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Labor Market Adjustment to Import Competition: Long-Run Evidence from Establishment Data*

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Abstract

We analyze how local labor markets in Mexico adjusted in response to an increase in Chinese import competition between 1998 and 2013. We exploit the spatial variation in import exposure arising from initial differences in industry specialization. We found that the adjustment took various forms: a decline in the number of wage employees, the substitution of some wage employees by contract workers, and the substitution of formally contracted employees by informally contracted ones. The reduction in employment levels was accompanied by an increase in the population that exited the labor force. The negative employment impact was three times more severe on production workers than on nonproduction workers, indicating that workers with lower skills were more severely affected. Overall, we find significant job losses to the order of 7.6% of the working-age population.

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1. INTRODUCTION

Since the beginning of the 1990s, many developing countries have experienced episodes of increased competition in their domestic markets. These episodes were triggered by trade liberalization that allowed more competition from foreign manufacturing firms, and also by the entry of large multinational firms that competed directly with local producers. One such example is the entry of big retailers (Atkin et al., 2018). Economic theory predicts that this increased competition should benefit consumers via lower prices and higher product quality, but these effects can also generate winners and losers by changing the relative labor demand for different types of workers. For many developed and developing economies, perhaps the most important competition shock in the manufacturing sector has been the rise of China as a manufacturing powerhouse whose exports of manufactured products have increased sixfold since 2001. In this paper, we study how local labor markets in Mexico adjusted to that increased competition.

We rely on an empirical methodology that essentially connects the change in a labor market outcome of a region with the supply-driven change in exposure to Chinese competition experienced by firms located in that region. Our methodology has three main ingredients. First, we design and implement an algorithm using data from the population census to define commuting zones (CZs) in Mexico. These local labor markets are determined geographically by the boundaries of work and residence (Tolbert and Sizer, 1996). Second, following Autor et al. (2013), we measure the change in import exposure faced by each local labor market by the change in an imports-per-worker measure that apportions the change in the value of imported goods from China by each (narrowly defined) industry to each local labor market using the share of that industry's employment located in that region before the shock took place. Third, in order to isolate the supply-side component of the shock, we instrument that measure with the change in imports experienced by other countries similar to Mexico. Finally, we use data from the population census and from the economic census to estimate the impact of the shock on quantities and prices and on different margins. We show that our research design is credible. We estimate a placebo experiment in which we relate the import exposure measure to outcomes in the previous decade and find no effects.

We report four sets of main results. First, we find that increased exposure to Chinese imports negatively affected Mexican manufacturing employment. A US$1,000 rise in a commuting zone's import exposure per worker induced a reduction of its manufacturing employment per working-age population of 0.026–0.342 percentage points (p.p.). These results correspond to 15-year differences and therefore we interpret them to be long-run impacts. The impact has been decreasing over time: the majority of the adjustment came in the initial years after the import competition shock took place.

Second, we investigate how the labor market adjusted to the shock. On the intensive margin, we find that there was a decline in the number of wage employees, who were partially replaced by contract workers. We also find that some formal workers were substituted by informal workers. The impact appears to be most pronounced on the workers with the lowest skill and education levels. On the extensive margin, we find that the shrinkage in the level of employment was met by an increase in the population that exited the labor force. The wages earned by these different types of workers adjusted accordingly.

Third, increased competition from Chinese firms was also faced by Mexican firms in US markets. We present a measure of competition that captures these indirect effects. Our results remain the same and suggest that the impact of competition in the US product market was not so important. These results are in line with those found by Chiquiar et al. (2017), who found that the increased competition in the US labor market induced an adjustment on the extensive margin, mainly through unemployment. Another potential indirect effect of China joining the WTO was that Mexican firms could have increased their exports to China. We find this effect to be very small.

Finally, we estimate the full impact on employment at the national level, taking into account the effects of increased competition in local labor markets in Mexico, the effects of increased competition in US markets, and the potentially positive effects of increased access to Chinese markets among Mexican firms. We find that had Chinese competition remained unchanged between 1998 and 2013, employment in the manufacturing sector in Mexico nationwide would have been about 7.6% higher in 2013. We also find substantial heterogeneity of job losses across local labor markets.

Our paper is related to three strands of the literature. First, our study is close to the body of literature analyzing how import competition affects workers differently in regions with different initial specialization patterns. We closely follow the methodology described by Autor et al. (2013), who present a model in which an exogenous increase in China's export supply (e.g., a positive productivity shock) generates a reduction in the demand for a region's goods sold in all markets (including within the region itself) in which it competes with China. The consequences are a decrease in the region's wages and employment in the tradable goods sector and an increase in employment in nontraded goods. Using other methodologies (the Heckscher-Ohlin or specific-factor models), other authors have arrived at similar implications regarding the impact of trade liberalization episodes on local labor markets (Kovak, 2013; Topalova, 2007; Topalova, 2010).

Second, our paper is also close to a strand of literature analyzing how labor markets adjust to different margins. Notably, Dix-Carneiro and Kovak (2015) study the effects of trade liberalization in Brazil. Like them, we find changes in the extensive margin (between sectors and between employment status) and the intensive margin (between formality and informality).

Third, our study is also related to a growing body of analyses that examine the impact of rising competition from China. One strand of the literature identifies the effects by exploiting variation in Chinese import competition at the industry level (Bernard et al., 2006; and Mion and Zhu, 2013), an approach that has been applied to Latin American countries in Alvarez and Claro (2008); Iacovone, Rauch, and Winters (2013); and Caamal-Olvera and Rangel-Gonzalez (2015). There are also a number of papers that examine the impact of Chinese competition by exploiting variation in import exposure across local labor markets (Autor et al., 2013; Acemoglu et al., 2016; Feler and Senses, 2017; Rothwell, 2017), and applications to Latin America (Costa et al., 2016). In the case of Mexico, Mendez (2015) and Chiquiar et al. (2017) also look at the impact of the China shock for Mexican labor markets. Our study differs from these in several respects: we cover a relatively longer period of time (15 years), we analyze the impacts across different types of workers, and we examine how the Mexican labor market adjusts to Chinese competition both in Mexico and also in the United States.

The rest of the paper is organized as follows. In section 2 we present basic facts about the China shock in Mexico. In section 3 we describe the empirical strategy, and section 4 presents the data we use, including how we construct local labor markets. Section 5 presents the main impact of the China shock on employment. Section 6 documents how the labor market adjusted along different margins. Section 7 presents results that include the indirect effects via competition in and access to third markets. Section 8 concludes and presents back-of-the-envelope calculations on the overall employment impacts of the import competition shock.

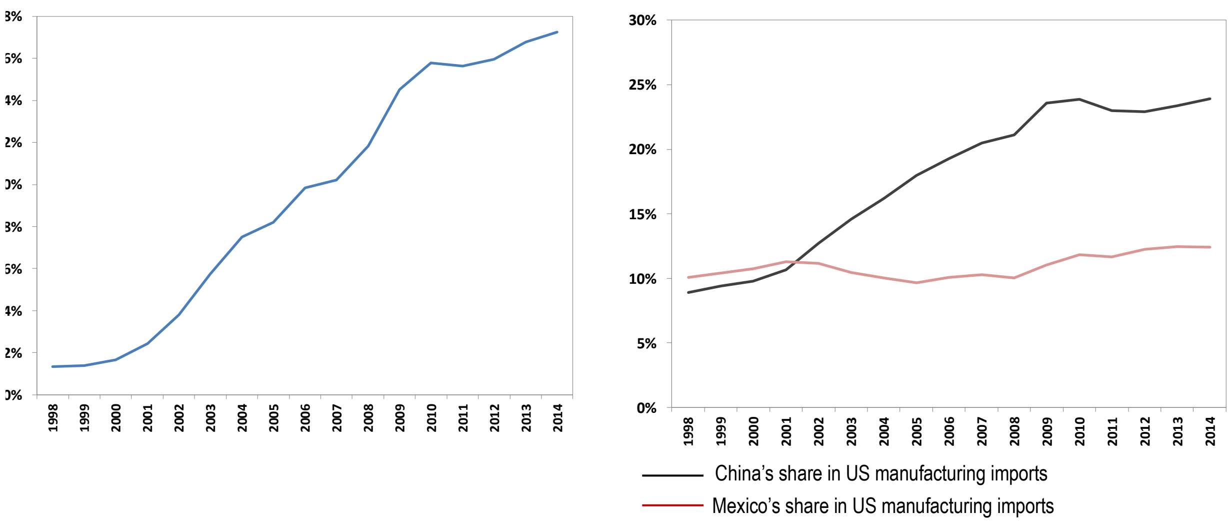
2. THE SPATIAL DISTRIBUTION OF IMPORT COMPETITION

Mexico is an interesting case among developing countries when it comes to understanding labor market responses to changes in import competition, for two reasons. First, Mexico's pattern of specialization has traditionally been more inclined toward the production of manufacturing goods than has been the case in other countries in Latin America. Second, Mexico is a relatively open economy. Thus, changes in the international prices of tradable goods that compete with domestic production can have potentially large impacts on Mexican labor markets through their effects on labor demand.

