the upstream export exposure), while the effect of downstream export exposure is not precisely estimated.

Column (3) considers only the non-manufacturing sector while columns (4) extends the sample to consider both manufacturing and non-manufacturing sectors. Although exposure at the upstream and downstream sectors exerts positive effects on non-manufacturing employment, the effects are not significant except for the downstream export exposure on non-manufacturing employment. Given that most effects come from the direct and the upstream exposure, columns (5)-(6) sum the upstream and direct trade exposures, confirming that import exposure reduces jobs while export expansion creates them.

[Table 6 about here]

Moreover, the above equations account for the direct transmission of shocks along the inter-sectoral input-output linkage. Upstream and downstream effects could also take force indirectly through iteration. For example, a shock to the plastics sector may affect the downstream computer industry, and further affect that transportation sector that relies on computers. Such impacts across sectors generate a full chain of implied responses based on the input-output matrix. Therefore we augment the results in Table 6 with the Leontief inverse of the matrix, in which case we find similar results and so we report them in the Appendix, Table A.3.

# 4 Export Exposure on Local Labor Markets

The industry level results compare changes in relative employment across manufacturing sectors with different exposure to import penetration and export expansion. As emphasized by Acemoglu et al (2016), this approach cannot identify the reallocation and demand effects which occur in general equilibrium. In their influential work, ADH (2013) quantify the reallocation effects by focusing on cross-regional variations in local commuting zones' responses to trade shocks. In this section, we follow ADH (2013) and Acemoglu et al. (2016) and explore the geographic differences in trade shocks, based on 722 commuting zones (CZs) that cover the entire US mainland.

We begin by first constructing the Bartik measures of CZ level import and export exposure as:

$$\Delta IP_{it}^{CZ} = \sum_s \frac{L_{is,t_0}}{L_{i,t_0}} \Delta IP_{st}, \qquad and \qquad \Delta EP_{it}^{CZ} = \sum_s \frac{L_{is,t_0}}{L_{i,t_0}} \Delta EP_{st}, \tag{14}$$

where $i$ denotes commuting zone, $s$ denotes SIC manufacturing sectors, $\Delta IP_{st}$ and $\Delta EP_{st}$ are sectoral import and export exposure that we have used in the previous sections. So $\Delta IP_{it}^{CZ}$ and $\Delta EP_{it}^{CZ}$ denote the increases in import and export exposures respectively, by commuting zone $i$ for time period $t$ (either 1990-2000, or 2000-2007/2011). Note that $L_{is,t_0}$ is the *start of period* employment in manufacturing sector $s$ and commuting zone $i$, while $L_{i,t_0}$ is the *start of period* total employment for commuting zone $i$, including both manufacturing and nonmanufacturing employment. The variation in import and export exposures across commuting zones comes entirely from the differences in local industry structure in employment in the initial year. Figure 3 presents a comparison of the regional exposures to imports and exports during the two subperiods.

[Figure 3 about here]

As with the industry measure of trade shocks, the CZ level import and export exposures are also likely to be subject to endogeneity problem. Therefore we apply the Bartik formula to the industry level instrument $\Delta IP_{st}^{OTH}$, obtaining commuting zone level instrument for import exposure. Directly applying the Bartik formula to the industrial export exposure, however, is subject to potential measurement error: the instruments $\Delta EP_{st}^{OTH}$ and $\Delta EP_{st}^{PRE}$ are intended to be *affine transformations* of actual US exports (up to an error) at the industry level, but not necessarily equal to such exports (up to an error). Because this transformation for each instrument can differ across industries, not correcting for it initially will lead to measurement error when aggregating to the commuting zone level. Accordingly, we correct for this potential error by regressing a panel of actual exports at SIC level on the predicted exports at the same industry aggregation, with industry fixed effects and year dummies: that is, $X_{st} = \alpha_t + \alpha_s + \delta \hat{X}_{st}^{SIC} + \nu_{st}$.[19] Then we apply the Bartik local employment weights to the fitted value of the above estimation, obtaining our two constructed commuting zone level instruments for $\Delta EP_{it}^{CZ}$.

With both exposure measures and their instruments, we estimate the following specification across 722 commuting zones:

$$\Delta L_{it}^{m} = \beta_t + \beta_1 \Delta IP_{it}^{CZ} + \beta_2 \Delta EP_{it}^{CZ} + \gamma X_{it_0}^{CZ} + \gamma_r + e_{it}, \quad (15)$$

where $\Delta L_{st}^{m}$ is the annual change in manufacturing employment share of the working age population in commuting zone $i$ over time period $t$. To be consistent with the industry level specification, we continue to stack the annualized first differences for the two periods, 1991-1999 and 1999-2007 or 1999-2011. In all regressions, we also include $\beta_t$ to control for different time trends between the two time periods, a set of census division dummies to control for regional specific trends, as well as the initial share of manufacturing workers (in 1991). All regressions are weighted by the start of period (1991) commuting zone's share of national population, and the standard errors are clustered at the commuting zone level.

Table 7 presents results for the manufacturing employment share, for both 1991-2007 and 1991-2011 and with different sets of instruments for export expansion (as indicated in the title

[19]Running this estimation prior to the industry-level estimation won't affect these previous results in section 3 since the industry specific effects are readily controlled by the long-difference specification that we have taken, while $\delta$ does not vary across industries.

row). The first four columns focus on 1991-2007, starting with $EP^{OTH}$ as the instrument for exports. It shows that the impact of CZ level import exposure on the local manufacturing employment share is negative and significant, while export impact is positive but not significant. Column (2) instead uses $EP^{PRE}$ as the export instrument, and then export exposure is found to have a substantial and significant impact on commuting zone manufacturing employment.

We further experiment with including both instruments for export, which is preferred because it utilizes the most information. The results are shown in column (3). We find that a one percentage point increase in average import penetration in the local commuting zone leads to a 1.24 percentage point reduction in the local manufacturing employment share. Export expansion, on the other hand, increases the local manufacturing employment share by 0.79 percentage point.[20] Throughout columns (1) to (3) we include a set of commuting zone level initial demographic and economic controls, in particular the start-of-period share of manufacturing employment. The local manufacturing employment share at the start of period has a strong negative effect on manufacturing employment share.[21] Other controls include the percentage of college-educated population, percentage of foreign-born population, percentage of employment among women, percentage of employment in routine occupations, and finally the average offshorability index of occupations.

Quantitatively, relying on the preferred results of column (3), accounting for local market effects implies that increased import exposure led to a loss of about 2.58 million manufacturing jobs in local labor market from 1999 to 2007, and another 0.97 million manufacturing job losses

[20]In the appendix Table A.4, we further report results which decompose the second IV (i.e., $EP^{PRE}$) into the tariff-related term and the multilateral import demand term according to equation (9). When using both the first IV ($EP^{OTH}$) and the tariff term of the second IV, the results are similar to using only the first IV: the impact of export expansion remains insignificant in 1991-2007, while becomes more significant in 1991-2011. Instead, when we use both the tariff component and the nontariff component of the second IV, the latter capturing multilateral demand, the export impact remains highly significant in both periods.

[21]The manufacturing share is positively correlated with both export expansion and import exposure because of the construction of the Bartik weights used in (14), where $L_{is,t_0}$ in the numerator is employment in manufacturing sector $s$ and commuting zone $i$, while $L_{i,t_0}$ in the denominator is the total employment for commuting zone $i$, including both manufacturing and nonmanufacturing employment. Thus if we omit the initial manufacturing share which has a negative coefficient, then the coefficient on import exposure becomes more negative (stronger), while the effect of export expansion becomes less positive (weaker). Bernard and Jensen (2000) were the first to notice the importance of the initial manufacturing share in determining labor market outcomes.

from 1991 to 1999. On the other hand, increased export exposure implies a gain of 2.01 million manufacturing jobs from 1991 to 1999 and 1.34 million from 1999 to 2007. In net, export exposure substantially offsets the reduction in jobs caused by import competition, although it does not eliminate them, leaving about only 0.2 million net job losses.

Columns (4)-(6) further examine the longer period 1991-2011, in which all estimates for export exposure become significant. Based on column (6), our preferred specification with two IVs for exports, the effect of export expansion on manufacturing employment is even stronger: now an 1 percentage point increase in average export exposure in a local commuting zone generates a 0.92 percentage point increase in the local manufacturing employment share. The effect of import exposure from China remains similar to the early period. Applying these estimated coefficients to actual trade values, then increased import exposure led to a loss of about 1.01 million manufacturing jobs in the first period (1991-1999) in local labor market, and 3.21 million manufacturing jobs during the longer period 1999-2011, while increased export exposure implies a gain of 2.33 manufacturing jobs in 1991-1999, and 1.91 million manufacturing jobs from 1999 to 2011. So over the full 2 decades, import exposure leads to about 4.22 million job losses, while export expansion generates about 4.24 million jobs. The net effect is roughly balanced over this longer period.

