

Import Competition and the Great US Employment Sag of the 2000s*

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Abstract

Even before the Great Recession, U.S. employment growth was unimpressive. Between 2000 and 2007, the economy gave back the considerable jump in employment rates it had achieved during the 1990s, with major contractions in manufacturing employment being a prime contributor to the slump. The U.S. employment “sag” of the 2000s is widely recognized but poorly understood. In this paper, we explore the role of the swift rise of import competition from China on sluggish U.S. employment growth. We find that the increase in U.S. imports from China, which accelerated after 2000, was a major force behind recent reductions in U.S. manufacturing employment and that, through input-output linkages and other general equilibrium effects, it appears to have significantly suppressed overall U.S. job growth. Our central estimates suggest job losses from the rise in import competition from China over the period 1999 to 2011 in the range of 0.6 to 1.25 million.

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1 Introduction

During the last decade of the twentieth century—christened the “Roaring Nineties” by Alan Krueger and Robert Solow (2002)—the U.S. labor market exhibited a vigor not seen since the 1960s. Between 1991 and 2000, the employment to population ratio rose by 1.5 percentage points among males, and by more than 3 percentage points among females. In the year 2000, following five years of rapid wage growth accompanied by minimal inflation, the national unemployment rate reached a nadir of 4.0 percent, its lowest level since 1969. Just one year later, however, the U.S. labor market commenced what Robert Moffitt (2012) terms a “historic turnaround” in which the gains of the prior decade were undone. Between 2001 and 2007, male employment rates ceded all of their gains achieved between 1991 and 2000. The rapid growth of female employment rates halted simultaneously, and reversed course among some subgroups. While the growth rate of the U.S. working age population was virtually identical during the 1990s and the 2000s, averaging 1.1 to 1.2 percent, the growth rate of employment averaged only 0.9 percent between 2000 and 2007—that is, during the seven years *before* the onset of the Great Recession—versus 1.4 percent between 1990 and 2000 (Figure 1).¹

This pre-Great Recession U.S. employment “sag” of the 2000s is widely recognized but little understood.² In this paper, we explore an under-appreciated force contributing to stagnating U.S. employment growth in the 2000s: the swift rise of import competition from China (Figure 2). Between 1990 and 2000, the share of world manufacturing exports originating in China increased from 2% to 5%, and then more dramatically climbed to 12% in 2007 and 16% in 2011. China’s export surge is the outcome of a major expansion in its manufacturing capacity, unleashed by economic reforms in the 1980s and 1990s, and reinforced by its accession to the World Trade Organization in 2001 (Naughton, 2007). China’s share in U.S. manufacturing imports has shown an equally meteoric rise, increasing from 4% in 1991 to 10% in 2001 before surging further to 19% in 2011 (Hanson, 2012).

The post-2001 acceleration in China’s manufacturing exports to the United States coincides with a historic contraction of U.S. manufacturing (Figure 1). Although U.S. manufacturing employment had been declining modestly since the start of the 1980s, this trend gained pace in the mid-1990s and accelerated sharply in the 2000, with the number of workers in U.S. manufacturing dropping by 9.7 percentage points between 1991 and 2001 and by an additional 16.1 percentage points between 2001

¹See <http://www.bls.gov/ilc/\#laborforce> for data on the size and the employment rate of the working age population.

²Moffitt (2012) studies a panoply of potential causes for the sag including wage levels, age structure, family structure, taxes, transfers, minimum wage policies, and population health. Only one of these factors is found to have substantial explanatory power: declining male wage rates, which can explain up to half of the observed decline in male employment. Yet, this explanation leaves unanswered the question of *why* male wages fell. The concurrence of falling wages and falling employment to population ratios suggests an inward shift in labor demand, the cause of which has yet to be established.

and 2007.³ While the overall U.S. employment growth rate of 0.9 percent between 2001 and 2007 was half as rapid as the rate of 1.8 percent between 1991 and 2000, this aggregate deceleration combines a roughly 40 percent slowdown in employment growth in non-manufacturing and a near-tripling of the rate of decline of manufacturing. Indeed, excluding manufacturing reduces the observed deceleration in employment growth between 2001 and 2007 by about 30 percent (Figure 1). Since adverse shifts in demand for manufactured goods are likely to have negative spillovers to related non-manufacturing sectors—as we document below—this simple 30 percent figure by no means constitutes the full contribution of manufacturing decline to the weak U.S. job creation record of the 2000s.