One important trade shock in the last 20 years has been the so-called China shock (see Autor et al., 2013; and Asquith et al., 2019), which was triggered by China becoming a member of the World Trade Organization within the most favored nation category in 2001. This shock was particularly important for Mexico because, due to the North American Free Trade Agreement of 1994, the country had been specializing in industries in which China would later show increased productivity and therefore increased ability to compete with Mexican firms both in their domestic and their export markets, most notably the United States (Amoroso et al., 2011; Chiquiar et al., 2017). Mexican local labor markets were affected by Chinese import competition not only in Mexico but also in the United States.

Figure 1 (panel A) provides an illustration of how Chinese products have been increasingly penetrating the Mexican market. China's share in Mexican manufacturing imports rose from 1.3% in 1998 to more than 16% 15 years later. China's import share also increased substantially in the United States, Mexico's main export market. Figure 1 (panel B) shows that China surpassed Mexico's share of US imports in 2002. Because the United States is by far the main destination market for Mexican manufacturing exports (around 90% of Mexican exports went to this market in 2000), increased Chinese competition in the United States might have also had an impact on Mexico.

FIGURE 1. TRADE SHOCK



Panel A: China's share of Mexican manufacturing imports

Panel B: Shares in US manufacturing imports

Source: Author's calculations based on United Nations Comtrade Database

The magnitude of this shock was large and unequally distributed across local labor markets (which we approximate using CZs described in section 4). Table 1 (panel A) presents descriptive statistics on the measure of exposure to Chinese imports. In 1998, the value of imports from China, measured as imports in constant 1998 dollars per worker in Mexico, was about US$52. In 2013, the per-worker value increased to US$919. There is, however, significant heterogeneity across local labor markets. For example, in the commuting zone that corresponds to the 90th percentile of the change in exposure, the value of Chinese imports per worker grew by US$1,390, while in the areas that correspond to the 50th percentile, the value of Chinese imports grew by only US$141. This reflects the geographic variation in industry specialization across space, in that some CZs specialize relatively more in industries that compete directly with imports from China than others. Figure 2 (panel A) complements table 1 by providing similar information on a map showing the 15-year change in import exposure by commuting zone. In general, zones in the north and in the center of the country experienced the largest increases in import exposure due to their relative specialization in industries that compete more directly with imports from China.

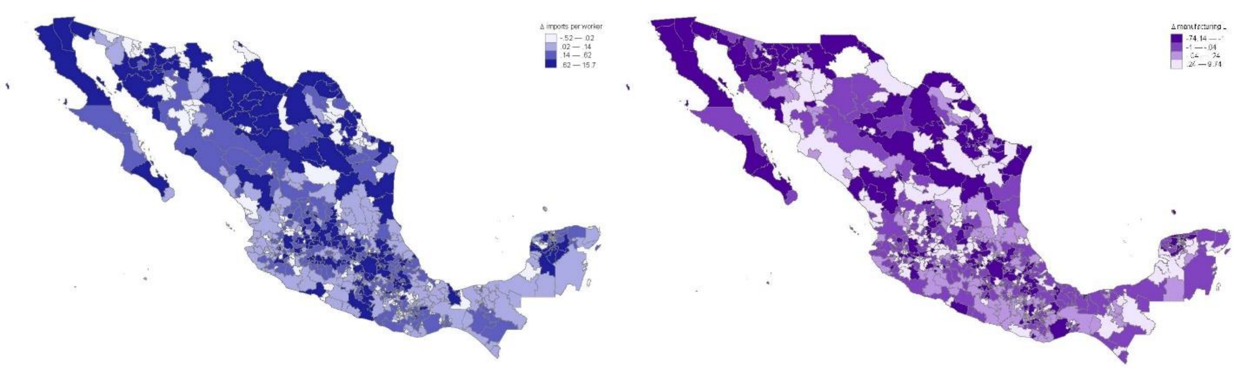
TABLE 1. SUMMARY STATISTICS

	1998	2013	Change 1998–2013
Imports from China to Mexico/workers in thousands of US$(1998)	0.052	0.919	0.753
	[0.103]	[2.075]	[2.362]
Percentiles			
90			1.390
75			0.615
50			0.141
Percentage of working-age population employed in manufacturing	3.412	2.709	-0.687
	[5.828]	[4.583]	[4.500]
Percentiles of Imports from China to Mexico/Workers in 1998			
90			-2.037
75			-0.339
50			0.060

Source: Author's calculations based on United Nations Comtrade Database and Mexican Population Censuses

After the China shock, the percentage of the working-age population employed in manufacturing decreased. Table 1 (panel B) presents these statistics. On average, the share of the working-age population employed in manufacturing declined by 0.69 p.p. over 15 years. While these percentages seem small, note that the table presents simple averages across all CZs. Recalculating the table using weighted averages (with the CZ population as a weight) instead of simple means give shares of total employment in manufacturing closer to 6%. Once again, there is significant heterogeneity across geographic areas. The change in this variable in the CZs associated with the 90th and 50th percentiles of import penetration from China was -2.037 and 0.06 p.p., respectively. Figure 2 (panel B) shows a pattern in which local markets in the north and the center of the country experienced some of the largest increases in import exposure, as well as some of the largest decreases (or smallest increases) in manufacturing employment.

FIGURE 2. SPATIAL HETEROGENEITY OF THE TRADE SHOCK



Panel A: Change in imports from China to Mexico per worker by CZ, 1998–2013

Panel B: Change in manufacturing employment share of working-age population by CZ, 1998–2013

Source: Author's calculations based on United Nations Comtrade Database, Mexican Economic Census, and Mexican Population Censuses

3. EMPIRICAL STRATEGY

The empirical strategy in this paper closely follows the methodology described by Autor, Dorn, and Hanson (2013), which relates the change in a labor market outcome of region *i* to the change in the exposure of that region to Chinese competition. The change in import exposure is captured by the change in a measure of imports-per-worker:

$$\Delta IPW_{it}^{c} = \frac{1}{L_{it}} \sum_j \frac{L_{ijt}}{L_{jt}} \Delta M_{jt}^{c} \qquad (1)$$

where ΔM_{cjt} is the change in the value of imported goods from China of industry *j* between the start and the end of the period under analysis; L_{ijt}/L_{jt} is the share of industry j's employment located in region *i* at the start of period t. In other words, the expression inside the summation allocates the increase in the imports of a given industry according to the spatial distribution of employment at the beginning of the period. We then divide by L_{it}, the total employment in region *i* at time t, to obtain a per-worker measure of the change in import competition from China. The expression is derived from a trade model with monopolistic competition in which each region is treated as a small open economy.[1] The intuition of the expression is straightforward: if at the start of the period (time t, before the China shock), employment in region *i* is concentrated in industries that manufacture goods that compete directly with imports from China, the import exposure of that region as measured by imports per worker will be high.

The changes observed in the import penetration measure might not be entirely driven from the supply side by China but instead might be partly the outcome of internal shocks that affect Mexican import demand within Mexican industries. Because we are interested only in the supply-driven component, we construct an instrument by substituting the change in imports from China in expression (1) with the change in imports from China bought by other countries in Latin America:

$$\Delta IPW_{it}^{o} = \frac{1}{L_{it}} \sum_j \frac{L_{ijt}}{L_{jt}} \Delta M_{jt}^{o} \qquad (2)$$

where ΔM_{jt}^{o} is the change in the value of 17 Latin American countries' imports from China.[2] The identifying assumption is that the change in imports from China by other countries in Latin America is uncorrelated with potential shocks to Mexican industries that come from Mexican demand for imported goods. There are two main potential threats to identification. The first is that Mexican shocks might be correlated with outcomes in other Latin American countries. While this is potentially possible, in practice, this should not be a major concern given that the transmission of Mexican shocks to the rest of Latin America is likely to be minimal due to the low trade ties that exist between the two areas. Latin America's shares in Mexican imports and exports are 4% and 6%, respectively. To strengthen our analysis, we perform a placebo test that supports our identification strategy. The second threat is that the outcome measures employed before the China shock took place might be affected by the anticipation of that shock. To address this, we rely on 10-year lag values for the employment variables that are used as weights in expression (1).

To estimate the effect of import exposure on employment at the CZ level, we estimate the following model:

$$\Delta L_{it}^{m} = \beta_1 \Delta IPW_{it} + X_{it}' \beta_2 + e_{it} \qquad (3)$$

where ΔL_{it}^{m} is the change in the manufacturing employment share of the working-age population in commuting zone i and $X_{it}^{`}$ is a vector of controls at the CZ level (we elaborate more about these controls below). While the baseline model is estimated for a 15-year change (between 1998 and 2013) in employment and the import exposure variables, we also present results for alternative subperiods. The model also includes several fixed effects—broad regions—for

[1] For a complete derivation, see Autor et al. (2013).

[2] The 17 Latin American countries are Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Guyana, Jamaica, Nicaragua, Panama, Peru, Paraguay, Uruguay, and Venezuela.

some specifications (we provide more detail on this below)[3] .[4] In all the models, the standard errors are clustered at the state level to account for potential spatial correlations across CZs.