[Table 7 about here]

In Figure 4 we report the percentage job losses due to import competition from China, and percentage job gains due to US exports, by commuting zones. These maps have much the same pattern as was shown for the changes in import and export exposure in Figure 3, and indeed, the percentage job changes are obtained by just multiplying those exposure-changes by their respective coefficients in regression (15). The highest job losses in any zone are 1.2% per year during 1991-1999 and 0.9% per year during 1999-2011, while the highest job gains are 1.0% during 1991-1999 and 2.1% per year during 1999-2011. There is an apparent correlation in Figure 4 between job losses and job gains across CZ, though that correlation is not as strong as it appears visually: the correlation between the percentage changes in job lost and job gained is 0.49 for the 1991-1999 period but it is only 0.20 for the 1999-2011 period.

[Figure 4 about here]

# 5 Conclusions

The work of Autor, Dorn, and Hanson (2013), Pierce and Schott (2016), and Acemoglu et al. (2016) has alerted us the impact of the China shock on US employment and unemployment. As exports from China grew rapidly following its WTO accession in 2001, there was a marked fall in US manufacturing employment, and in particular a geographic correlation between the inflow of goods from China and the fall in employment within regions formerly producing those goods. What has not received the same degree of attention in the literature is the potential for a rise in employment within regions that produce and benefit from growing US exports. ADH (2013) experimented with using net manufacturing imports from China, or the difference between US imports and exports (per worker) by commuting zone, but that did not give results that were greatly different from what they obtained with gross imports from China.

In this paper, we have re-examined the employment impact of US exports, using exports to the world rather than just exports to China. We believe that this is a better way to evaluate the employment impact of US exports: the growth in Chinese demand as compared to the growth in demand from other countries for US goods are of equal interest when evaluating the employment impact, so there is no reason to focus on Chinese demand alone.[22] But demand for US exports is endogenous. The China shock created a compelling supply-side instrument for Chinese exports to the US, i.e. by using its exports to other industrial countries, and likewise we have had to develop viable instruments for US exports to the world. In addition to using the exports of other industrial countries to foreign markets, we have derived a gravity-type specification for US exports that uses those exports of other countries along with the tariffs charged in foreign

[22] See notes 2 and 5.

countries. A careful examination of the predicted US exports makes us believe that it is less subject to a common demand shock that affects both US exports and imports, and that both the tariff component and the multilateral demand component of the predicted exports add extra information to our estimation.[23]

Our results fit the textbook story that job opportunities in exports make up for jobs lost in import-competing industries, or nearly so. At the industry level, the US export of manufactured goods created enough jobs to offset all but 0.3-0.4 million of the jobs lost due to imports from China, over the entire 1991-2011 period. When we shift to considering commuting zones, then the net job loss over 1991-2007 is still about 0.2 million jobs, but over the longer period 1991-2011 the job losses are just balanced with the job gains. There is also a positive geographic correlation between those losses and gains, so that commuting zone with higher percentage losses are also more likely to have higher percentage gains. This result helps to explain how local labor markets reached equilibrium even in the absence of strong mobility across regions, though admittedly, this correlation is much weaker during the second decade (only 0.20 during 1999-2011) than the first (0.49 during 1991-1999).[24] It would be desirable to further explore the job losses and gains at the CZ level, and within broader regions rather than CZ, to understand the equilibrating mechanism in local labor markets due to import and export shocks. We leave this task for further research.

[23]See notes 15 and 20, and the Appendix with Tables A.2 and A.4.

[24]Kovak and Cadena (2016) show that low-skilled native-born workers have limited mobility between regions and will suffer a wage or employment loss due to an adverse demand shock, whereas low-skilled immigrants and high-skilled workers are more likely to move.

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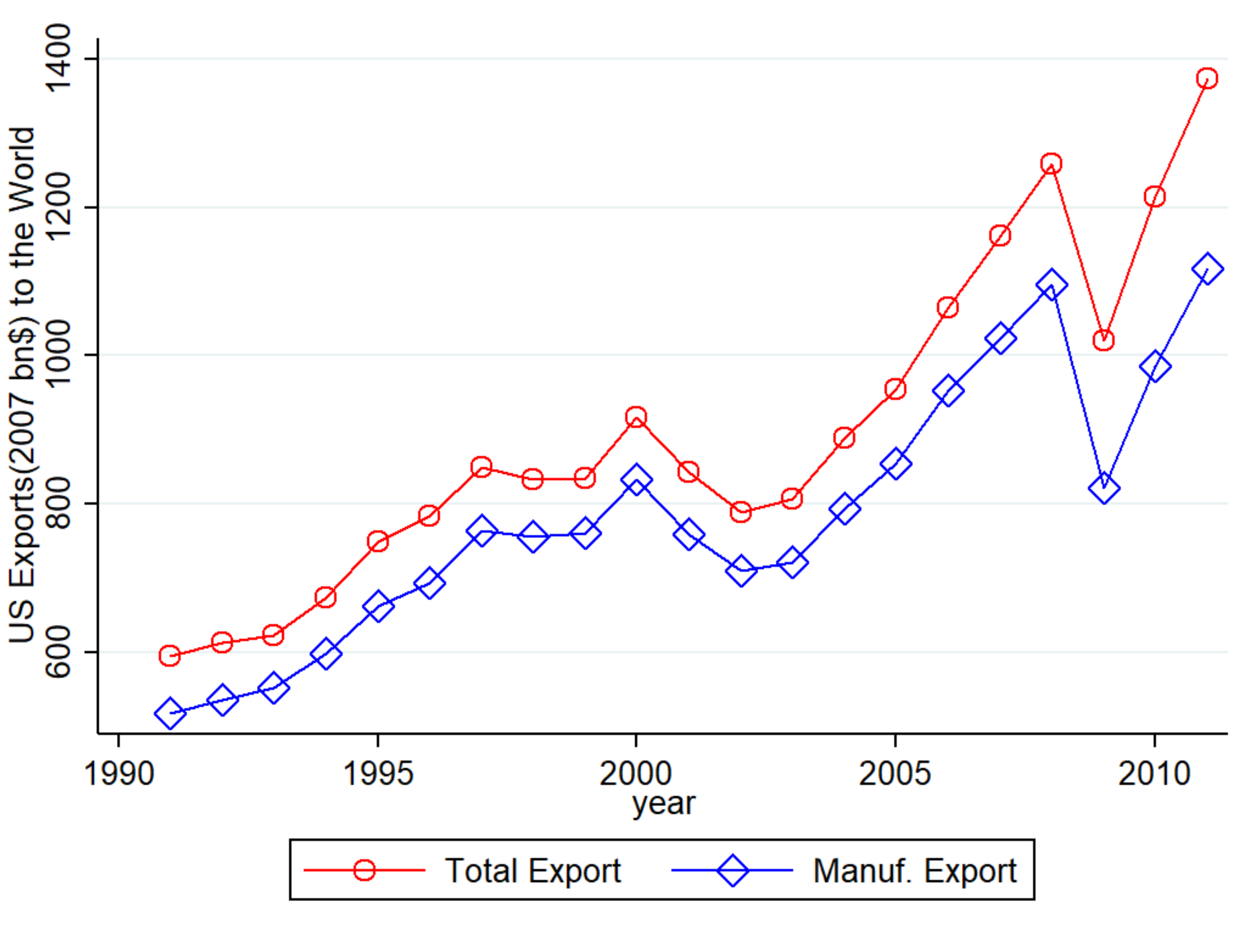
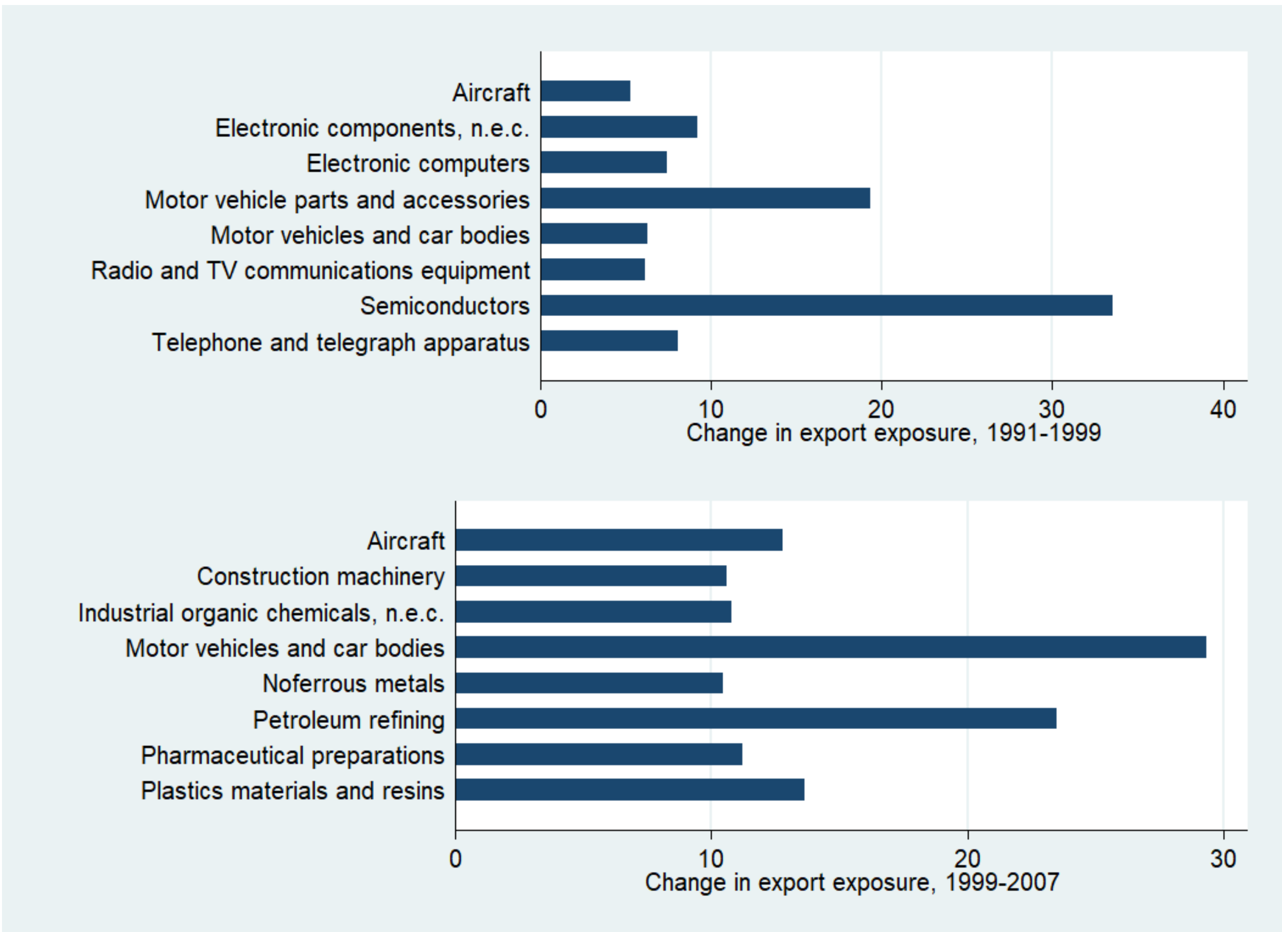
Figure 1: US Export: 1991-2011