In this paper, we explore how much of the U.S. employment sag of the 2000s can be attributed to rising import competition from China. Our methodology builds on and extends several recent papers, most notably Autor, Dorn and Hanson (2013a) as well as related work by Autor, Dorn, Hanson and Song (2013), Bloom, Draca and Van Reenen (2011), and Pierce and Schott (2012). Akin to Pierce and Schott (2012), we begin our analysis with industry-level empirical specifications. This approach enables us to estimate the *direct* effect of exposure to Chinese import competition, or rather the exogenous component thereof identified by adapting the instrumental-variables strategy of Autor, Dorn and Hanson (2013a), on industry employment at the U.S. national level. Our direct industry-level employment estimates come from comparing changes in employment across four-digit manufacturing industries from 1991 to 2011 as a function of each industry’s potential exposure to Chinese import competition. The first part of our paper shows that there is a sizable, and robust, effect of growing Chinese imports on industry employment in U.S. manufacturing. The impact is present both for production and non-production workers, though somewhat larger for the former.

Quantitatively, our basic estimates from an industry-level analysis imply that had import penetration from China not grown after 1999, there would have been 284,000 fewer manufacturing jobs lost through the year 2011. Actual U.S. manufacturing employment declined from 17.2 million workers in 1999 to 11.4 million workers in 2011, making the counterfactual job loss correspond to approximately 5 percent of the realized job destruction in manufacturing.

These direct effects do not correspond to the full general equilibrium impact of growing Chinese imports on U.S. employment. The full impact encompasses several indirect (“general equilibrium”) channels through which increases in exposure to import competition impact employment levels. One source of indirect effects, also studied by Pierce and Schott (2012), is industry *input-output linkages*. These linkages can create both positive and negative changes in U.S. industry labor demand and therefore produce a net employment change that is ambiguous in sign. If a U.S. industry contracts

³Using County Business Patterns data, we calculate that U.S. manufacturing employment was 18.3 million in 1991, 16.6 million in 2001, 13.9 million in 2007, and 11.4 million in 2011.

because of Chinese competition, it may reduce both its demand for intermediate inputs produced in the United States and its supply of inputs to other domestic industries. A U.S. industry may thus be negatively affected by trade shocks either to its *upstream* domestic suppliers or to its *downstream* domestic buyers. At the same time, increased imports in upstream industries may lower the cost of obtaining inputs, potentially offsetting the disruptions to domestic input supply.⁴ In response to a negative upstream trade shock, an industry’s employment may either rise or fall. A negative downstream trade shock, by contrast, should have unambiguously contractionary consequences.

We use the U.S. input-output table for 1992 to construct upstream and downstream trade shocks for U.S. industries in both manufacturing and non-manufacturing sectors. The upstream shock will be high for sectors whose suppliers are exposed to Chinese import competition, while the downstream shock will be high for sectors whose customers are increasingly competing with China. Our measure of downstream (respectively, upstream) trade shocks for an industry, which sums over the direct shocks to all other industries using their share in the total output demands (input supplies) of the industry in question, captures this notion.⁵ Estimates from this exercise indicate sizable negative downstream effects, though—consistent with the anticipated ambiguity of upstream effects—the upstream magnitudes are imprecisely estimated and unstable in sign. Incorporating these indirect employment implications of trade with China increases our estimates of trade competition-induced job loss from 1999 to 2011 to 657,000 workers, when just considering manufacturing industries, and to 1.3 million workers when also including non-manufacturing sectors. Inter-industry linkages thus magnify the employment effects of trade shocks substantially.

There are other general equilibrium effects from trade that we cannot capture at the level of national industries, leading to our second empirical strategy of studying local labor markets, as in Autor, Dorn and Hanson (2013a). One additional channel is a *reallocation effect* from growing trade with China, which works through the standard movement of factors of production from declining sectors to new opportunities and potentially counteracts any negative direct or industry linkage effects. In both Heckscher-Ohlin and Ricardo-Viner models of international trade, stronger import competition for some sector reduces prices for final goods and induces the reallocation of factors of production to other sectors whose relative prices have increased (Feenstra, 2004). This reallocation triggers an employment expansion in non-affected sectors. Under fully inelastic labor supply, no labor market frictions, and other neoclassical assumptions which ensure that the aggregate economy is

⁴Trade shocks to an industry’s suppliers will have negative effects on that industry if, due to specific investments, existing supply relationships are more productive or are able to provide highly customized inputs as generally presumed in the industrial organization literature on vertical integration (e.g., Williamson, 1975; Hart and Moore, 1990).

⁵See Long and Plosser (1983) and Acemoglu, Carvalho, Ozdaglar and Tahbaz-Salehi (2012) for the reasoning for this value share definition, which also corresponds to the relevant entries in the input-output tables.

always at full employment, reallocation effects would by definition exactly offset direct and upstream and downstream effects so as to restore full employment. However, with imperfections in housing markets, distortions to labor supply from tax and transfer policies, or positive demand for leisure there is no guarantee that reallocation effects would be sufficient to restore employment to the same level that would have emerged in the absence of trade growth from China.