4. DATA

A. Trade data

We use data on international trade produced by the United Nations Comtrade Database, a repository of official international trade information. This data is converted from the six-digit Harmonized System (HS) codes to five-digit North American Industry Classification System (NAICS) codes using the concordance developed by Pierce and Schott (2012). This results in 168 manufacturing industries.

B. Labor market data

The main source of information on labor outcomes is the Mexican Economic Census, from which we extract information on employment and payroll by municipality and industry. The census is conducted every five years. It covers all firms with a fixed address in the economy regardless of size. The industry classifications in the census use the six-digit NAICS codes, which we aggregate to five digits to match the trade data.[5]

We supplement data from the economic census with information from the population census, which provides data on the working-age population by municipality. From this census data, we also extract information on certain population characteristics (such as educational levels) that we use as control variables. Though the years of the economic census and population census do not overlap exactly, the gap between them is only two years. Accordingly, the data from the Mexican Economic Census for 1998. 2003. 2008, and 2013 is matched with the data from the population census for 2000. 2005. 2010, and 2015, respectively. All the information at the municipality level is aggregated at the CZ level. Appendix table A.1 exactly describes all the variables used in the paper and their respective sources.

C. CZs

As shown in expression (1), the trade data by industry is combined with employment data by industry and region to construct a measure of exposure to Chinese imports at the regional level. A region or local labor market is defined by commuting zone. We start by using 59 metropolitan statistical areas defined by the *Instituto Nacional de Estadística y Geografía* (INEGI), the Mexican statistics agency. Each area consists of a group of municipalities that exhibit a high degree of socioeconomic interaction. The 59 zones do not cover the entire country, however. We therefore create additional CZs using procedures and criteria like those used by Mexican Census Bureau based on census tract information. These criteria include interactions that reflect commuting between workers' residences and workplaces.

The algorithm to form CZs is as follows. First, we identified central locations: we considered a municipality to be central if it attracts people from other municipalities for employment purposes. In other words, these are places where economic activity tends to be concentrated. To identify them in the data we created an index of urbanity at the municipality level which is the sum of the following standardized variables: municipality population, percentage of the population that is urban, urban density, percentage of the population working in nonprimary activities, and the number of municipalities from where people come to work. We classified a municipality as central if the municipality has an

[3] Manufacturing employment in a region might change for demographic reasons: old workers might retire while young workers enter the labor market. Accordingly, the level of manufacturing employment is likely to depend on the region's working-age population, which might evolve differently across regions for reasons that are unrelated to the China shock. Therefore, to assess the impact of China on the level of employment at the CZ level, we want to control for these differences. One possibility is to include the working-age population as an additional regressor. An alternative solution is to divide the dependent variable by the region's working-age population. This is the strategy we adopt in this paper.

[4] The working-age population is defined as people between 15 and 64 years of age.

[5] The various economic censuses are originally reported in different versions of the NAICS classifications (2002. 2007. and 2012). We employ concordance tables, provided by INEGI, to express all of these in the NAICS classification version 2002.

urban index score above the 25th percentile. This process led us to identify 599 municipalities as being central, while the remainder are peripheral.

Second, we assigned a peripheral municipality to a central municipality in multiple rounds, as follows. In round one, we found peripheral municipalities that satisfied three criteria: (i) its centroid is less than 100 kilometers from the centroid of a central municipality;[6] (ii) at least one person from the peripheral municipality worked in the central municipality; and (iii) there was a positive correlation in the urban employment rates between their census tracts.[7,8] At the end of this, an initial set of peripheral municipalities were adjoined to a central municipality.

Third, we repeated this procedure by adding peripheral municipalities until no more municipalities could be assigned. After seven rounds, this procedure had assigned 1,068 municipalities to a central municipality (73% of the municipalities in Mexico). Finally, to assign the residual municipalities we continued the process of assignment by lifting criteria (iii). After five new rounds, 291 more municipalities were assigned. In the end, there was a small residual of municipalities that were not assigned using this process. These were very rural[9] and small,[10] so we treated them as independent CZs. All in all, the algorithm assigned the whole universe of Mexican municipalities to 780 CZs or local labor markets.

5. EFFECT OF IMPORTS COMPETITION ON LOCAL LABOR MARKETS

A. Placebo test

We start by assessing the plausibility of the identification assumption. We estimate the coefficients in equation (3) using the change in the share of the working-age population employed in manufacturing between 1988 and 1998, before the Chinese import shock took place, as the dependent variable. The import penetration variable is the change in the value of imports from China to Mexico per worker between 1998 and 2013, in constant US$(1998)1,000, as defined in expression (1), and instrumented with the change in the rest of Latin America's imports as defined in expression (2). Column 1 of table 2 presents the results. The bottom panel of the table shows the first stage. The top panel shows that, reassuringly, the estimated coefficient is small and not statistically significant at normal levels. This suggests that the proposed research design is likely valid.

[6] Two municipalities were so large that they did not have a neighboring municipality within the 100km threshold. We treated these municipalities as independent commuting zones.
[7] We created the following measure of employment correlation between municipalities *M* and *N*: $\alpha_{M,N} = L'PW_L/L'PW$, where: L_{mx1} is the vector of employment rate for municipality *M* census tracts. This measure is standardized by the state average and standard deviation. W_{mxn} is a weighting matrix for each municipality *M* and *N*'s census tracts, defined as the inverse of the distance of each census tract. The sum of all the values in each row is standardized to equal be to one. $W_L = W * L^n$ is the vector of the weighted average employment rate of municipality *N*'s census tract. *P* is a diagonal matrix that weights the census tract of municipality *M* by the population share of each municipality *M*.
[8] If one municipality was a neighbor of two or more central municipalities we created an index that took into account the three assignment criteria described above. We assigned each peripheral municipality to the central municipality with the highest index value.
[9] On average, 72% of the population in these municipalities work in primary activities, the urban area accounts for less than 19% of the total, and most of them (77) are located in the state of Oaxaca.
[10] The population of these municipalities is always below 19,000 inhabitants.

TABLE 2. EFFECTS ON MANUFACTURING EMPLOYMENT (2SLS ESTIMATES OF CHANGE IN MANUFACTURING EMPLOYMENT OVER WORKING-AGE POPULATION IN CZ)

		1998–2013 (Long difference)					
	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Change in imports from China to Mexico/worker	0.0273	-0.3417***	-0.3241***	-0.3318***	-0.2626**	-0.2638**	-0.2662**
	[0.1809]	[0.1141]	[0.0911]	[0.1040]	[0.0965]	[0.1094]	[0.1101]
Percentage of employment in manufacturing pretrend (1988–1998)			0.0140	-0.0194	-0.0266*	-0.0263	-0.0239
			[0.0269]	[0.0147]	[0.0152]	[0.0169]	[0.0178]
Percentage of population with secondary education					-0.1531***	-0.1539***	-0.1581***
					[0.0518]	[0.0503]	[0.0510]
Routine intensity level of occupations						-0.0050	0.0111
						[0.1067]	[0.1163]
Change in imports from ROW to Mexico/worker							0.0100
							[0.0162]
Region fixed effect	no	no	no	yes	yes	yes	yes
Number of observations	780	780	780	780	780	780	780
	2SLS first-stage estimates						
Change in imports from China to LAC/worker	0.2401***	0.2401***	0.2675***	0.2348***	0.2509***	0.1932***	0.1930***
	[0.0546]	[0.0547]	[0.0581]	[0.0552]	[0.0562]	[0.0474]	[0.0475]
Weak identification test F statistic	19.2	19.3	21.2	18.1	15.9	16.6	8.3

Notes. Each column reports the results for regressions for 1988–1998 (column 1) or 1998–2013 (columns 2–7). The dependent variable is the change in manufacturing employment over the working-age population in the CZ between the years in question (in p.p.). The main explanatory variable is the change in imports from China to Mexico per worker, in kUS$. The instrument is the change in imports from China to LAC per worker. The control variables are the percentage of employment in the manufacturing pretrend for 1988–1998 (3–7), the percentage of the population with secondary education (5–7), the level of routine intensity of the average occupation (6–7), and the change in imports from the ROW to Mexico per worker, in kUS$(1976). The additional control is a region fixed effect (4–7). Observations are weighted by the CZ's share of the national population at the start of the period. Robust standard errors in parentheses are clustered by state. The weak identification test is the Kleibergen-Paap Wald F statistic. ***; **; * significant at the 1%, 5%, and 10% level, respectively.

B. Main results

Column 2 of table 2 shows the results of estimating equation (3) without controls using 2SLS.[11] The coefficient for import exposure is negative and significant.[12] The value of -0.342 indicates that a US$1,000 rise in a commuting zone's import exposure per worker induces a reduction of its manufacturing employment per working-age population of 0.342 p.p.

In columns 3 to 7, we proceed to include a number of variables to control for various labor force and demographic factors. A first concern is that the estimated effect is partly capturing the general downward trend in manufacturing employment observed in many countries. In the United States, for example, the share of manufacturing employment in the working-age population has experienced an overall trend decline since the late 1980s. Not controlling for this trend might lead to attributing a decline in manufacturing employment entirely to Chinese imports even though independent factors may play a role. In Mexico, the share of manufacturing employment in the working-age population has remained more stable than in the United States over similar periods. For example, between 1988 and 1998 the share of manufacturing employment in the working-age population increased from 5.1% to 6.8% and then hovered at around 5.5% to 6% between 2003 and 2013. Despite this, we add a pretrend control for the change in manufacturing employment as a share of total employment from 1988 to 1998.[13] Column 3 shows the results. The coefficient for the pretrend control is not statistically significant, while the coefficient for the import exposure does not change significantly.