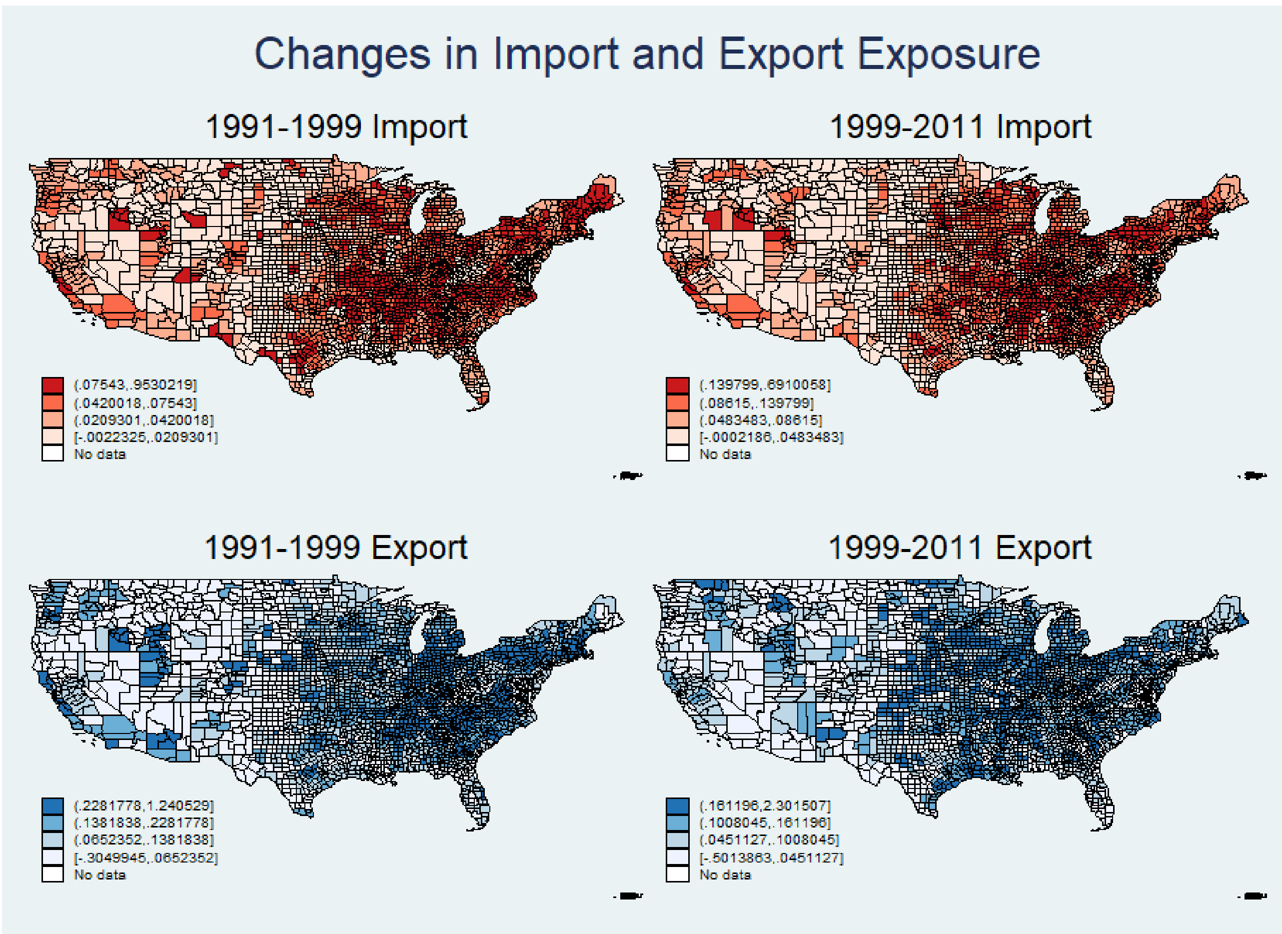

Note: Red line shows the aggregate export of the United States, while the blue line shows the manufacturing exports. All values are in billion US$, deflated to 2007 US dollars using the PCE price index. Data source: UN-Comtrade

Figure 2: Changes in US Industry Real Exports: 1991-2007



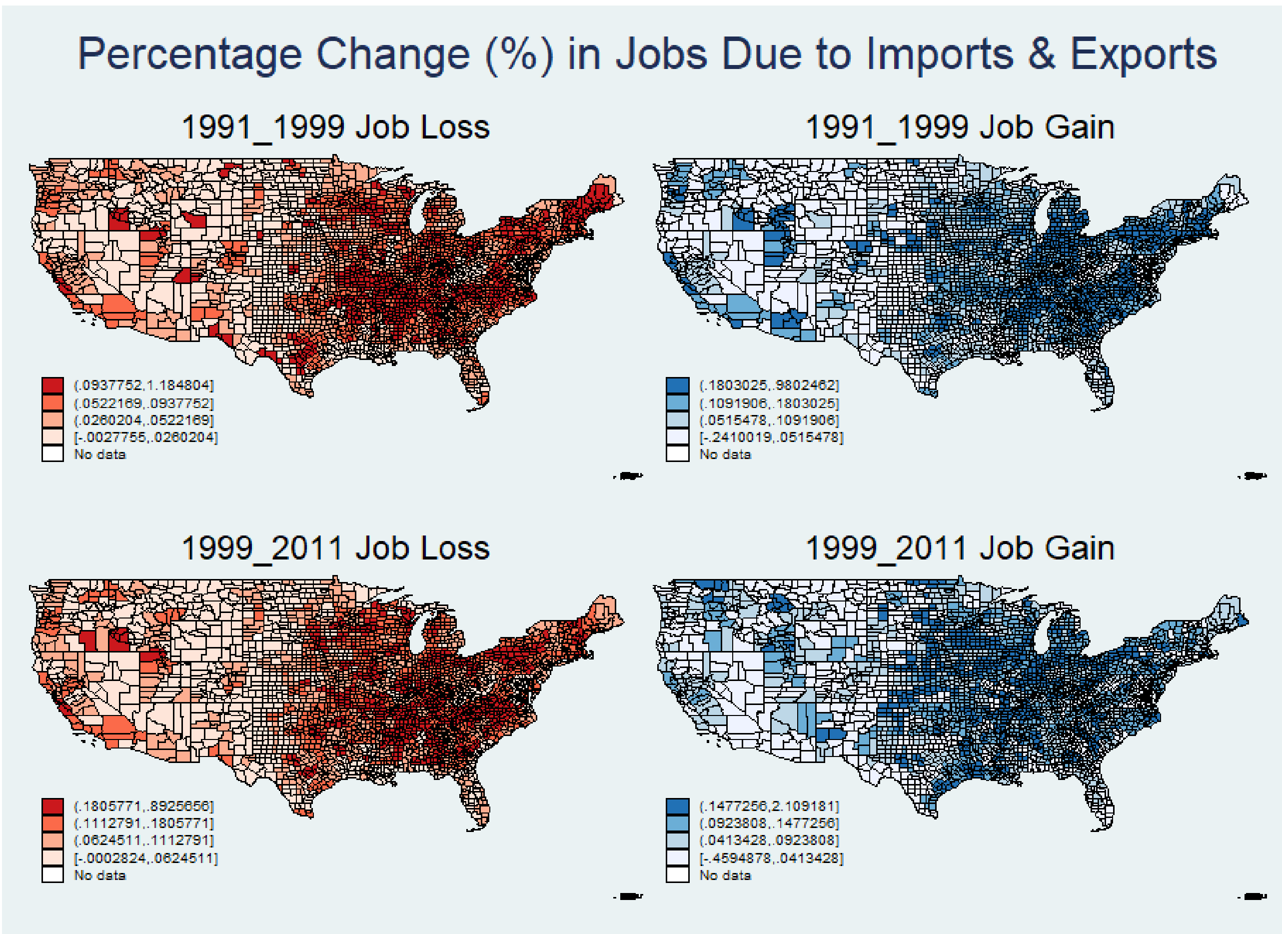

Note: This figure shows the top 8 SIC products in US exports, in terms of changes in real export value for two subperiods 1991-1999 and 1999-2007. All values are in billion US$, deflated to 2007 US dollars using the PCE price index. Data source: UN-Comtrade