A yet third general equilibrium channel operates through *aggregate demand effects*, multiplying the negative direct and indirect effects of import growth from China. Through familiar Keynesian-type multipliers, domestic consumption and investment may be depressed, extending employment losses to sectors not otherwise exposed to import competition. A negative effect of increased import competition on aggregate demand necessarily requires that employment reallocation in response to a negative trade shock is incomplete, such that aggregate earnings decline and this decline is multiplied throughout the economy via demand linkages.⁶

Our second empirical strategy jointly estimates reallocation and aggregate demand effects by exploiting their operation in local labor markets, which we proxy by commuting zones that cluster U.S. counties according to cross-county commuting ties. If the reallocation mechanism is operative, then when an industry contracts in a commuting zone as a result of Chinese competition, some other industry in the same labor market should expand. Therefore, quantity adjustments can be studied from changes in employment in a given local labor market even though the price responses to increasing import competition are, at least in part, determined at the national or global level. In the neoclassical benchmark model, these reallocation effects will undo all of the direct employment losses from increased trade competition, though the same conclusion does not hold with realistic market imperfections. An important component of aggregate demand effects should also take place within local labor markets, as shown by Mian and Sufi (2013) in the context of the recent U.S. housing bust. If increased trade exposure lowers aggregate employment in a location, reduced earnings will decrease spending on non-traded local goods and services, magnifying the negative impact throughout the local economy. Aggregate demand effects also have a national component, which our approach does not capture. For example, some part of aggregate demand effects interact with monetary policy rules and future tax expectations, which operate mostly at the national level.

Empirically, our second strategy combines our focus on industries with Autor, Dorn and Hanson's (2013a) approach of exploiting changes at the level of local labor markets. In particular, we look at

⁶It is in theory possible for the aggregate demand effect to be positive; for instance, aggregate demand may increase because the aggregate price level declines as a result of the lower costs of imported products from China. We view this positive channel as second-order and in general presume that the aggregate demand effect, working in the standard Keynesian fashion, amplifies the potential negative direct impact of trade shocks.

changes in employment in commuting zones that have different levels of exposure to Chinese competition by virtue of differences in their initial pattern of industrial specialization. The reallocation effects should exhibit themselves in a greater expansion of non-exposed industries—meaning non-tradable industries as well as tradable industries not significantly exposed to trade with China—in local labor markets that have been more adversely affected by Chinese competition. Our estimates do find that this is the case qualitatively, though quantitatively the effects are small, and they are swamped by larger negative effects on exposed industries in harder hit local labor markets.

Our estimates of these (local) general equilibrium effects imply that import growth from China between 1999 and 2011 led to an employment reduction of 591,000 workers, inclusive of offsetting employed reallocation to non-exposed sectors, a figure that *exceeds* our national-level estimate of the direct disemployment effects of rising import exposure. Our interpretation is that the larger negative effects on exposed industries detected at the level of commuting zones partly reflect the negative aggregate demand effects working at the local level. At the same time, this estimate only partially incorporates the indirect effects working through input-output linkages, which operate at least in part at the national level and, as mentioned above, are estimated to contribute to a total of 1.3 million jobs lost. Thus, the direct plus industry linkage effects on employment, based on data from national industries, exceed the direct plus aggregate demand plus reallocation effects on employment, based on data from local labor markets. Because neither set of effects wholly encompasses the other and because our analysis of local general equilibrium finds only limited reallocation effects, especially compared to the competing local aggregate demand spillovers, the larger industry-level estimate of about 1.3 million jobs can be considered as our central (and still lower bound) estimate of jobs lost due to the rise in import competition from China. More conservatively, one could take the range of 591,000 to 1.3 million jobs lost as our range of estimates.

Our paper builds on Autor, Dorn and Hanson (2013a) but differs from it and others in this literature in important respects. Most significantly, our approach includes analysis at both the national industry level and the local labor market level. Autor, Dorn and Hanson (2013a) lack a national industry component to their analysis and when considering employment changes do not evaluate the mechanisms behind the transmission of shocks between sectors.⁷ We use the two levels of analysis—national industries and local labor markets—to compare trade-induced employment changes based on direct plus upstream and downstream effects, as seen in industry data, with

⁷In a complementary analysis, Autor, Dorn, Hanson and Song (2013) estimate long run impacts of exposure to China trade on individual workers based on their industry of employment in 1991, when China’s export surge began. This approach concentrates on the worker-level costs of adjusting to trade shocks rather than on equilibrium changes in industry employment.

estimates that incorporate reallocation and aggregate demand effects, as seen in local labor market data.