[11] The OLS estimate (not shown here) for import exposure is negative (-0.264) and significant at the 1% level.

[12] The downward bias of the OLS estimation is a common result in this literature (see Iacovone et al. [2013]; Autor et al. [2013]) and arises from potential demand shocks that could raise domestic production (at the same time as imports from China), mitigating the negative impacts of increased Chinese import penetration. The IV estimate tries to shut down the domestic demand shock channel.

[13] This is also similar to the approach used by Dix-Carneiro and Kovak (forthcoming), who examine the impact of trade liberalization in Brazil on employment growth by controlling for a preliberalization trend in employment to account for possible spurious correlations.

In column 4 we add geographic dummies for eight regions to control for region-specific trends in employment.[14] Once again, the coefficient of import exposure from China does not change.

A second concern is that the evolution of employment in manufacturing might be driven in part by the skills of the population in the commuting zone. We therefore only include the share of the zone's population that had secondary education before the China shock. The coefficient is negative and significant at conventional levels, while the coefficient for the import penetration variable declines slightly (in absolute value). The estimate, however, is still significant at the 5% level. A US$1,000 rise in a zone's import exposure per worker induces a 0.263-p.p. reduction in its manufacturing employment per working-age population.

The regressions in Autor, Dorn, and Hanson (2013) also control for the extent to which the occupations in the CZs have a high risk of being displaced by technology or by offshoring. The authors control for this issue by matching information on job requirements from the US Department of Labor with the highly disaggregated levels of occupations that the authors have in their employment dataset. In particular, the authors use the US Department of Labor's Dictionary of Occupational Titles (DOT) to perform two exercises: (i) to classify occupations as routine or nonroutine, and (ii) to construct an index of offshorability. Unfortunately, the types of occupations available in our dataset are not disaggregated enough to perform such exercises.

Third, we control for the intensity of routine tasks in each sector, for which we draw on the work of Costinot, Oldenski, and Rauch (2009). These authors use the Occupational Information Network data, which characterizes the level of routineness of the tasks performed by workers in each occupation, combined with information on the distribution of occupation in each (NAICS four-digit) sector, to generate an index of level of routineness by sector. We use this index to construct an average level of occupational routineness at the CZ level at the start of the period.[15] The results of including this control are reported in column 6. As shown, the estimated coefficient for the routine intensity variable is not significant, while the coefficient for the import penetration variable remains very similar to that estimated in the previous models.[16]

Finally, in column 7, we add Mexico's import exposure to the rest of the world. The increased import exposure to China might be just a reflection of a more general overall exposure to imports, not only imports from China. If this were the case, the import variable from China might capture import exposure from other countries as well, possibly overstating the effect of imports from China. We construct exposure to imports from other countries in expression (1), where the change in imports from China is replaced by the change in imports from the rest of the world. The results in column 7 show that the import exposure from the rest of the world is not statistically significant, while the coefficient for the import exposure to China does not significantly change.

C. Robustness

As a robustness test, we employ an alternative set of countries for the instrumental variables in expression (2). The rationale behind using Latin American countries to construct the instruments is that a shock in Mexico is likely to be uncorrelated with Latin American countries' Chinese import demand because of the relatively limited trade linkages between Mexico and Latin America. We modify this instrument in our second robustness test by employing an alternative group of countries based on similarities with Mexico in terms of economic development: Argentina, Brazil,

[14] We follow the national statistical agency and group Mexico's 32 states into eight regions according to cultural, economic, and geographical similarities.

[15] We assume that the distribution of occupations by sector in Mexico is similar to the one observed in the United States.

[16] Another potentially important dimension is the degree of offshorability of the activities performed in different sectors. This is potentially relevant in the case of a developed country such as the United States, where many goods that used to be made from start to finish domestically are now produced in stages that are carried out in plants in different parts of the world. We lack such information for Mexico. However, it is important to note that Mexico participates in global value chains not by internationally fragmenting domestic production, but by receiving the bundles of fragmented production from the rest of the world, particularly from the United States (Blyde et al., 2014). Therefore, controlling for offshorability, while potentially important for a developed country such as the United States, is likely less relevant for a developing country such as Mexico.

Colombia, Costa Rica, Malaysia, Peru, Poland, and Romania.[17] We argue that because of similarities in economic structure and levels of development, these countries and Mexico are similarly exposed to growth in imports from China. Changing the countries employed in the construction of the instruments does not alter the results in any significant way, as shown in appendix table B.1. In the rest of the paper, we continue to use the Latin American countries as instruments.

6. MARGINS OF ADJUSTMENT TO IMPORT COMPETITION

The evidence in table 2 indicates that the competition from China impacted manufacturing jobs negatively. In this section, we look at whether the effects are heterogeneous across different types of workers.

A. Intensive margins

The results presented in table 2 show the impact of Chinese imports on manufacturing employment using the sum of all the employees, both wage employees and contract workers: wage employees earn a predetermined amount of money while contract workers are paid hourly rates. Contract workers are not considered by law to be the firm's employees and are thus not covered by the labor regulations that govern wage employees' labor relationships. Wage employees have the right to a severance payment when fired and the right to form a labor union, whereas contract workers do not. Firms also have certain legal obligations to wage employees that do not apply to contract workers. These include enrolling wage employees in the Mexican Social Security Institute, paying social security contributions, and paying at least the minimum wage. These differences between wage and contract workers imply a differential labor cost. One conjecture is that while firms can lay off workers (or shut down entire plants), they can also reduce their labor costs by relying relatively more on contract workers or not fully complying with social security payments—that is, hiring wage employees informally.

Table 3 reports the results of our estimates of separate effects for each group[18,19]. For comparison, the first column presents the results for all the employees (as reported in column 7 of table 2). The results in column 2 show that the impact of import competition from China on wage employees is larger than the impact on all workers (the point estimate is -0.465). Column 3 shows the effect on contract workers. In line with our prior assumptions, the effect on contract workers is positive[18, 19, 20]. The Chinese import shock induced a decline in the reliance on wage employees, and part of this decline was offset by an increase in the use of contract workers.

[17] We found the set of countries that are most similar to Mexico in five aspects: GDP per capita, physical capital, human capital, population, and export basket composition.

[18] In 1998, paid employees represented about 90% of the total labor force in manufacturing.

[19] According to the economic census, firm owners and the family members working for the firm are also nonpaid employees. To simplify matters, we have excluded the people in this group from the entire analysis because it is likely that they behave differently to contract workers.

[20] The sum of the coefficients for production and nonproduction workers is equal to the coefficient for paid employees. Likewise, the sum of the coefficients for paid employees and contract workers is equal to the coefficient for all workers.

TABLE 3. EFFECTS ON MANUFACTURING EMPLOYMENT BY LABOR TYPE

	All employees (1)	by type of contract: Wage employees (2)	by type of contract: Contract employees (3)	by type of worker: Production workers (4)	by type of worker: Nonproduction workers (5)	by firm's legal status: Formal employees (6)	by firm's legal status: Informal employees (7)
Change in imports from China to Mexico/worker	-0.266**	-0.465***	0.199*	-0.356**	-0.109***	-0.496***	0.031*
	[0.110]	[0.159]	[0.100]	[0.145]	[0.029]	[0.164]	[0.016]
% of manufacturing employment pre-trend	-0.024	-0.000	-0.024**	-0.008	0.008*	0.002	-0.002
	[0.018]	[0.019]	[0.011]	[0.016]	[0.004]	[0.018]	[0.004]
% of population with secondary education	-0.158***	-0.214***	0.056	-0.141**	-0.073***	-0.232***	0.018
	[0.051]	[0.062]	[0.042]	[0.052]	[0.015]	[0.064]	[0.011]
Routine intensity level of occupations	0.011	-0.127	0.138*	-0.113	-0.014	-0.240**	0.113**
	[0.116]	[0.094]	[0.080]	[0.080]	[0.022]	[0.092]	[0.053]
Change in imports from ROW to Mexico/worker	0.010	0.001	0.009	-0.002	0.003	0.004	-0.003
	[0.016]	[0.009]	[0.012]	[0.008]	[0.002]	[0.009]	[0.005]
Observations	780	780	780	780	780	780	780

Notes. Pre-trend defined as the period between 1988–1998. Each column reports the results for regressions for 1998–2013. The dependent variable is the 15-year change in manufacturing employment over the working-age population in CZ for all employees (1), for paid employees (2), for production workers (3), for nonproduction workers (4), and for contract workers (5). The main explanatory variable is the change in imports from China to Mexico per worker, in kUS$. The instrument is the change in imports from China to LAC per worker. The control variables are the percentage of employment in the manufacturing pretrend for 1988–1998, the percentage of population with secondary education, the level of routine intensity of the average occupation, and the change in imports from the ROW to Mexico per worker, in kUS$. All the regressions also include a region fixed effect. Observations are weighted by the share of the national population. Robust standard errors in parentheses are clustered by state. * significant at 10%; ** significant at 5%; *** significant at 1%.