Figure 3: US Commuting Zone Export and Import Exposure: 1991-2011




Note: This figure shows the changes in export and import exposure across US commuting zones, for two subperiods 1991-1999 and 1999-2011. Data source: UN-Comtrade

Figure 4: US Commuting Zone Percentage Job Changes due to Global Exports and Imports from China: 1991-2011




Note: This figure shows the annualized percentage changes in job gains due to exports and job losses due to imports across US commuting zones, for two subperiods 1991-1999 and 1999-2011. Data source: UN-Comtrade

Table 1: Predicting US Exports: 1990-2011

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| $\ln(\tau_{st}^{us,j})$ | -6.78*** | -9.80*** | -7.06*** | -10.25*** | -7.12*** |
| | (0.04) | (0.06) | (0.04) | (0.06) | (0.04) |
| $\ln(\sum_{k\neq US} X_{s,t-1}^{k,j})$ | 0.75*** | 0.70*** | 0.76*** | 0.71*** | 0.76*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| $\ln(T_{st}^{j})$ | 7.06*** | 10.74*** | 6.90*** | 10.83*** | 6.95*** |
| | (0.04) | (0.06) | (0.04) | (0.06) | (0.04) |
| $\ln Dist$ | -1.95*** | -1.68*** | -1.94*** | -1.69*** | -1.95*** |
| | (0.004) | (0.005) | (0.004) | (0.005) | (0.004) |
| $\Delta \ln IMP_{s,t}^{us}$ | | 0.062*** | | 0.006 | |
| | | (0.011) | | (0.011) | |
| Observations | 1,256,201 | 511,629 | 1,256,201 | 511,629 | 1,255,646 |
| R-squared | 0.560 | 0.620 | 0.565 | 0.625 | 0.574 |
| SITC | YES | YES | YES | YES | |
| YEAR | | | YES | YES | |
| SITC×Year | | | | | YES |

Notes: We use the total export by other countries (excluding the US) with a lag of 0 year to measure the global demand of the given products; The weights in calculating the average tariff faced by other countries (excluding the US) are fixed in year 1990. $\Delta \ln IMP_{s,t}^{us}$ denotes the one year log change of US import from the rest of the world in sector $s$. $\Delta \ln \widetilde{IMP}_{s,t}^{j,us}$ denotes the one year log change of US import from the rest of the world (excluding the destination country $j$) in sector $s$ The elasticity of substitution, i.e., $\sigma$, is seven. Robust standard errors are clustered at country-year level and reported in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

## Table 2: Descriptive Statistics

| | N | Mean | S.D. | Median | Min | Max |
|---|---|---|---|---|---|---|
| | | | 1991-1999 | | | |
| 100 × annual Δ in US import exposure | 392 | 0.27 | 0.75 | 0.04 | -0.25 | 12.15 |
| Instrument for Δ in US import exposure | 392 | 0.18 | 0.44 | 0.04 | -1.51 | 6.62 |
| 100 × annual log Δ in manufacturing employment | 392 | -0.30 | 3.49 | 0.36 | -18.15 | 14.18 |
| 100 × annual log Δ in non-manufacturing employment | 87 | 2.46 | 2.38 | 1.79 | -11.80 | 11.75 |
| 100 × annual Δ in US export exposure | 392 | 0.89 | 1.53 | 0.41 | -1.80 | 21.65 |
| Instrument for Δ in US export exposure (PR method) | 392 | 0.74 | 1.59 | 0.27 | -8.22 | 7.84 |
| Instrument for Δ in US export exposure (OT method) | 392 | 0.49 | 1.83 | 0.21 | -28.67 | 11.26 |
| | | | 1999-2007 | | | |
| 100 × annual Δ import exposure | 392 | 0.84 | 1.61 | 0.25 | -1.52 | 19.69 |
| Instrument for Δ import exposure | 392 | 0.60 | 1.07 | 0.22 | -0.27 | 14.15 |
| 100 × annual log Δ manufacturing employment | 392 | -3.62 | 4.15 | -2.74 | -47.50 | 9.00 |
| 100 × annual log Δ non-manufacturing employment | 87 | 1.54 | 1.59 | 1.24 | -8.97 | 16.90 |
| 100 × annual Δ export exposure | 392 | 0.61 | 2.40 | 0.17 | -8.82 | 93.38 |
| Instrument for Δ export exposure (PRE) | 392 | 0.50 | 2.31 | 0.07 | -20.34 | 16.64 |
| Instrument for Δ export exposure (OTH) | 392 | 3.02 | 4.66 | 1.56 | -14.25 | 55.12 |
| | | | 1999-2011 | | | |
| 100 × annual Δ import exposure | 392 | 0.66 | 1.33 | 0.20 | -2.88 | 14.03 |
| Instrument for Δ import exposure | 392 | 0.60 | 1.07 | 0.22 | -0.69 | 13.34 |
| 100 × annual log Δ manufacturing employment | 392 | -4.32 | 3.85 | -3.63 | -58.63 | 7.56 |
| 100 × annual log Δ non-manufacturing employment | 87 | 0.57 | 1.56 | 0.29 | -9.27 | 11.04 |
| 100 × annual Δ export exposure | 392 | 0.43 | 2.53 | 0.15 | -6.06 | 104.37 |
| Instrument for Δ export exposure (PRE) | 392 | 0.37 | 2.69 | 0.14 | -14.39 | 17.27 |
| Instrument for Δ export exposure (OTH) | 392 | 2.42 | 4.36 | 1.22 | -9.67 | 76.19 |

Note: For each manufacturing industry, the change in US import (or export) exposure,is computed by dividing 100 × the annualized increase in the value of US imports (exports) over the indicated periods by 1991 US market value (1991 US industry output) in that industry. All observations are weighted by 1991 industry employment.

Table 3: US Trade Exposure and Industrial Manufacturing Employment

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | *Dep var: 100 × annualized log change in industrial employment* | | | | | | |
| | 1991-2007 | | | | 1991-2011 | | |
| | OLS | $EP^{OTH}$ | $EP^{PRE}$ | both IV | $EP^{OTH}$ | $EP^{PRE}$ | both IV |
| Δ Imports | -0.74*** | -1.30*** | -1.28*** | -1.30*** | -1.41*** | -1.37*** | -1.41*** |
| | (0.16) | (0.31) | (0.34) | (0.32) | (0.40) | (0.41) | (0.41) |
| Δ Exports | 0.39** | 0.83*** | 0.50** | 0.69*** | 0.79*** | 0.52** | 0.65*** |
| | (0.15) | (0.22) | (0.25) | (0.17) | (0.17) | (0.24) | (0.17) |
| 1{1991-1999} | -0.44 | -0.69 | -0.40 | -0.56 | -0.63 | -0.39 | -0.49 |
| | (0.40) | (0.45) | (0.46) | (0.44) | (0.41) | (0.45) | (0.42) |
| 1{1999-2007} | -3.24*** | -3.04*** | -2.86*** | -2.96*** | | | |
| | (0.38) | (0.42) | (0.37) | (0.39) | | | |
| 1{1999-2011} | | | | | -3.75*** | -3.65*** | -3.69*** |
| | | | | | (0.36) | (0.34) | (0.34) |
| | | *First Stage Results* | | | | | |
| | | (2) | (3) | (4) | (5) | (6) | (7) |
| Dep. var: Δ Imports | | | | | | | |
| $\Delta IP^{OTH}$ | | 1.215*** | 1.209*** | 1.215*** | 1.008*** | 0.993*** | 0.992*** |
| | | (0.146) | (0.139) | (0.147) | (0.148) | (0.143) | (0.140) |
| $\Delta EP^{OTH}$ | | -0.016 | | -0.016 | -0.022 | | -0.026 |
| | | (0.015) | | (0.020) | (0.015) | | (0.016) |
| $\Delta EP^{PRE}$ | | | -0.020 | -0.000 | | -0.006 | 0.028 |
| | | | (0.054) | (0.068) | | (0.034) | (0.041) |
| F-test | | 41.9 | 40.2 | 28.0 | 30.2 | 24.2 | 23.0 |
| Dep. var: Δ Exports | | | | | | | |
| $\Delta IP^{OTH}$ | | -0.293*** | -0.560 | -0.633*** | -0.064 | -0.428 | -0.417* |
| | | (0.110) | (0.410) | (0.239) | (0.120) | (0.313) | (0.239) |
| $\Delta EP^{OTH}$ | | 0.287*** | | 0.212*** | 0.249*** | | 0.169*** |
| | | (0.041) | | (0.048) | (0.047) | | (0.053) |
| $\Delta EP^{PRE}$ | | | 0.791*** | 0.534*** | | 0.844*** | 0.622*** |
| | | | (0.217) | (0.203) | | (0.210) | (0.212) |
| F-test | | 36.2 | 11.1 | 27.1 | 21.0 | 12.8 | 15.6 |
| Kleibergen-Paap rk Wald F stat | | 25.3 | 6.9 | 26.7 | 14.8 | 8.0 | 13.2 |
| Implied Net Job Change | | | | | | | |
| 1991-1999 | 204 | 487 | 120 | 324 | 400 | 104 | 233 |
| 1999-2007/2011 | -300 | -539 | -760 | -642 | -599 | -744 | -697 |