With its focus on the industry level, our paper is closest in spirit to Bloom, Draca and Van Reenen (2011) and Pierce and Schott (2012). The first of these combines country and industry-level analyses to estimate the impact of Chinese import competition on innovation and productivity in Europe. Pierce and Schott explore how China’s 2001 WTO accession affected U.S. manufacturing employment. Our paper, while complementary to theirs, differs in scope, in the time period studied, and in approach. We capture changes in China’s competitive position using the covariance between growing Chinese import penetration of the U.S. and other rich country product markets, while Pierce and Schott use tariff changes following WTO entry as a source of identification. Their strategy necessitates comparing contained time periods following U.S. business cycle peaks, whereas we are free to cover the entire two decade period centered on the onset of the U.S. employment sag. Our approach further lends itself to evaluating the transmission of trade shocks to non-manufacturing sectors, which expands on the manufacturing-only focus of Pierce and Schott’s analysis. Most importantly, our strategy also enables us to estimate the extent of reallocation and aggregate demand effects which operate in addition to the impact of input-output linkages.

In addition, our analysis also extends the literature on the labor market impacts of imports of intermediate inputs (e.g., Feenstra and Hanson, 1999; Ebenstein, Harrison, McMillan, and Phillips, 2013; Hummels, Jorgensen, Munch, and Xiang, 2013), which considers how offshoring affects the internal industry structure of production and employment. Our contribution is to explore the intersectoral transmission of trade shocks working through changes in the demand for inputs by manufacturing industries from other sectors and changes in the supply of inputs from manufacturing to the rest of the economy.

We begin in Section 2 by describing our empirical approach to estimate the effects of exposure to trade shocks and briefly discussing the data. Section 3 gives our primary OLS and 2SLS estimates of the impact of trade shocks on employment. Section 4 expands the analysis to include intersectoral linkages and considers additional labor market outcomes. Section 5 presents estimation results for data on local labor markets. Section 6 concludes.

2 Empirical approach

To motivate our analysis, consider the change in China’s export supply capacity in the last two decades. Rapid industrial productivity growth (Hsieh and Ossa, 2011; Zhu, 2012), rural to urban

migration flows in excess of 150 million workers (Li, Li, Wu, and Xiong, 2012), and massive capital accumulation (Brandt, Van Biesebroeck, and Zhang, 2012) permitted manufacturing production to expand at a breathtaking pace. What did this growth mean for U.S. employment inside and outside manufacturing? We seek to capture the changes in U.S. industry employment induced by shifts in China’s competitive position and the subsequent increase in its exports, accounting for input-output linkages between industries and other indirect channels of transmission. We subsequently consider how these labor demand shifts can be aggregated to national totals.

2.1 Industry Trade Shocks

Our baseline measure of trade exposure is the change in the import penetration ratio for a U.S. industry over the period 1991 to 2011, defined as,

$$\Delta IP_{j,\tau} = \frac{\Delta M_{j,\tau}^{UC}}{Y_{j,91} + M_{j,91} - E_{j,91}}, \quad (1)$$

where for U.S. industry j , $\Delta M_{j,\tau}^{UC}$ is the change in imports from China over the period 1991 to 2011 (which in most of our analysis we divide into two subperiods, 1991 to 1999 and 1999 to 2011) and $Y_{j,91} + M_{j,91} - E_{j,91}$ is initial absorption (measured as industry shipments, $Y_{j,91}$, plus industry imports, $M_{j,91}$, minus industry exports, $E_{j,91}$). We choose 1991 as the initial year as it is the earliest period for which we have the requisite disaggregated bilateral trade data for a large number of country pairs that we can match to U.S. manufacturing industries.⁸ The quantity in (1) can be motivated by tracing export supply shocks in China—due, e.g., to productivity growth—through to demand for U.S. output in the markets in which the United States and China compete. Trade models with a gravity structure, as in Arkolakis, Costinot and Rodriguez-Clare (2012), yield such a specification. Supply-driven changes in China’s exports will tend to reduce demand for U.S. industrial production. Over the period we consider, China’s ongoing transition from a centrally planned economy to a more market-oriented one contributed to a massive supply push in manufacturing, generating the country’s phenomenal export surge (Naughton, 2007; Hsieh and Klenow, 2009).