The group of wage employees can be separated into two subgroups: production and nonproduction workers. The impact of the China import competition shock was three times larger for production workers (column 4) than for nonproduction workers (column 5). This suggests that workers with lower skills were more severely affected.

Alternatively, the group of wage employees can be split into those that are hired formally and those that are hired informally. Even though a firm is required to pay social security contributions for its wage employees, in practice, compliance with this obligation is not uniform. In other words, some firms may hire wage employees but may not make social security contributions for them. We categorize these workers as informal. Given this situation, one can conjecture that faced with a negative trade shock, a potential adjustment is that firms might stop paying social security taxes on some of their wage employees by using informal workers rather than formal ones. We test this hypothesis by separating the wage employees into these two groups and then examining the effects. We create these two groups as follows: first, we add up all the wage employees at all the firms in the commuting zone for which the ratio of total social security contributions paid to total wages paid is equal to zero. These are the informally hired wage employees. We consider the rest of the wage employees to be formally hired. Measured this way, about 93% of all the wage employees in the manufacturing industry in Mexico are classified as formally hired. This is a conservative measure of informality: workers at firms that only make partial social security contributions are considered formal.[21]

Columns 6 and 7 show the results for the informality margin. There is some evidence that firms replace some formally hired wage employees with informally hired wage employees as a response to Chinese import shock. The coefficient for the formally hired workers is negative and statistically significant, and the coefficient for informally hired workers is positive and also statistically significant (at the 10% level). Accordingly, the decline we observe in paid employees overall is the result of a decline in the formally hired paid employees.

[21] Total social security contributions for wage employees in Mexico represent approximately 32% of wages. However, because the census data excludes some contributions (such as the housing fund or subnational taxes), a firm that fully complies with the components of the labor regulations included in the census would pay 18% of wages as social security contributions. Busso, Fazio, and Levy (2013) use this ratio of total social security contributions paid to total wages paid to define firms that hire paid employees legally or not. They define three groups: legal (the ratio is equal or larger than 18%), semilegal (the ratio is greater than 0% and lower than 18%), and illegal (the ratio is equal to 0%). For simplicity's sake, we create only two groups, informal workers and all other workers (who we categorize as formal).

B. Extensive margins

The import exposure from China induced a decline in the wage employees that was only partly mitigated by an increase in contract workers. What happened to these former wage employees? We consider various possibilities. If the working-age population does not move away from the commuting zone, then the net decline of employment in the manufacturing sector must be met by a corresponding increase in nonmanufacturing employment, an increase in unemployment, an increase in the population not in the labor force (NILF), or a combination of all of these options. We consider, first, the impact of the China shock on the share of the working-age population in each of these four categories: employment in manufacturing sectors, employment in nonmanufacturing sectors, unemployment, and NILF. A decline in the population share in one category must yield equivalent gains in the other categories.

To address these questions, we rely solely on data from the population census. In the previous sections, our dependent variable (the share of manufacturing employment among the working-age population) was constructed using data on manufacturing employment from the economic census and data on the working-age population from the population census. The advantage of using the economic census is that it allows us to decompose manufacturing employment into the various categories. But the economic census does not have information on the population in unemployment or the NILF population. For this reason, in this section, we rely exclusively on the population census to calculate the share of manufacturing employment among the working-age population, as well as the shares of the working-age population in nonmanufacturing and unemployment and the NILF population. This means that the share of manufacturing employment among the working-age population measured solely with data from the population census differs slightly from the share used previously, which was measured using employment data from the economic census, for two reasons. First, the population census includes some employees (such as the self-employed) who are not necessarily working in a fixed establishment and are therefore not included in the economic census. Second, the categorization of employees as working in the manufacturing sector is determined by the sector of the firm in the economic census and by the decision of the worker responding to the population census.

Table 4 reports the results. First, column 1 shows that the impact of exposure to the China import competition shock on the share of manufacturing employment measured using the population census is, reassuringly, similar to the corresponding estimate obtained when we used the economic census. Second, the decline in the share of manufacturing employment is not offset by increases in the share of nonmanufacturing employment and also is not accompanied by an increase in the share of the unemployed. Instead, it seems that those workers displaced from their positions in manufacturing after the China shock exited the labor force. Third, the next two rows of the table show that manufacturing workers who lack a college education experience the main negative impacts: a US$1,000-per-worker increase in a commuting zone's import exposure causes manufacturing employment among this group to decrease by 0.188 p.p., and the share of those who exit the labor force among this group to increase by 0.246 p.p. In contrast, the coefficients for manufacturing workers with a college education are not statistically significant.

TABLE 4. EFFECTS ON WORKING-AGE POPULATION SHARES BY EMPLOYMENT CATEGORIES

	Manufacturing employment (1)	Nonmanufacturing employment (2)	Unemployment (3)	Not in the labor force (4)
15-year change in employment shares				
All education levels				
Change in imports from China to Mexico/worker	-0.2021***	-0.0948	0.0118	0.2851***
	[0.0702]	[0.1004]	[0.0245]	[0.0997]
College education				
Change in imports from China to Mexico/worker	-0.0782	0.0105	-0.0257	0.0934
	[0.0636]	[0.1520]	[0.0220]	[0.1243]
No college education				
Change in imports from China to Mexico/worker	-0.1882**	-0.0772	0.0197	0.2458**
	[0.0699]	[0.0932]	[0.0256]	[0.0991]
Observations	780	780	780	780

Notes. Each cell in the table reports the result from a regression for 2000–2015. In panel A, the dependent variable is the 15-year log change in the number of working-age population (1), the number of working-age population employed in manufacturing (2), the number of working-age population employed in nonmanufacturing (3), the number of the working-age population that is unemployed (4), and the number of the working-age population that is not in the labor force (NILF) (5). In panel B the dependent variable is the 15-year change in the manufacturing employment share of the working-age population (2), the nonmanufacturing employment share of the working-age population (3), the unemployed share of the working-age population (4), and the NILF population's share of the working-age population (5). The main explanatory variable is the change in imports from China to Mexico per worker, in kUS$. The instrument is the change in imports from China to LAC per worker. All the regressions include the full set of control variables from table 2. Observations are weighted by the CZ's share of the national population at the start of the period. Robust standard errors in parentheses are clustered by state. ***; **; * significant at the 1%, 5%, and 10% level respectively.

C. Timing of adjustments

So far, we have presented results of the impact of Chinese competition on manufacturing labor for the full 15-year period (1998 to 2013) in our data. To understand whether the labor impacts from China have been increasing or decreasing over time, we analyze the results for the short and medium terms. For a clean comparison, we hold constant the start-of-period analysis, 1998 and change the end-of-period to 2003 (five years), 2008 (10 years), and 2013 (15 years). This allows us to employ the same start-of-period labor weights in the import exposure measures (1998 for *AIPWu* and 1988 for $AIPWO_{it}$), thereby minimizing the possibility that these weights are influenced by the Chinese import shock.

TABLE 5. EFFECTS ON WORKING-AGE POPULATION SHARES BY EMPLOYMENT CATEGORIES

		by type of contract		by type of worker		by firm's legal status	
	All employees (1)	Wage employees (2)	Contract employees (3)	Production workers (4)	Nonproduction workers (5)	Formal employees (6)	Informal employees (7)
Change in imports from China to Mexico/worker:							
(a) Period 1998–2003 -1.620*	-1.620*	-1.856**	0.236*	-1.472**	-0.384**	-2.054**	0.198*
	[0.824]	[0.785]	[0.125]	[0.648]	[0.153]	[0.833]	[0.112]
(b) Period 1998–2008	-0.729**	-0.918**	0.188*	-0.692**	-0.179***	-0.925**	0.007
	[0.332]	[0.344]	[0.104]	[0.290]	[0.045]	[0.347]	[0.029]
(c) Period 1998–2013	-0.266**	-0.465***	0.198*	-0.356**	-0.109***	-0.496***	0.031*
	[0.110]	[0.159]	[0.100]	[0.145]	[0.029]	[0.164]	[0.016]
Observations	780	780	780	780	780	780	780

Notes. Each column reports results from regressions over the periods 1998–2003 (a), 1998–2008 (b) and 1998–2013 (c). The dependent variable is the 15-year change in manufacturing employment over working-age population in the CZ, for all employees (1), for paid employees (2) and for contract workers (3). The main explanatory variable is the change in imports from China to Mexico per worker, in kUS$. The instrument is the change in imports from China to LAC per worker. All the regressions include the full set of control variables from table 2. Observations are weighted by the CZ's share of the national population at the start of the period. Robust standard errors in parentheses are clustered by state. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5 presents the findings for all employees (including both wage employees and contract workers). The short-run (five-year) impacts are reported in row (a), and the medium-run (10-year) impacts are reported in row (b). For comparison purposes, row (c) shows the 15-year impacts discussed above. The point estimates for "all employees" indicate that the largest impact took place within the first five-year subperiod. A similar result is found with respect to paid employees; the magnitude of the impact on this group also declines over time.[22] Finally, for contract workers, the positive impact is also larger during the first five-year subperiod, with smaller and relatively similar impacts for the 10-year and 15-year subperiods.[23] Overall, these results suggest that the effects of the Chinese import competition shock on Mexican manufacturing employment was most pronounced during the first years after the shock, with the effects progressively declining over time.