Note: Robust standard errors in parentheses, clustered on three digit SIC industries. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ The sample includes 392 SIC manufacturing sectors during different periods. All regressions are weighted by start-of-period employment share of the sector. Lower panels present the first stage regression results and F statistics for excluded instruments.

Table 4: US Trade Exposure and Manufacturing Employment: Robustness Checks

| | *Dep var: 100 × annualized log change in industrial employment* | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | | | 1991-2007 | | | 1991-2011 | |
| Δ Imports | -0.83*** | -1.16*** | -1.31*** | -0.81*** | -0.68*** | -0.77*** | -0.41 |
| | (0.20) | (0.30) | (0.33) | (0.20) | (0.24) | (0.23) | (0.28) |
| Δ Exports | 0.60*** | 0.61*** | 0.82*** | 0.63*** | 0.44*** | 0.57*** | 0.48** |
| | (0.11) | (0.16) | (0.18) | (0.11) | (0.14) | (0.13) | (0.19) |
| 1{1991-1999} | -0.61* | -0.53 | -0.68 | -0.64** | | -0.60* | |
| | (0.34) | (0.39) | (0.41) | (0.30) | | (0.32) | |
| 1{1999-2007} | -3.30*** | -3.03*** | -3.03*** | -3.33*** | -2.82*** | | |
| | (0.30) | (0.41) | (0.37) | (0.29) | (0.38) | | |
| 1{1999-2011} | | | | | | -14.57 | -3.65*** |
| | | | | | | (14.70) | (0.46) |
| Sector controls | Yes | No | No | Yes | No | Yes | No |
| Production controls | No | Yes | No | Yes | No | Yes | No |
| Pretrend controls | No | No | Yes | Yes | No | Yes | No |
| Industry fixed effects | No | No | No | No | Yes | No | Yes |
| Observations | 784 | 784 | 784 | 784 | 784 | 784 | 784 |
| First-stage F for Δ Imports | 25.17 | 28.01 | 28.79 | 25.74 | 41.58 | 22.99 | 14.19 |
| First-stage F for Δ Exports | 18.83 | 20.73 | 25.22 | 18.79 | 6.40 | 12.13 | 4.65 |

Note: Robust standard errors in parentheses, clustered on three digit SIC industries. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ The sample includes 392 SIC manufacturing sectors during different periods. All regressions are weighted by start-of-period employment share of the sector. First stage F-test for excluded instuments are reported in bottom. Detailed first stage results are available upon request.

## Table 5: US Trade Exposure and Other Labor Market Outcomes

| | *Dep var: 100 × annualized log change in industrial outcome* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | County Business Patterns Dataset | | | | NBER-CES Dataset | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| | Emp. | Num Estabs. | Emp Per Estab. | Real Wage Bill | Real Wage | Prod. Emp. | Non-Prod. Emp. | Real Prod. Wage | Real Non-Prod. Wage | Real shipments |
| $\Delta$ Imports | -0.83*** | -0.24*** | -0.59*** | -0.69*** | 0.13** | -0.93*** | -0.72*** | 0.11 | -0.07 | -0.24 |
| | (0.20) | (0.08) | (0.18) | (0.18) | (0.07) | (0.22) | (0.19) | (0.11) | (0.08) | (0.35) |
| $\Delta$ Exports | 0.60*** | 0.34*** | 0.25** | 0.67*** | 0.07 | 0.63*** | 0.57*** | 0.13** | 0.12 | 1.07** |
| | (0.11) | (0.11) | (0.11) | (0.12) | (0.05) | (0.13) | (0.17) | (0.06) | (0.08) | (0.52) |
| 1{1991-1999} | -0.61* | 0.17 | -0.78*** | 0.94*** | 1.55*** | -0.26 | -0.72** | 1.04*** | 1.71*** | 3.04*** |
| | (0.34) | (0.20) | (0.28) | (0.32) | (0.09) | (0.39) | (0.34) | (0.06) | (0.11) | (0.57) |
| 1{1999-2007} | -3.30*** | -1.21*** | -2.08*** | -2.92*** | 0.37*** | -3.54*** | -2.52*** | 0.37*** | 0.08 | -0.87** |
| | (0.30) | (0.22) | (0.24) | (0.31) | (0.12) | (0.33) | (0.33) | (0.08) | (0.12) | (0.35) |
| Observations | 784 | 784 | 784 | 784 | 784 | 768 | 768 | 768 | 768 | 768 |
| $R^2$ | 0.545 | 0.198 | 0.406 | 0.508 | 0.628 | 0.558 | 0.385 | 0.436 | 0.437 | 0.408 |
| First-stage F for $\Delta$ Imports | 27.62 | | | | | | | | | |
| First-stage F for $\Delta$ Exports | 17.40 | | | | | | | | | |

Note: Robust standard errors in parentheses, clustered on three digit SIC industries. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
The sample includes 392 SIC manufacturing sectors during two subperiods (1991-1999 and 1999-2007), the NBER-CES database excludes 8 industries due to missing data.
All regressions are weighted by start-of-period employment share of the sector. First stage F-test for excluded instuments are reported in bottom. Detailed first stage results are available upon request.

Table 6: US Trade Exposure and Employment: Inter-sectoral Linkages

| *Dep var: 100 × annualized log change in industrial employment, 1991-2011* | | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | manufacturing | | non-manuf | all sectors | | manufacturing |
| Direct Import Exposure | -1.28*** | -1.38*** | | -1.15** | | |
| | (0.49) | (0.47) | | (0.48) | | |
| First-Order Upstream Import Exposure | -2.44** | -3.16** | -7.99 | -2.85 | | |
| | (1.13) | (1.58) | (4.94) | (1.79) | | |
| First-Order Downstream Import Exposure | 2.31 | 3.69 | -7.41 | -0.62 | | |
| | (2.66) | (2.55) | (9.27) | (3.94) | | |
| Direct Export Exposure | | 0.43*** | | 0.44*** | | |
| | | (0.15) | | (0.16) | | |
| First-Order Upstream Export Exposure | | 1.94* | 1.07 | 0.58 | | |
| | | (0.99) | (1.90) | (1.03) | | |
| First-Order Downstream Export Exposure | | 0.29 | 5.17** | 1.37 | | |
| | | (0.53) | (2.17) | (0.92) | | |
| Combined Direct/Upstream Import Exposure | | | | | -1.42*** | -1.38*** |
| | | | | | (0.39) | (0.38) |
| Combined Direct/Upstream Export Exposure | | | | | 0.57*** | 0.62*** |
| | | | | | (0.17) | (0.17) |
| Observations | 784 | 784 | 174 | 958 | 958 | 784 |

Note: Robust standard errors in parentheses, clustered on three digit SIC industries. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ The sample includes 392 SIC manufacturing sectors and 87 non-manufacturing sectors during different periods. All regressions are weighted by start-of-period employment share of the sector. All regressions have sector (manufacturing/nonmanufacturing) × year fixed effects. Detailed first stage results are available upon request.