One concern about (1) as a measure of trade exposure is that observed changes in the import penetration ratio may in part reflect domestic shocks to U.S. industries that affect U.S. import demand. Even if the dominant factors driving China’s export growth are internal supply shocks, U.S. industry import demand shocks may still contaminate observed bilateral trade flows. To develop

⁸Our empirical approach requires data not just on U.S. trade with China but also on China’s trade with other partners. Specifically, we require trade data reported under Harmonized System (HS) product codes in order to match with U.S. SIC industries. The year 1991 is the earliest in which many countries began using the HS classification.

an instrumentation strategy, we observe that the supply-driven component of China’s export growth should be evident in the growth of its shipments to other high-income countries. To capture this supply-driven component in U.S. imports from China, we instrument for trade exposure in (1) with the variable,

$$\Delta IPO_{j\tau} = \frac{\Delta M_{j,\tau}^{OC}}{Y_{j,88} + M_{j,88} - X_{j,88}} \quad (2)$$

where $\Delta M_{j,\tau}^{OC}$ is the growth in imports from China during the period 1991 to 2007 in eight other high income countries excluding the United States.⁹ The denominator in (2) is initial absorption in the 1988 industry. The motivation for the instrument in (2) is that high income economies are similarly exposed to growth in imports from China that is driven by supply shocks in the country. The identifying assumption is that industry import demand shocks are weakly correlated across high-income economies.¹⁰

Appendix Figure 1 plots the value in (1) against the value in (2) for all U.S. manufacturing industries at the four digit level, as defined below, which is equivalent to the first-stage regression in our subsequent estimation without detailed controls. The coefficient is 0.98 and the t-statistic and R-squared are 7.0 and 0.62 respectively, indicating the strong predictive power of import growth in other high income countries for U.S. import growth from China.

Modeling the China trade shock as manifested in (1) does not exclude the role of global production chains. China’s export production relies to an important degree on imported intermediates. During the 1990s and 2000s, approximately half of China’s manufacturing exports were produced by export processing plants, which import parts and components from abroad and assemble these inputs into final export goods (Feenstra and Hanson, 2005). The importance of processing plants in China’s exports suggests that the country’s production may be limited to product assembly and other simple tasks. Because assembly occurs at the end of the production chain, the gross value of China’s exports thus likely overstates the actual value added in China. Recent evidence suggests, however, that the domestic content of China’s exports is both large and growing. Koopman, Wang, and Wei (2012) find that the share of domestic value added in China’s total exports rose from 50% in 1997 to over 60% in 2007. Even within the export processing sector, domestic value added rose from 32% of gross exports in 2000 to 46% in 2006 (Kee and Tang, 2012). Further, the reduction

⁹These countries are Australia, Denmark, Finland, Germany, Japan, New Zealand, Spain, and Switzerland, which represent all high income countries for which we can obtain disaggregated bilateral trade data at the Harmonized System level back to 1991.

¹⁰See Autor, Dorn and Hanson (2013a) for further discussion of threats to identification using this instrumentation approach.

in China’s trade barriers associated with its WTO accession have shifted exports away from export processing plants, which receive duty-free access to imported inputs, and toward “ordinary” exports, which embody much higher shares of domestic value added (Brandt and Morrow, 2013). Our instrumental variable strategy does not require that China is the sole producer of the goods it ships abroad; rather, we require that the growth of its gross manufacturing exports is driven largely by factors internal to China (as opposed to shocks originating in the United States), as would be the case if, plausibly, the recent expansion of global production chains involving China is primarily the result of its hugely expanded manufacturing capacity.¹¹

A related concern about our analysis is that we ignore U.S. exports to China, focusing exclusively on trade flows in the opposite direction. One rationale for our import focus arises from the magnitudes of the trade flows themselves. U.S. manufacturing imports from China are approximately five times U.S. manufacturing exports to China (Figure 2), making the former of much greater significance for U.S. labor market outcomes. As stated above, Autor, Dorn, Hanson and Song (2013) find little change in results when they replace the growth in China’s *gross* manufacturing imports with growth in its *net* manufacturing imports (U.S. imports from China minus U.S. exports to China), results that Autor, Dorn and Hanson (2013a) corroborate for commuting zones. A second rationale for our import focus is data constraints. Much of U.S. exports to China are in the form of indirect exports to China via third countries or embodied services of intellectual property, management expertise, or other activities involving skilled labor. These indirect and service exports are difficult to measure because the direct exporter may be a foreign affiliate of a U.S. multinational (e.g., the revenue stream resulting from Apple’s portfolio of technology patents flows largely to its subsidiary based in Ireland) and because they often occur via a chain of transactions involving multiple locations (e.g., Korea based Samsung Electronics imports chipsets from U.S. based Qualcomm for cellphones Samsung ultimately assembles in China and then exports to the rest of the world). Our empirical analysis misses the employment impacts of these hard-to-measure exports. As such exports tend to