Price adjustments. Finally, we evaluate the impact on wages. We combine information from the economic census on the annual wage bill and the number of paid employees to obtain a measure of the average wage within a given commuting zone.[24] It is worth noting that the fact that we do not see individual wages means that we cannot say whether the observed changes in the average wage are due to changes in wages for individual workers or to changes in the composition of workers. Not being able to keep the composition of workers constant might introduce a bias in the estimation.[25] Accordingly, the results should be viewed with some caution. Table 6 presents the findings. The dependent variable is expressed as the log change of wages. To examine the existence of heterogeneous effects across different types of paid employees, we estimate separate effects for production and nonproduction workers, as well as for formal and informal wage employees. The results in table 6 show some negative impacts on wages, although the magnitudes are modest. For instance, a comparison of the impact on the wages of production and nonproduction workers shows that only nonproduction workers' wages are negatively affected: a US$1,000-per-worker increase in a commuting zone's exposure to Chinese imports reduces the annual wages of nonproduction workers by 0.04 log points. A comparison of the impact on the earnings of formal and informal employees shows a small negative effect on the wages of the formal employees: a US$1,000-per-worker increase in a zone's exposure to Chinese imports reduces the annual wage of formal workers by 0.036 log points.

[22] A more precise way to see that the effects decline over time is through the following annual comparison: the first five-year change in import exposure was 0.111 (kUS$). This implies that, among the working-age population, the Chinese trade shock induced a decline in the share of paid employees of 0.179 p.p. over these five years (0.111*1.856 = 0.206) or a decline of 0.04 p.p. annually (0.206/5 = 0.04). Comparatively, the 10-year change in import exposure was 0.431 (kUS$). This implies that the China trade shock induced a decline in the share of paid employees of 0.395 p.p. over 10 years (0.431*0.917 = 0.395) or 0.039 p.p. annually (0.395/10 = 0.039). Finally, the 15-year change in import exposure was 0.753 (kUS$). This implies that the trade shock induced a decline in the share of paid employees of 0.349 p.p. over the 15 years (0.753*0.446 = 0.349) or 0.023 p.p. annually (0.349/15 = 0.023).

[23] Unfortunately, we lack data to conduct a similar analysis of the four components of the working-age population presented in table 4. INEGI did not conduct a full population census in 2005; this precludes us from examining the short-run impact of the Chinese import shock on nonmanufacturing employment, the unemployed, and the population no longer in the labor force.

[24] We express wages in constant terms by using the GDP deflator.

[25] As mentioned in Autor, Dorn and Hanson (2013), if workers with lower wages are more likely to lose employment, then the observed changes in the average wage will understate the changes in wages relative to the case when the composition is kept constant.

TABLE 6. EFFECTS ON WAGES

	Whole wage worker population (1)	Production workers (2)	Nonproduction workers (3)	Formal employees (4)	Informal employees (5)
Change in imports from China to Mexico/worker					
(c) 1998–2003	-0.083	-0.102	-0.146**	-0.180**	0.160
	[0.058]	[0.065]	[0.062]	[0.085]	[0.144]
(c) 1998–2008	0.000	-0.005	-0.033*	-0.040	0.002
	[0.019]	[0.022]	[0.018]	[0.032]	[0.060]
(c) 1998–2013	-0.014	-0.0132	-0.0396**	-0.0355**	0.0187
	[0.013]	[0.0137]	[0.0149]	[0.0168]	[0.0214]
Observations	780	780	780	780	780

Notes. The dependent variable is the 5-, 10-, and 15-year log change in wages for the whole worker population (1), production workers (2), nonproduction workers (3), formal employees (4), and informal employees (5). The main explanatory variable is the change in imports from China to Mexico per worker, in kUS$. The instrument is the change in imports from China to LAC per worker. The control variables are the share of manufacturing in the country's total employment, the percentage of the population with secondary education, the level of routine intensity of the average occupation, and the change in imports from the ROW to Mexico per worker, in kUS$. All the regressions also include a region fixed effect. Observations are weighted by the CZ's share of the national population at the start of the period. Robust standard errors in parentheses are clustered by state. * significant at 10%; ** significant at 5%; *** significant at 1%.

7. OTHER EFFECTS OF THE CHINA SHOCK

A. Accounting for the increased competition in external markets

The increased competition experienced by Mexican firms also came through an indirect channel: because about 90% of Mexican manufacturing exports go to the United States, Mexican firms might have also experienced increased competition from Chinese manufacturers in the US market. We define a measure of Chinese import exposure through the US market using the following expression:

$$\Delta IPW_{it}^{US} = \frac{1}{L_{it}} \sum_j \frac{L_{ijt}}{L_{jt}} \frac{M_{jt}^{Mex\to US}}{M_{jt}^{US}} \Delta M_{jt}^{China\to US} \qquad (4)$$

where M_{jt}^{US}, $M_{jt}^{Mex\to US}$ and $\Delta M_{jt}^{China\to US}$ are the US total imports in industry *j*, the US imports from Mexico in industry *j,* and the change in US imports from China in industry *j*, respectively, while the labor weights are the same as in expression (1). Expression (4) specifically captures the growth in US imports from China ($\Delta M_{jt}^{China\to US}$), weighted by the initial share of US spending on Mexican goods ($M_{jt}^{Mex\to US}/M_{jt}^{US}$). Accordingly, the larger the share of US expenditure on Mexican products, the greater Mexico's exposure to Chinese competition through the US market.[26]

One potential problem of adding the import exposure as measured in (4) to equation (3) is the high level of correlation between ΔIPW_{it} and ΔIPW_{it}^{US}, which is equal to 0.74. This is not surprising, as the labor weights used in both expressions are the same. With a variance-inflation factor (VIF) of 10.4, there is likely a severe case of multicollinearity between the two variables. To avoid this problem, we only include in the model represented by equation (3) one measure of import exposure, which consists of the sum of the domestic plus the international exposure to Chinese exports. Specifically, our overall import exposure variable is given by the sum of ΔIPW_{it} and ΔIPW_{it}^{US}:

[26] One way to think about this expression is to consider an extreme case: suppose that Mexican region *i* is highly specialized in producing goods in industry *j* (L_{ijt}/L_{jt} is large), but that the country does not export any good in industry *j* to the United States ($M_{jt}^{Mex\to US}/M_{jt}^{US} = 0$). In this situation, then, the increase in US imports from China in industry *j* does not entail an increase in import exposure to region *i* through the US market.

$$\Delta IPW'_{it} = \frac{1}{L_{it}} \sum_j \frac{L_{ijt}}{L_{jt}} \Delta M_{cjt} + \frac{1}{L_{it}} \sum_j \frac{L_{ijt}}{L_{jt}} \frac{M_{jt}^{Mex \to US}}{M_{jt}^{US}} \Delta M_{jt}^{China \to US} \quad (5)$$

By adding up import exposure in the domestic market and import exposure through the US market, the mean change in import exposure increases. For instance, while the 15-year mean change of ΔIPW was US$(1998)753, the mean change in $\Delta IPW'$ is now US$(1998)1,254, an increase of 67%.

The first row in table 7 presents the results after estimating β_1 in equation (3) using the composite import exposure measure $\Delta IPW'$.[27] For comparison purposes, the third row shows the results when we employ ΔIPW, as reported in table 3. The results are qualitatively similar to our baseline estimations. Note that, on the one hand, the coefficients are smaller in absolute values, but, on the other hand, the mean change in the new import exposure is larger, as mentioned above. The net effect is a slight increase in the negative impact on wage employees and a somewhat similar positive impact on contract workers.

TABLE 7. DIRECT AND INDIRECT EFFECTS ON EMPLOYMENT

	All (1)	Wage (2)	Contract (3)	Production (4)	Nonproduction (5)	Formal (6)	Informal (7)
Panel A:							
Change in imports from China (Mexico and USA) / worker	-0.194*** [0.0610]	-0.311*** [0.0874]	0.116** [0.0486]	-0.247*** [0.075]	-0.063*** [0.020]	-0.329*** [0.089]	0.019** [0.008]
Panel B:							
Change in net imports from China (Mexico) / worker	-0.275** [0.113]	-0.477*** [0.163]	0.202* [0.101]	-0.366** [0.148]	-0.111*** [0.030]	-0.508*** [0.167]	0.032* [0.016]
Panel C:							
Change in imports from China (Mexico)/worker	-0.266** [0.110]	-0.465*** [0.159]	0.199* [0.100]	-0.356** [0.145]	-0.109*** [0.029]	-0.496*** [0.164]	0.031* [0.016]
Number of Observations	780	780	780	780	780	780	780

Notes: Each column reports results from regressions over the period 1998–2013. The dependent variable is the 15-year change in manufacturing employment over working-age population in the CZ for all employees (1), paid employees (2), and contract workers (3). The main explanatory variable is the change in imports from China to Mexico and the USA per worker, in kUS$ (a), and the change in imports from China to Mexico per worker, in kUS$ (b). (See the main text.) All the regressions include the full set of control variables from table 2. Observations are weighted by the CZ's share of the national population at the start of the period. Robust standard errors in parentheses are clustered by state. * Significant at 10%; ** significant at 5%; *** significant at 1%.