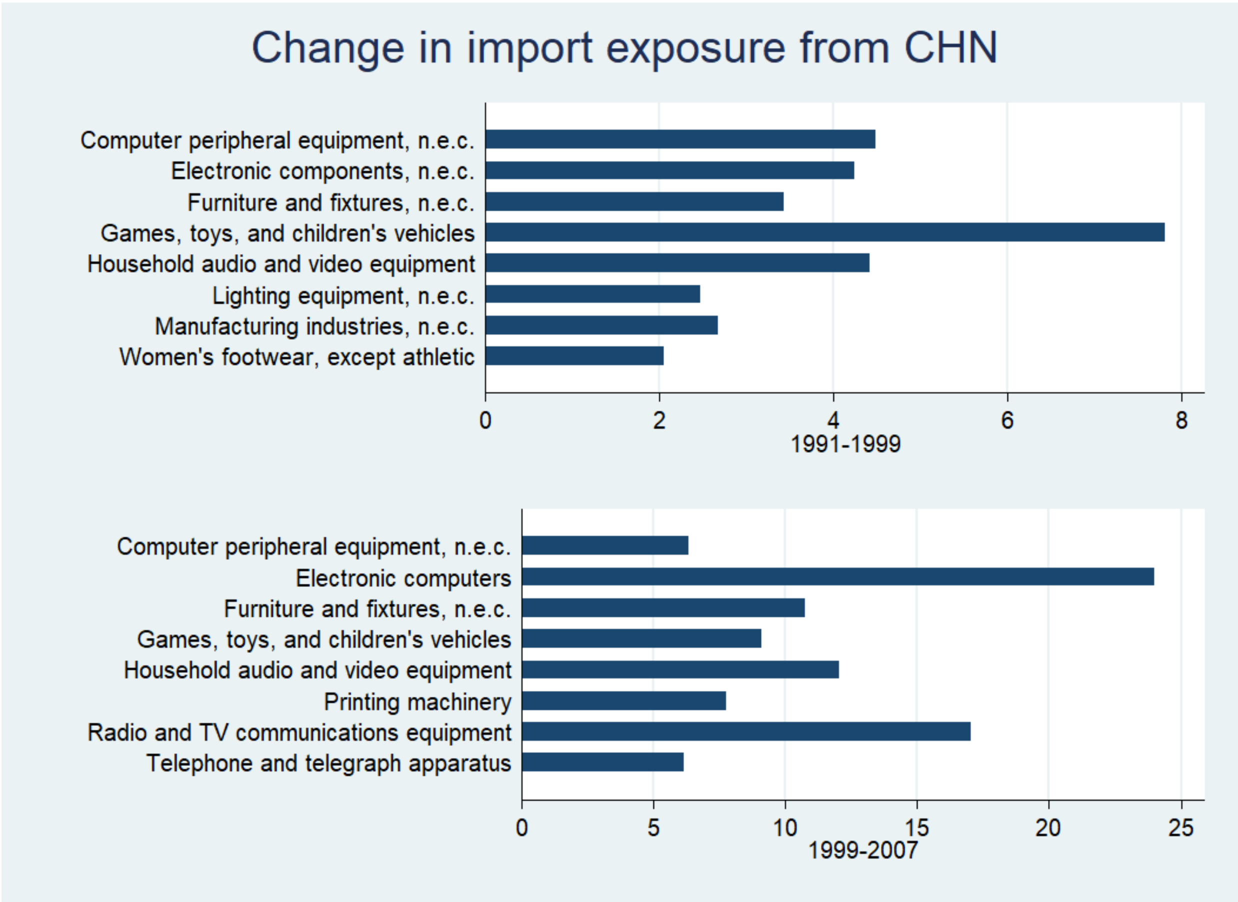
Table 7: US Trade Exposure and Commuting Zone Manufacturing Employment

| | *Dep. var: changes in mfg employment-workingage population ratio* | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | 1991-2007 | | | 1991-2011 | |
| | $EP^{OTH}$ | $EP^{PRE}$ | *Both* | $EP^{OTH}$ | $EP^{PRE}$ | *Both* |
| Δ Imports | -1.442*** | -1.121*** | -1.243*** | -1.427*** | -1.276*** | -1.292*** |
| | (0.228) | (0.253) | (0.208) | (0.266) | (0.297) | (0.267) |
| Δ Exports | 0.467 | 1.256*** | 0.790*** | 0.751*** | 1.105*** | 0.916*** |
| | (0.344) | (0.394) | (0.279) | (0.286) | (0.337) | (0.275) |
| mfg employment | -0.753** | -1.574*** | -1.130*** | -1.023*** | -1.368*** | -1.218*** |
| | (0.371) | (0.371) | (0.287) | (0.267) | (0.282) | (0.235) |
| Controls | YES | YES | YES | YES | YES | YES |
| | | | *First Stage Results* | | | |
| | | (2) | (3) | (4) | (5) | (6) |
| | Dep. var: | Δ Imports | | | | |
| $\Delta IP^{OTH}$ | 0.663*** | 0.625*** | 0.608*** | 0.459*** | 0.415*** | 0.406*** |
| | (0.051) | (0.061) | (0.061) | (0.054) | (0.061) | (0.062) |
| $\Delta EP^{OTH}$ | -0.014 | | -0.048* | 0.024 | | -0.033 |
| | (0.027) | | (0.026) | (0.031) | | (0.034) |
| $\Delta EP^{PRE}$ | | 0.065* | 0.096** | | 0.091** | 0.116*** |
| | | (0.038) | (0.038) | | (0.036) | (0.041) |
| F-test | 84.2 | 96.3 | 157.8 | 36.8 | 46.6 | 33.3 |
| | Dep. var: | Δ Exports | | | | |
| $\Delta IP^{OTH}$ | -0.283** | -0.502*** | -0.409*** | -0.228** | -0.426*** | -0.347*** |
| | (0.117) | (0.139) | (0.138) | (0.109) | (0.126) | (0.115) |
| $\Delta EP^{OTH}$ | 0.344*** | | 0.266*** | 0.398*** | | 0.271*** |
| | (0.064) | | (0.073) | (0.084) | | (0.096) |
| $\Delta EP^{PRE}$ | | 0.399*** | 0.222* | | 0.462*** | 0.258* |
| | | (0.116) | (0.134) | | (0.123) | (0.146) |
| F-test | 15.8 | 7.4 | 10.4 | 11.5 | 8.0 | 7.8 |
| Kleibergen-Paap rk Wald F stat | 17.0 | 8.7 | 11.8 | 14.4 | 10.2 | 9.9 |

Note: Robust standard errors in parentheses, clustered on commuting zones. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
The sample includes 722 commuting zones over two stacked subperiods (1991-1999, and 1999-2007 or 1999-2011). All regressions are weighted by start-of-period population share of the commuting zone. All columns include controls for initial economic and demographic conditions, including initial percentage of college-educated workers, foreign-born workers, women employment, routine occupation, and finally the average offshorability index of occupation. All regressions have US census regions dummies and a time dummy for the second period. Lower panels present the first stage regression results and F statistics for excluded instruments.

# Appendix

Figure A.1: US Industry Import Exposure: 1991-2007




Note: This figure shows the top 8 SIC products in US imports, in terms of changes in real import value for two subperiods 1991-1999 and 1999-2007. All values are in billion US$, deflated to 2007 US dollars using the PCE price index. Data source: UN-Comtrade

## Predicting US Exports and Decomposition

*Table A.1:* In Appendix Table A.1, we examine a similar specification to equation (9) but focus on *each* of the eight high-income countries. More specifically, we explore the relationship between exports of country $n$ and the US import growth. The estimation is specified as:

$$\ln X_{st}^{n,j} = \beta_{st}^{n} + \beta_1 \ln(\tau_{st}^{n,j}) + \beta_2 \ln\left(\sum_{i \neq US,\ n} X_{st-k}^{i,j}\right) + \beta_3 \ln(T_{st}^{j}) + \beta_4 \ln(d^{n,j}) + \Delta \ln IMP_{s,t}^{us} + \epsilon_{st}^{j},$$

where $T_{st}^{j} = \sum_{i \neq us,n} \frac{X_{st_0}^{ij}}{\sum_{h \neq us,n} X_{st_0}^{hj}} \left(\tau_{st}^{i,j}\right)^{\sigma-1}$ is the multilateral tariff faced by importing country $j$, and $\Delta \ln IMP_{s,t}^{us}$ denotes the one year log change of US import from the rest of the world in sector $s$.

*Table A.2 and A.4:* As we discuss in detail in section 2, our second instrument for US exports, $\Delta EP_{st}^{PRE}$, is constructed as the predicted US exports due to tariff changes of foreign countries on exports from the US and from other countries, and a multilateral import term that captures the import demand by foreign countries. Equation (9) in section 2 guides the construction of this IV. We re-state predicted exports as:

$$\ln \hat{X}_{st}^{us,j} \equiv \hat{\beta}_0 + \hat{\beta}_1 \ln(\tau_{st}^{us,j}) + \hat{\beta}_2 \ln\left(\sum_{k \neq US} X_{st}^{k,j}\right) + \hat{\beta}_3 \ln(T_{st}^{j}) + \hat{\beta}_4 \ln\left(d^{us,j}\right). \tag{A.1}$$

Note that this prediction *does not* include the SITC×year fixed effects shown in column (5) of Table 1, which reflect the US supply-side term $\beta_{st}^{us}$ in equation (9). Instead we include a single constant term $\beta_0$ in the prediction, whose value $\hat{\beta}_0$ is chosen so that the mean of predicted exports $\hat{X}_{st}^{us,j}$ equals the mean of actual US exports $\hat{X}_{st}^{us,j}$ over all $s$ and $t$. After the conversion of predicted exports from SITC to SIC industries, the instrument $\Delta EP_{st}^{PRE}$ is obtained as in equation (10) in section 2. Note that the normalization to predicted exports affects the first-stage coefficients on that instrumental variable, because predicted exports appear as a level in equation (10), but it has no impact on the second-stage coefficients or standard errors.