¹¹To account for how complexities in global production may affect the transmission of trade shocks in China to U.S. industries, we refer the reader to the detailed analysis in Autor, Dorn, Hanson and Song (2013), who study the impact of industry-level trade shocks on the employment and earnings trajectories of affiliated workers. Their analysis develops six alternative measures of changes in import competition at the industry level, which they use alongside our principal measure in (1). These include (i) the change in import penetration from China calculated using the gravity model of trade, (ii) changes in import penetration due to trade with all low-wage countries and not just China, (iii) changes in import penetration due to China in all domestic and foreign markets that U.S. industries serve (and not just the U.S. market), (iv) changes in net imports (imports minus exports) from China, (v) changes in the net labor content of U.S. trade with China, and (vi) changes in import penetration due to China net of changes in imported intermediate inputs from China. They document that each of these six measures performs well in capturing industry-level trade shocks that are manifest in excess worker separations, mass layoffs, and firm closures, with the qualitative impacts of trade on labor-market outcomes being similar across these measures. In light of these results, we limit our focus in this paper to the import penetration measure in (1).

be intensive in highly skilled labor, they may have only modest direct impacts on the employment of production workers—though their indirect impacts are difficult to gauge with available data.

2.2 Data sources

Data on international trade for 1991 to 2011 are from the UN Comtrade Database,¹² which gives bilateral imports for six-digit HS products. To concord these data to four-digit SIC industries, we first apply the crosswalk in Pierce and Schott (2009), which assigns 10-digit HS products to four-digit SIC industries (at which level each HS product maps into a single SIC industry), and aggregate up to the level of six-digit HS products and four-digit SIC industries (at which level some HS products map into multiple SIC industries). To perform the aggregation, we use data on US import values at the 10-digit HS level, averaged over 1995 to 2005. The crosswalk assigns HS codes to all but a small number of SIC industries. We therefore slightly aggregate the 4-digit SIC industries so that each of the resulting 397 manufacturing industries matches to at least one trade code, and none is immune to trade competition by construction. To ensure compatibility with the additional data sources below, we aggregate together a few additional industries such that our final data contains 392 manufacturing industries. All import amounts are inflated to 2007 US\$ using the Personal Consumption Expenditure deflator.

Our main source of data on U.S. employment is the County Business Patterns for the years 1991, 1999, 2007 and 2011. CBP is an annual data series that provides information on employment, firm size distribution, and payroll by county and industry. It covers all U.S. employment except self-employed individuals, employees of private households, railroad employees, agricultural production employees, and most government employees.¹³

To supplement the employment and establishment count measures available from the CBP, we utilize the NBER-CES Manufacturing Industry Database for the years 1971 through 2009 (the latter being the latest year available).¹⁴ These data allow us to explore labor market outcomes not reported in the CBP, as well as to perform a falsification exercise not possible in the CBP. We additionally draw on the NBER-CES data to compute measures of the production structure in each industry,

¹²See <http://comtrade.un.org/db/default.aspx>.

¹³CBP data is extracted from the Business Register, a file of all known U.S. companies that is maintained by the U.S. Census Bureau; see <http://www.census.gov/econ/cbp/index.html>. The CBP does not disclose information on individual employers, and to preserve confidentiality, information on employment by industry is sometimes reported as an interval instead of an exact count. We compute employment in these cells using the fixed-point imputation strategy described in Autor, Dorn and Hanson (2013a).

¹⁴A joint effort between the National Bureau of Economic Research (NBER) and U.S. Census Bureau's Center for Economic Studies (CES), the NBER-CES database contains annual industry-level data from 1958-2009 on output, employment, payroll and other input costs, investment, capital stocks, TFP, and various industry-specific price indexes. Data and documentation are at <http://www.nber.org/data/nberces5809.html>.

subsequently used as controls, including: production workers as share of total employment, the log average wage, the ratio of capital to value added, computer investment as share of total investment, and high-tech equipment as share of total investment. Additionally, we create industry pre-trend controls for the years 1976 through 1991, including the changes in industry log average wages and in the industry share of manufacturing employment.

A final data source used in our analysis is the U.S. Bureau of Economic Analysis 1992 input-output table for the U.S. economy, which we use to trace upstream and downstream demand linkages between industries both inside and outside of U.S. manufacturing.¹⁵ We discuss our application of input-output tables in more detail below.

3 Initial employment estimates

We start off the analysis by estimating the direct effect of trade exposure on employment in U.S. manufacturing industries over the period 1991 through 2011 using a set of simple bivariate regressions. We then expand the set of covariates and explore additional outcome measures.