B. Accounting for increased exports to China

While this study focuses primarily on measuring the impact of Chinese import penetration on labor outcomes in the Mexican manufacturing industry, the rapid growth of China may have also provided opportunities for Mexico to export to this country with potentially positive impacts on labor. We can use the same methodology applied so far to examine whether the change in Mexican exports to China has had any impact on Mexican employment. Similarly to Autor et al. (2013), we construct a measure of net import exposure (imports minus exports). We then compare the results with those on gross import exposure. The difference between the two results can be attributed to the impact of Mexican exports to China. Specifically, Mexico's net import exposure to China is given by the following expression:

$$\Delta IPWN_{it} = \frac{1}{L_{it}} \sum_j \frac{L_{ijt}}{L_{jt}} (\Delta M_{jt}^{c} - \Delta E_{jt}^{Mex}) \quad (6)$$

[27] We try different instruments for $\Delta IPW'$. The first instrument is the same instrument as for ΔIPW. The second instrument is an adjustment of the instrument for ΔIPW that includes the second part of (4). In both cases, we implicitly assume that no instrument is needed for China's import penetration in the United States because Mexico is too small to exert any significant change in the overall US demand for imports. The results are essentially the same with any of the instruments.

where ΔE_{jt}^{Mex} is the 15-year change in Mexican exports to China in industry j and the rest of the variables are the same as in expression (1). We instrument this import measure using two variables: the import exposure in expression (2), and a net export exposure instrument constructed analogously to that in expression (2), which is based on exports to China from the same Latin American countries used previously.

The second row in table 7 presents the findings. All the coefficient estimates are now slightly larger in absolute values although we can never reject the null of equality between the two sets of coefficients. Note, however, that the changes in net import exposure are smaller than the changes in gross import exposure. For instance, while the average 15-year change in gross import exposure is US$(1998)753, the average 15-year change in the net import exposure is equal to US$(1998)722. The overall impact on employment is slightly less negative after accounting for Mexican exports to China, which implies that Mexican exports to China exert a positive effect on employment.

8. CONCLUSION

We examine the impact of China's emergence as a manufacturing powerhouse on Mexican manufacturing employment. To identify the effects of this trade shock on various labor outcomes, we exploit the heterogeneity that exists across local labor markets in terms of industry specialization and exposure to import competition. We find that in the most exposed zones, the adjustments in the labor market took various negative forms: a decline in the number of paid employees, the substitution of some wage employees by contract workers, and the substitution of some formally hired wage employees by informally hired ones. We find that the shrinkage in employment levels was met by an increase in the population that exited the labor force. The results show that the effects are most pronounced among workers with lower skill and education levels. Among the wage employees, the negative impact was three times more severe among production workers than among nonproduction workers, and noncollege manufacturing workers experienced the main negative effects. Our estimates account for the increased competition from Chinese products in the domestic market, as well as the increased competition that Mexican exporters faced in the US (their main export market). The estimates also account for the small increase in employment due to increased access to the Chinese market. We provide evidence that the largest impacts took place during the first five years of the 15-year period that we analyze, indicating that the magnitude of the impacts declined overtime.

We can use our results to provide a back-of-the-envelope calculation of the job losses faced in Mexico due to increased competition. To do this, we first calculate the number of jobs lost as the result of direct Chinese competition within Mexico itself. We calculate how much manufacturing employment would have grown between 1998 and 2013 if the import exposure from China had remained at 1998 levels, and we then compare the resulting number of jobs with figures of actual jobs created. The difference is the number of job losses due to Chinese import shock. Following Acemoglu et al. (2016), the counterfactual can be calculated as follows:

$$\Delta L_{i2013}^{CFactual} = -\hat{\beta}_1 \times \widetilde{\Delta IPW_i} \times WAP_{i2013} \qquad (7)$$

where $\Delta L_{i2013}^{CFactual}$ is the number of additional jobs that commuting zone *i* would have had in 2013 if the import penetration from China had remained at the 1998 level; $\hat{\beta}_1$ is the 2SLS coefficient estimate from equation (3); WAP_{i2013} is the working-age population of commuting zone *i* in 2013, and $\widetilde{\Delta IPW_i}$ is the portion of the import penetration from China in commuting zone *i* that can be attributed to Chinese import shock.[28] The latter is calculated by multiplying the original import penetration measure, ΔIPW_i, by the partial R-square from the first-stage regression of equation (3). This R-square gives the variation of ΔIPW_i that is explained by the instrument in expression (1). Thus $\widetilde{\Delta IPW_i}$ is a proxy of the supply-driven component of ΔIPW_i (see Acemoglu et al., 2015). We calculate a counterfactual for each commuting zone and then add the results across all zones. We do this separately for wage employees (who

[28] Recall that the original ΔIPW_i, or the change in imports per worker from China, might reflect not only a Chinese supply shock but also Mexican demand factors.

experienced a negative impact) and for contract workers (who experienced a positive impact) using the estimates from columns 2 and 5 of table 6.[29]

We find four main results. First, had import exposure from China remained unchanged between 1998 and 2013, there would have been approximately 480,000 more wage employees in manufacturing in 2013. That is, wage manufacturing employment would have been 14.1% higher than it actually was in 2013. Additionally, there would have been 205,000 fewer contract workers in the economy; that is, contract manufacturing labor levels would have been 21% lower. Second, we can consider the indirect effect via competition from Chinese products in the US and recalculate our counterfactual exercise using this new measure of import exposure and the new estimates from table 7. Had import exposure from China in Mexico and the United States remained unchanged between 1998 and 2013, there would have been approximately 546,000 more wage employees in 2013. Therefore, import exposure through the US channel induces an additional job loss of 65,989 wage employees. At the same time, there would have been 204,000 fewer contract workers in the economy (which is very similar to the previous counterfactual). Third, we can include a measure of the impact of Mexican exports to China on employment by calculating the same type of counterfactuals. The result of this exercise shows an increase of 17,121 wage employees and a reduction of 9,109 contract workers, for a net increase of 8,012 employees. In other words, in 2013 there were 8,012 more employees as the result of the increase in Mexican exports to China during the period of analysis. Note that this impact on labor associated with Mexican exports to China is very small relative to the impacts associated with Mexican imports from China. This should not come as a surprise as Mexican manufacturing exports to China are just a fraction of Mexican imports from China (5%).

The overall job loss in the manufacturing sector, as measured by the change in wage employees plus the change in contract workers, is approximately 335,000 workers: ~(546,023 - 204,165 - 8,012 = 333,846). In other words, had import exposure from China in Mexico and the United States remained unchanged between 1998 and 2013, the number of total workers in the manufacturing sector would have been larger by 335,000 (i.e., employment in the manufacturing sector would have been about 7.6% higher in 2013).[30] These results are heterogeneous across local labor markets. For example, the 15-year increase in overall import exposure in the Mexicali CZ (on the northern border of Mexico) was equal to 15.29 (kUS$), compared to the national average of 1.25 (kUS$). Had import penetration from China remained unchanged between 1998 and 2013, manufacturing employment in Mexicali would have been 17.3% higher in 2013. This illustrates that, in the context of local labor markets, there were significant job losses in some CZs.

[29] We can illustrate the calculation using one CZ, Valle de Mexico, which includes Mexico City. The 15-year supply-driven change in import exposure in Valle de Mexico is equal to 0.996 (kUS$) which arises from multiplying the import exposure in Valle de Mexico 1.61 (kUS$) by the R-square from the first-stage regression of 0.6186 (0.996 = 1.61 x 0.6186). Given the point estimate for paid employees of -0.465, the share of paid employees per working-age population would have increased by 0.463 p.p. more than it did (0.996 x 0.465 = 0.463). The working-age population in Valle de Mexico in 2013 was 14.4 million people. Therefore, the estimates imply that in 2013 there would have been approximately 67,000 more paid employees in manufacturing (14,475,137 x 0.0046 = 67,017). The equivalent point estimate for contract workers is 0.1985. Accordingly, the share of contract workers per working-age population would have increased by 0.198 p.p. less than it did (-0.996 x 0.1985 = -0.198). Therefore, the estimates imply that in 2013 there would have been approximately 29,000 fewer contract workers in manufacturing (14,475,137 x (-0.00198) = -28,627).

[30] The economic census is the source for the figure, indicating that 4.4 million workers were employed in the manufacturing sector year 2013. Note that we have excluded business owners and the family members working for the firm from our analysis. In 2013, this group represented around 700,000 people.