In appendix tables A.2 and A.4, we break apart the instrument $\Delta EP_{st}^{PRE}$ into its two components, one of which reflects the tariffs faced by the United States and other countries in each foreign market, and the other of which reflects multilateral import demand in each foreign market for all countries (other than the US). Because $\Delta EP_{st}^{PRE}$ is constructed using the *level* of predicted exports and not its log, whereas the *log* of exports is used in equation (9) and (A.1), there is not a unique method to decompose $\Delta EP_{st}^{PRE}$ into its two components. Accordingly, we construct and report results from two methods, as follows.

*Method 1:* In the first method, we make use of country $j$'s tariffs applied to the US and all other countries, which are the second and fourth terms on the right of (A.1) and appear in levels as $e^{\hat{\beta}_0}(\tau_{st}^{us,j})^{\hat{\beta}_1}(T_{st}^{j})^{\hat{\beta}_3}$. We have included the constant term $\hat{\beta}_0$ in this expression to indicate that we make the same normalization on this definition of the tariff term as discussed just above for predicted exports: namely, that the mean value of this tariff term equals the mean value of actual US exports.[25] After converting this tariff term from SITC to SIC industries, the new instrument $\Delta EP_{st}^{TAR1}$ is then obtained by dividing the changes in that SIC-based based tariff term by the initial US shipments, analogous to equation (10). After this construction, we define another new instrument, reflecting the change in multilateral demand, as:

$$\Delta EP_{st}^{MLD1} \equiv \Delta EP_{st}^{PRE} - \Delta EP_{st}^{TAR1}. \tag{A.2}$$

In the appendix tables A.2 and A.4 we make use of the two instruments $\Delta EP_{st}^{TAR1}$ and $\Delta EP_{st}^{MLD1}$, which are designed to break up the combined instrument $\Delta EP_{st}^{PRE}$ into its two components: i.e., tariff changes and multilateral demand. In addition, we include $\Delta EP_{st}^{TAR1}$ with our first instrument for US exports, $\Delta EP_{st}^{OTH}$. This instrument follows Acemoglu et al. (2016) and uses the export expansion of eight other high-income economies to the world except the United States, and is therefore similar to the multilateral demand instrument, except that the latter has a more careful specification of *all* the countries (excluding the US) selling to each foreign market.

*Method 2:* In the second method, we make use of country $j$'s multilateral import demand from the rest of world except the United States, which is the third term on the right of (A.1), and we also include distance which then appear in levels as $e^{\hat{\beta}_0}\left(\sum_{k\neq US} X_{st}^{k,j}\right)^{\hat{\beta}_2}(d^{us,j})^{\hat{\beta}_4}$. Once again, we have included the constant term $\hat{\beta}_0$ in this expression to indicate that we normalize the mean of this multilateral demand term to equal the mean value of actual US exports. After converting this multilateral demand term from SITC to SIC industries, the new instrument $\Delta EP_{st}^{MLD2}$ is then obtained by dividing the changes in that SIC-based based multilateral demand by the initial US shipments, analogous to equation (10). After this construction, we define a second instrument reflecting the change in tariffs, as:

$$\Delta EP_{st}^{TAR2} \equiv \Delta EP_{st}^{PRE} - \Delta EP_{st}^{MLD2}. \tag{A.3}$$

In the appendix tables A.2 and A.4 we also make use of the two instruments $\Delta EP_{st}^{MLD2}$ and $\Delta EP_{st}^{TAR2}$, which again break up the combined instrument $\Delta EP_{st}^{PRE}$ into its two components. As mentioned above, there is not a unique way to break up this instrument, so this second method provides an alternative to the first method.

By construction, we expect that first-stage coefficients on $\Delta EP_{st}^{MLD1}$, $\Delta EP_{st}^{TAR1}$, $\Delta EP_{st}^{MLD2}$ and $\Delta EP_{st}^{TAR2}$ are all positive. That holds in most cases in Tables A.2 and A.4, except for $\Delta EP_{st}^{TAR1}$ when it is used along with the first export instrument, $\Delta EP_{st}^{OTH}$. But when $EP_{st}^{TAR2}$ is used along with $\Delta EP_{st}^{OTH}$ then both instruments are positive and significant in the first stage regressions, indicating that the tariff variable is adding information to the ADH-style export instrument $\Delta EP_{st}^{OTH}$ or to multilateral demand itself. See also notes 15 and 20.

[25]This is a slight abuse of notation, because the value $\hat{\beta}_0$ needed to normalize the mean of predicted exports to equal the mean of actual exports differs from the value needed to likewise normalize the tariff term to equal the mean of exports.

Table A.1: Predicting Exports - Other Eight Countries

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Country | Australia | Denmark | Finland | Germany | Japan | New Zealand | Spain | Switzerland |
| $\ln(\tau_{st}^{n,j})$ | -15.32*** | -1.16*** | -0.36** | -4.92*** | -7.55*** | -0.95*** | -3.54*** | -3.10*** |
| | (0.13) | (0.14) | (0.15) | (0.07) | (0.08) | (0.17) | (0.11) | (0.08) |
| $\ln(\sum_{k \neq n} X_{s,t-1}^{k,j})$ | 0.56*** | 0.68*** | 0.69*** | 0.85*** | 0.83*** | 0.64*** | 0.65*** | 0.87*** |
| | (0.003) | (0.002) | (0.003) | (0.001) | (0.002) | (0.003) | (0.002) | (0.002) |
| $\ln(T_{st}^{j})$ | 15.52*** | -0.42*** | -0.06 | 3.73*** | 8.79*** | -0.60*** | 3.26*** | 2.95*** |
| | (0.13) | (0.14) | (0.16) | (0.07) | (0.08) | (0.17) | (0.11) | (0.09) |
| $\ln Dist$ | -0.23*** | -0.90*** | -0.99*** | -0.82*** | -1.75*** | -2.69*** | -0.87*** | -0.55*** |
| | (0.003) | (0.004) | (0.005) | (0.002) | (0.005) | (0.013) | (0.004) | (0.003) |
| $\Delta \ln IMP_{s,t}^{us}$ | 0.014 | -0.013 | 0.076*** | 0.007 | 0.073*** | -0.051* | 0.011 | 0.002 |
| | (0.023) | (0.019) | (0.022) | (0.011) | (0.015) | (0.029) | (0.016) | (0.016) |
| Observations | 289,918 | 331,012 | 253,078 | 475,425 | 402,290 | 172,411 | 407,615 | 390,115 |
| R-squared | 0.35 | 0.56 | 0.55 | 0.76 | 0.68 | 0.46 | 0.52 | 0.64 |
| SITC | YES | YES | YES | YES | YES | YES | YES | YES |
| YEAR | YES | YES | YES | YES | YES | YES | YES | YES |

Notes: for each county n, we run a regression similar to equation (9) but use country **n**'s exports (excluding the US) as dependent variable, with a lag of 0 year to measure the global demand of the given products. The weights in calculating the average tariff faced by other countries (excluding the US) are fixed in year 1990. $\Delta \ln IMP_{s,t}^{us}$ denotes the one year log change of US import from the rest of the world in sector $s$. The elasticity of substitution, i.e., $\sigma$, is seven. Robust standard errors are clustered at country-year level and reported in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table A.2: Trade Exposure and Manufacturing Employment, SIC Industry Level