3.1 Baseline Results for National Industries

We begin by fitting models of the following form:

$$\Delta L_{j\tau} = \alpha_\tau + \beta_1 \Delta IP_{j\tau} + \gamma X_{j0} + e_{j\tau}, \quad (3)$$

where $\Delta L_{j\tau}$ is 100 times the annual log change in employment in industry j over time period τ ; $\Delta IP_{j\tau}$ is 100 times the annual change in import penetration from China in industry j over period τ as defined in (1); X_{j0} is a set of industry-specific start of period controls (specified later); α_τ is a period specific constant; and $e_{j\tau}$ is an error term. We fit this equation separately for stacked first differences covering the two subperiods 1991-1999 and 1999-2011, where in some specifications we shorten the second subperiod to 1999-2007 in order to evaluate employment impacts prior to the onset of the Great Recession. Variables specified in changes (denoted by Δ) are annualized since equation (1) is estimated on periods of varying lengths. Additionally, the elements in the vector of controls X_{j0} , when included, are each normalized with mean zero so that the constant term in (1) reflects the change in the outcome variable conditional only on the variable of interest, $\Delta IP_{j\tau}$. Most outcome variables are measured at the level of 392 four-digit manufacturing industries, while later models estimate spillovers to 87 non-manufacturing sectors. Regression estimates are weighted by

¹⁵These data are at http://www.bea.gov/industry/io_benchmark.htm.

start-of-period industry employment, and standard errors are clustered at the 3-digit industry level to allow for unspecified error correlations within larger industries over time.¹⁶

Table 1 summarizes the import exposure and employment variables used in initial estimates of equation (1). The employment-weighted mean industry saw Chinese import exposure rise by 0.5 percentage points per year between 1991 and 2011, with far more rapid penetration during 1999 through 2007 than during 1991 through 1999: 0.8 versus 0.3 percentage points, respectively. Growth from 2007 to 2011, at 0.3 percentage points per year, indicates a marked slowdown in import expansion in the late 2000s. Slowing during that period is the combined effect of a steep decline in U.S. trade in 2008 and 2009 and an equally dramatic recovery in trade flows in 2010 (Levchenko, Lewis, and Tesar, 2011), which together left import penetration rates only modestly higher.¹⁷

Changes in import penetration are highly right-skewed across manufacturing industries, with the mean increase exceeding the median by a factor of 3.6. We find a similar pattern of import penetration change and skewness in the eight other high income countries used to construct the import penetration instrument. Skewness reflects China’s strong comparative advantage in labor-intensive manufacturing, including apparel, consumer electronics (e.g., assembly of computers and cellphones), footwear, furniture, and children’s toys. Manufacturing decline accelerated throughout the sample: the average industry contracted by 0.3 log points per year between 1991 and 1999, by 3.6 log points per year between 1999 and 2007, and by 5.7 log points per year in the final period 2007 to 2011. The within-industry growth rate of non-manufacturing employment also slowed across the three subperiods of our sample, but the deceleration was not nearly as pronounced as in manufacturing.

Table 2 presents a simple stacked first-difference model for the two time periods, 1991-1999 and 1999-2011, with no covariates beyond the change in import penetration and a time dummy. Alongside these estimates, we also present results separately for the three subperiods 1991-1999, 1999-2011, and 1999-2007, which permit inspection of results before and after the commencement of the 2000 U.S. employment sag, and a comparison of results for the 2000s with and without including

¹⁶There are 135 three-digit manufacturing industry clusters encompassing the 392 four-digit industries. Because our non-manufacturing data have already been extensively aggregated to 87 sectors for concordance with the BEA input-output table, we do not additionally cluster standard errors among these sectors and each of the 87 non-manufacturing sectors is treated as a single cluster.

¹⁷The behavior of international trade during the Great Recession is the subject of an active literature. Explanations for the excess sensitivity of trade flows during the crisis include the exposure of international trade to credit market shocks through its strong dependence on trade finance (Amiti and Weinstein, 2011; Chor and Manova, 2012), especially when trade involves substantial flows of intermediate inputs through global production networks (Levchenko, Lewis, and Tesar, 2011). Other explanations dwell on the consequences of the relatively large drop in durable good spending during the crisis, given that durable goods account for a relatively large share of overall trade flows (Eaton, Kortum, Neiman, and Romalis, 2011).

the Great Recession years. We also present results for the single long time difference, 1991-2011, for comparison against the stacked first differences.