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APPENDIX A: VARIABLE DEFINITIONS AND SOURCES

TABLE A.1. DESCRIPTION OF VARIABLES AND DATA SOURCES

Variable	Description	Source
Share of working-age population in manufacturing	Employment in manufacturing divided by total employment at the CZ level	Based on Mexican Economic Census and Population Census from INEGI
Import penetration from country c in CZ	Weighted average of Mexican imports from country *c* in industry *i* divided by total employment in CZ *i*. The weight is the share of CZ *i* in employment in industry *j*.	Based on Comtrade from UN and Mexican Economic Census from INEGI
Instrument for import penetration from country c in CZ i	Weighted average of the imports of 17 Latin American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Guyana, Jamaica, Nicaragua, Panama, Peru, Paraguay, Uruguay, and Venezuela) from country *c* in industry *i* divided by total employment in CZ *i*. The weight is the share of the CZ *i* in employment in industry *j*.	Based on Comtrade from UN and Mexican Economic Census from INEGI
Alternative import penetration from country *c* in CZ i	Weighted average of Mexican imports from country *c* in industry *i* divided by Mexican apparent consumption (output + imports - exports) in industry *i*. The weight is the share of the CZ *i* in employment in industry *j*.	Based on Comtrade from UN and Mexican Economic Census from INEGI
Instrument for alternative import penetration from country *c* in CZ *i*	Weighted average of the imports of 17 Latin American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Guyana, Jamaica, Nicaragua, Panama, Peru, Paraguay, Uruguay and Venezuela) from country *c* in industry *i* divided by Mexican apparent consumption (output + imports - exports) in industry *i*. The weight is the share of the CZ *i* in industry *j*'s employment	Based on Comtrade from UN and Mexican Economic Census from INEGI
Import penetration from China through the US market	Weighted average of US imports from China in industry *i* divided by total employment in CZ *i*. The weight is the share of the CZ i in industry j's employment multiplied by the share of Mexico in US imports of industry j	Based on Comtrade from UN and Mexican Economic Census from INEGI
Percentage of employment in manufacturing pretrend (1988–1998)	10-year change in the share of employment in manufacturing (1988–1998) at the CZ level	Based on Mexican Economic Census from INEGI
Percentage of population with secondary education	Population with secondary education completed divided by total population at the CZ level	Based on Mexican Economic Census and Population Census from INEGI
Routine intensity level of occupations	Weighted average of the level of routineness of all the sectors that are active in the CZ in 1998. The weights are the shares of the CZ's employment in sector *j*. The sectoral level of routineness is taken from Costinot, Oldenski, and Rauch (2011)	Based on Mexican Economic Census from INEGI and Costinot, Oldenski,, and Rauch (2011)
Paid employee	A paid employee earns a predetermined amount of money, has the right to a severance payment when fired and is entitled social security benefits	Based on Mexican Economic Census from INEGI
Contract workers	A contract worker is paid hourly or by a project, does not receive severance payment, and is not entitled to social security benefits	Based on Mexican Economic Census from INEGI
Production workers	Blue-collar paid employees	Based on Mexican Economic Census from INEGI
Nonproduction workers	White-collar paid employees	Based on Mexican Economic Census from INEGI
Legal employees	Sum of all paid employees minus all the illegal paid employees in the CZ	Based on Mexican Economic Census from INEGI
Illegal employees	Sum of paid employees of all the firms in the CZ for which the ratio of total social security taxes paid to total wages is equal to zero	Based on Mexican Economic Census from INEGI

APPENDIX B: ALTERNATIVE INSTRUMENTAL VARIABLE

In this appendix, we present a similar set of regressions as in table 5 but we employ a different instrument. Specifically, we replace the 17 Latin American countries used in the construction of expression (2) by eight countries that are similar to Mexico in five aspects (GDP per capita, physical capital, human capital, population, and export basket composition). The countries are Argentina, Brazil, Colombia, Costa Rica, Malaysia, Peru, Poland, and Romania. Table B.1 presents the results.

TABLE B.1: CHANGE IN MANUFACTURING EMPLOYMENT IN CZS, 1998–2013 (2SLS ESTIMATES)

	[1]	[2]	[3]	[4]	[5]	[6]
Change in imports from China to	-0.317***	-0.306***	-0.323***	-0.262***	-0.264***	-0.266***
Mexico/worker	[0.091]	[0.077]	[0.092]	[0.085]	[0.089]	[0.090]
Percentage of employment in		0.013	-0.020	-0.027*	-0.026	-0.024
manufacturing pretrend (1988–1998)	[0.027]	[0.015]	[0.015]	[0.017]	[0.018]	
Percentage of population with secondary				-0.153***	-0.154**	-0.158***
education				[0.055]	[0.056]	[0.057]
Routine intensity level of occupations					-0.005	0.011
					[0.087]	[0.096]
Change in imports from ROW to						0.010
Mexico/worker						[0.016]
Region fixed effect	no	no	yes	yes	yes	yes
Number of observations	780	780	780	780	780	780
			2SLS first-stage estimates			
Change in imports from China to	0.219***	0.235***	0.207***	0.195***	0.175***	0.175***
LAC/worker	[0.046]	[0.047]	[0.044]	[0.042]	[0.038]	[0.038]
Weak identification test F statistic	23.0	25.2	22.1	21.0	21.1	10.5

Notes. Each column reports results from regressions over the period 1998–2013. The dependent variable is the 15-year change in manufacturing employment over working-age population in the CZ between 1998 and 2013 (in p.p.). The main explanatory variable is the change in imports from China to Mexico over Mexico's apparent consumption, in p.p. The instrument is the change in imports from China to LAC over Mexico's apparent consumption. The control variables are the share of manufacturing in the country's total employment (2–6), the percentage of population with secondary education (3–6), the level of routine intensity of the average occupation (5–6), and the change in imports from the ROW to Mexico over Mexico's apparent consumption (6). Additional control is a region fixed effect (3–6). Observations are weighted by the CZ's share of the national population at the start of the period. Robust standard errors in parentheses are clustered by state. The weak identification test is the Kleibergen-Paap Wald F statistic. ***; **; * significant at the 1%, 5%, and 10% level respectively.

APPENDIX C: ALTERNATIVE IMPORT EXPOSURE VARIABLE

In this appendix, we present results when we employ an alternative measure of import exposure. In particular, Chinese import exposure is expressed in terms of the imports from China to Mexican apparent consumption instead of imports per worker. The construction of this import exposure at the CZ level follows the work in Acemoglu et al. (2015) and is given by the following expression:

$$\Delta IPW_{it} = \Sigma_j (L_{ijt}/L_{it})(\Delta M_{cjt}/(Y_{jt} + M_{jt} - E_{jt})) \qquad (8.8)$$

where Y_{jt}, M_{jt} and E_{jt} refer to industry *j*'s total output, imports, and exports, respectively, while the rest of the variables are defined as before. Also, following a strategy similar to Acemoglu et al. (2015), the instrument for this variable is constructed by substituting the change in Mexican imports from China in the numerator with the change in other countries' imports from China, where the group of other countries consists of 17 Latin American economies. Table 9 presents a set of regressions similar to those in table 5 but when this alternative import exposure variable is employed.

TABLE C.1: CHANGE IN MANUFACTURING EMPLOYMENT IN CZS, 1998–2013 (2SLS ESTIMATES)

	[1]	[2]	[3]	[4]	[5]	[6]
Change in imports from China to Mexico/worker	-0.096***	-0.103***	-0.112***	-0.100**	-0.100**	-0.108**
	[0.0323]	[0.033]	[0.038]	[0.040]	[0.041]	[0.043]
Percentage of employment in manufacturing pretrend (1988–1998)	0.021	-0.010	-0.017	-0.018	-0.014	
	[0.026]	[0.014]	[0.014]	[0.014]	[0.014]	
Percentage of population with secondary education				-0.129**	0.127**	-0.132**
				[0.060]	[0.058]	[0.061]
Routine intensity level of occupations					0.008	0.031
					[0.093]	[0.077]
Change in imports from ROW to Mexico/worker						0.016
						[0.026]
Region fixed effect	no	no	yes	yes	yes	yes
Number of observations	780	780	780	780	780	780
			2SLS first-stage estimates			
Change in imports from China to LAC/worker	0.597***	0.606***	0.578***	0.565***	0.547***	0.498***
	[0.053]	[0.050]	[0.050]	[0.050]	[0.041]	[0.035]
Weak identification test F statistic	129.0	147.1	134.7	128.8	174.9	203.9

Notes. Each column reports results from regressions over the period 1998–2013. The dependent variable is the 15-year change in manufacturing employment over working-age population in CZ between 1998 and 2013 (in p.p.). The main explanatory variable is the change in imports from China to Mexico over Mexico's apparent consumption, in p.p. The instrument is the change in imports from China to LAC over Mexico's apparent consumption. The control variables are the share of manufacture in the country's total employment (2–6), the percentage of population with secondary education (3–6), the level of routine intensity of the average occupation (5–6), and the change in imports from the ROW to Mexico over Mexico's apparent consumption (6). Additional control is a region fixed effect (3–6). Observations are weighted by the share of the national population at the start of period CZ. Robust standard errors in parentheses are clustered by state. The weak identification test is the Kleibergen-Paap Wald F statistic. ***; **; * significant at the 1%, 5%, and 10% level respectively.