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | $EP^{OTH}$&$EP^{TAR1}$ | | $EP^{MLD1}$&$EP^{TAR1}$ | | $EP^{OTH}$&$EP^{TAR2}$ | | $EP^{MLD2}$&$EP^{TAR2}$ | |
| | 1991-2007 | 1991-2011 | 1991-2007 | 1991-2011 | 1991-2007 | 1991-2011 | 1991-2007 | 1991-2011 |
| Δ Imports | -1.31*** | -1.40*** | -1.28*** | -1.36*** | -1.30*** | -1.40*** | -1.28*** | -1.36*** |
| | (0.32) | (0.41) | (0.35) | (0.42) | (0.31) | (0.40) | (0.34) | (0.41) |
| Δ Exports | 0.75*** | 0.63*** | 0.46* | 0.45* | 0.86*** | 0.86*** | 0.52** | 0.59** |
| | (0.21) | (0.16) | (0.25) | (0.23) | (0.21) | (0.19) | (0.24) | (0.24) |
| | | | | First stage: Δ Imports | | | | |
| $\Delta IP^{OTH}$ | 1.213*** | 1.007*** | 1.209*** | 0.993*** | 1.214*** | 1.007*** | 1.210*** | 0.993*** |
| | (0.148) | (0.151) | (0.140) | (0.144) | (0.146) | (0.147) | (0.138) | (0.142) |
| $\Delta EP^{OTH}$ | -0.017 | -0.022 | | | -0.017 | -0.023 | | |
| | (0.015) | (0.015) | | | (0.016) | (0.015) | | |
| $\Delta EP^{TAR1}$ | -0.045 | -0.006 | -0.070 | -0.012 | | | | |
| | (0.084) | (0.065) | (0.096) | (0.090) | | | | |
| $\Delta EP^{MLD1}$ | | | -0.023 | -0.006 | | | | |
| | | | (0.053) | (0.035) | | | | |
| $\Delta EP^{TAR2}$ | | | | | 0.008 | 0.016 | -0.015 | 0.007 |
| | | | | | (0.039) | (0.036) | (0.060) | (0.033) |
| $\Delta EP^{MLD2}$ | | | | | | | -0.023 | -0.007 |
| | | | | | | | (0.055) | (0.036) |
| $F-Statistic$ | 31.2 | 32.4 | 33.8 | 27.4 | 28.2 | 20.7 | 27.4 | 16.3 |
| | | | | First stage: Δ Exports | | | | |
| $\Delta IP^{OTH}$ | -0.318*** | -0.110 | -0.564 | -0.440 | -0.306*** | -0.068 | -0.555 | -0.428 |
| | (0.108) | (0.120) | (0.404) | (0.305) | (0.115) | (0.121) | (0.410) | (0.314) |
| $\Delta EP^{OTH}$ | 0.284*** | 0.248*** | | | 0.281*** | 0.247*** | | |
| | (0.042) | (0.048) | | | (0.041) | (0.047) | | |
| $\Delta EP^{TAR1}$ | -0.457 | -0.690* | 0.546* | 0.445 | | | | |
| | (0.276) | (0.362) | (0.318) | (0.303) | | | | |
| $\Delta EP^{MLD1}$ | | | 0.779*** | 0.823*** | | | | |
| | | | (0.216) | (0.202) | | | | |
| $\Delta EP^{TAR2}$ | | | | | 0.101** | 0.076* | 0.816*** | 0.913*** |
| | | | | | (0.047) | (0.046) | (0.220) | (0.221) |
| $\Delta EP^{MLD2}$ | | | | | | | 0.777*** | 0.837*** |
| | | | | | | | (0.217) | (0.206) |
| $F-Statistic$ | 25.4 | 15.6 | 7.6 | 11 | 27.0 | 15.6 | 7.4 | 9.2 |
| Observations | 784 | 784 | 784 | 784 | 784 | 784 | 784 | 784 |

Note: Robust standard errors in parentheses, clustered on three digit SIC industries. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ The sample includes 392 SIC manufacturing sectors during different periods. All regressions are weighted by start-of-period employment share of the sector and include decadal dummies. The definitions of the first-stage variables are discussed above in the Appendix, see especially (A.2) and (A.3).

Table A.3: Trade Exposure and Employment: Inter-sectoral Linkages - Leontief Full Matrix

| *Dep var: 100 × annualized log change in industrial employment, 1991-2011* | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | manufacturing | | non-manuf | all sectors | | manufacturing |
| Direct Import Exposure | -1.30*** | -1.36*** | | -1.12** | | |
| | (0.49) | (0.46) | | (0.47) | | |
| Full Upstream Import Exposure | -1.78** | -2.58** | -4.87 | -2.35 | | |
| | (0.82) | (1.31) | (3.84) | (1.46) | | |
| Full Downstream Import Exposure | 1.74 | 3.02 | -5.20 | -0.60 | | |
| | (2.10) | (2.01) | (7.30) | (3.14) | | |
| Direct Export Exposure | | 0.44*** | | 0.47*** | | |
| | | (0.15) | | (0.16) | | |
| Full Upstream Export Exposure | | 1.50* | 0.99 | 0.70 | | |
| | | (0.76) | (1.11) | (0.78) | | |
| Full Downstream Export Exposure | | 0.33 | 1.84 | 0.92 | | |
| | | (0.45) | (1.81) | (0.64) | | |
| Combined Direct/Upstream Import Exposure | | | | | -1.42*** | -1.36*** |
| | | | | | (0.39) | (0.38) |
| Combined Direct/Upstream Export Exposure | | | | | 0.56*** | 0.62*** |
| | | | | | (0.17) | (0.17) |
| Observations | 784 | 784 | 174 | 958 | 958 | 784 |

Note: Robust standard errors in parentheses, clustered on three digit SIC industries. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ The sample includes 392 SIC manufacturing sectors and 87 non-manufacturing sectors during different periods. All regressions are weighted by start-of-period employment share of the sector. All regressions have sector (manufacturing/nonmanufacturing) × year fixed effects. Detailed first stage results are available upon request.

Table A.4: Trade Exposure and Manufacturing Employment Share, Commuting Zone Level

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | $EP^{OTH}$&$EP^{TAR1}$ | | $EP^{MLD1}$&$EP^{TAR1}$ | | $EP^{OTH}$&$EP^{TAR2}$ | | $EP^{MLD2}$&$EP^{TAR2}$ | |
| | 1991-2007 | 1991-2011 | 1991-2007 | 1991-2011 | 1991-2007 | 1991-2011 | 1991-2007 | 1991-2011 |
| Δ Imports | -1.431*** | -1.399*** | -1.273*** | -1.353*** | -1.498*** | -1.479*** | -1.306*** | -1.371*** |
| | (0.227) | (0.260) | (0.202) | (0.248) | (0.224) | (0.250) | (0.205) | (0.247) |
| Δ Exports | 0.428 | 0.707** | 0.827*** | 0.847*** | 0.312 | 0.608** | 0.695*** | 0.795*** |
| | (0.347) | (0.285) | (0.277) | (0.277) | (0.285) | (0.254) | (0.253) | (0.260) |
| mfgsh | -0.729* | -1.004*** | -1.141*** | -1.133*** | -0.596* | -0.887*** | -1.016*** | -1.085*** |
| | (0.374) | (0.266) | (0.253) | (0.199) | (0.325) | (0.236) | (0.254) | (0.194) |
| | | | | First stage: Δ Imports | | | | |
| $\Delta IP^{OTH}$ | 0.644*** | 0.443*** | 0.620*** | 0.404*** | 0.663*** | 0.459*** | 0.629*** | 0.405*** |
| | (0.057) | (0.059) | (0.060) | (0.059) | (0.051) | (0.054) | (0.059) | (0.058) |
| $\Delta EP^{OTH}$ | -0.021 | 0.008 | | | -0.006 | 0.024 | | |
| | (0.025) | (0.030) | | | (0.030) | (0.032) | | |
| $\Delta EP^{TAR1}$ | 0.038 | 0.042 | 0.069* | 0.100*** | | | | |
| | (0.027) | (0.029) | (0.037) | (0.035) | | | | |
| $\Delta EP^{MLD1}$ | | | 0.096* | 0.171*** | | | | |
| | | | (0.056) | (0.054) | | | | |
| $\Delta EP^{TAR2}$ | | | | | -0.057 | 0.005 | 0.028 | 0.184*** |
| | | | | | (0.059) | (0.053) | (0.062) | (0.058) |
| $\Delta EP^{MLD2}$ | | | | | | | 0.057 | 0.111*** |
| | | | | | | | (0.036) | (0.035) |
| $F-Statistic$ | 68.2 | 33.5 | 65.8 | 31.7 | 65.8 | 32.5 | 67.3 | 32.7 |
| | | | | First stage: Δ Exports | | | | |
| $\Delta IP^{OTH}$ | -0.261** | -0.203** | -0.659*** | -0.576*** | -0.286** | -0.230* | -0.653*** | -0.553*** |
| | (0.105) | (0.092) | (0.166) | (0.161) | (0.125) | (0.119) | (0.172) | (0.162) |
| $\Delta EP^{OTH}$ | 0.352*** | 0.423*** | | | 0.287*** | 0.379*** | | |
| | (0.069) | (0.101) | | | (0.052) | (0.078) | | |
| $\Delta EP^{TAR1}$ | -0.043 | -0.066 | 0.555*** | 0.585*** | | | | |
| | (0.065) | (0.093) | (0.127) | (0.129) | | | | |
| $\Delta EP^{MLD1}$ | | | 1.461*** | 1.565*** | | | | |
| | | | (0.296) | (0.311) | | | | |
| $\Delta EP^{TAR2}$ | | | | | 0.436*** | 0.435*** | 1.585*** | 1.604*** |
| | | | | | (0.144) | (0.148) | (0.326) | (0.336) |
| $\Delta EP^{MLD2}$ | | | | | | | 0.640*** | 0.703*** |
| | | | | | | | (0.145) | (0.153) |
| $F-Statistic$ | 10.9 | 7.9 | 8.8 | 9.7 | 13.1 | 8.2 | 8.9 | 8.2 |
| Observations | 1444 | 1444 | 1444 | 1444 | 1444 | 1444 | 1444 | 1444 |

Note: Robust standard errors in parentheses, clustered on states. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
The sample includes 722 commuting zone manufacturing sectors during different periods. All regressions are weighted by start-of-period population share of the commuting zone. All columns include controls for initial economic and demographic conditions, including initial percentage of college-educated workers, foreign-born workers, women employment, routine occupation, and finally the average offshorability index of occupation. All regressions have US census regions dummies and a time dummy for the second period. The definitions of the first-stage variables are discussed above in the Appendix, see especially (A.2) and (A.3).