In column 1, which excludes the import penetration variable, the time dummy reflects the (employment-weighted) mean annual within-industry change in employment. Column 2 adds the observed import exposure measure without instrumentation. This variable is negative and highly significant, consistent with the hypothesis that rising import penetration lowers domestic industry employment. Nevertheless, we would not expect this OLS point estimate to be consistent. If, plausibly, growth in import penetration is driven partly by outward shifts in domestic demand for industry output, this will tend to cause domestic employment and foreign imports to grow simultaneously, which will bias the OLS point estimate towards zero. Column 3 mitigates this simultaneity bias by instrumenting the observed change in industry import penetration with changes in other-country China imports as outlined above. The point estimate of -1.30 implies that a one percentage point rise in industry import penetration reduces domestic industry employment by 1.3 percentage points (t-ratio of 3.2).

The remaining columns of Table 2 present bivariate estimates of this relationship separately by subperiod. The coefficient on trade exposure is statistically significant in all time periods, being largest in absolute value for 1991 to 1999 and smallest for 1999 to 2007. Even though the sensitivity of employment to import penetration is greater before 2000, the much faster growth in China's imports after 2000 produces an overall impact of trade on employment that, as we discuss below, is much greater in the latter period. The sensitivity of employment to trade from 1999 to 2011 is similar to the estimate for 1999 to 2007, despite the onset of the global financial crisis in 2007 and the associated dislocation of worldwide trade patterns.¹⁸

A simple long-difference model for the change in manufacturing employment over the full 1991 through 2011 period (column 7) also supports a well-determined negative relationship between import penetration and U.S. manufacturing employment. The coefficient estimates in column 3, for the stacked first differences, and column 7, for the long time difference, are quite similar, reflecting strong persistence in the growth in China's import penetration within industries. Replacing stacked first differences with the long difference may remove cyclical variation in the data, accounting for the mildly larger coefficient estimates in the latter case.

¹⁸Globally, trade fell by 30 percent relative to GDP between 2007 and 2009 (Eaton, Kortum, Neiman, and Romalis, 2011). In the United States, imports plus exports divided by GDP fell by a stunning 22% from the first quarter of 2008 to the first quarter of 2009. However, imports fully recovered in 2010 and continued to grow in 2011. The exaggerated cyclical swings in trade surrounding the Great Recession thus mix with the continued secular growth in China's exports to the United States over the period.

3.2 Controlling for Industry Confounds and Pre-trends

An obvious challenge for our analysis is that industries subject to greater import competition may be exposed to other economic shocks that are correlated with China trade. We begin to address this concern in Table 3 by incorporating extensive controls for potential industry confounds. Additionally, we offer falsification tests, described below.

We consider three groups of variables that proxy for different potential confounds. A first set addresses sectoral skill intensity. The sectors with the largest increase in Chinese import exposure from 1991 to 2011 were those intensive in the use of production workers, as would be expected given China’s comparative advantage in labor intensive goods. These sectors include toys, sports equipment, and other products; apparel, leather (footwear), and textiles; and furniture and wood products. Also exposed is machinery, electrical machinery, and electronics, reflecting China’s large global role in final assembly of consumer electronics. The least exposed sectors include food products, beverages and tobacco, chemical and petroleum products, and transportation equipment. The latter group makes intensive use of natural resources (land, oil reserves) or physical capital, which China has in scarce supply.¹⁹ To account for cross-sector heterogeneity, the first set of controls added to the specifications in Table 3 is a set of indicator variables designating ten manufacturing sectors. These sectors are chosen to consist of industries that have relatively similar production-worker employment shares.²⁰ Their inclusion means that the regression identifies the industry-level impacts of trade exposure using variation in import growth among industries with more similar skill intensities.

In recent decades, technological progress within manufacturing has been most rapid in computer and skill intensive sectors (Doms, Dunne, and Troske, 1997; Autor, Katz, and Krueger, 1998). To capture the extent to which industries are exposed to technical change, we add a second set of control variables, drawn from the NBER-CES database, measuring the intensity of their use of production labor and capital. These variables, summarized in Appendix Table 1, include the share of production workers in total employment, the log of the average wage, the ratio of capital to value added (all measured in 1991), as well as computer and high-tech equipment investment in 1990, each expressed as a share of total 1990 investment.

U.S. manufacturing as a *share* of employment has been in decline since the 1950s, and the level of manufacturing employment has also been on a downward trend since the 1980s. This longstanding secular trend highlights a concern that the correlation we document between rising industry trade penetration and contemporaneous, within-industry declines in manufacturing employment during

¹⁹Despite these sectoral contrasts, Autor, Dorn, Hanson and Song (2013) document that there remains wide variation in the change in industry import penetration *within* broad sectors defined by production worker intensity.

²⁰Sector indicators are de-meant so as not to change the interpretation of the constant.

1991 through 2011 could potentially predate the recent rise in import exposure. In that case, our estimates would likely overstate the impact of trade exposure in the current period. We therefore add measures of pre-trends in industry employment and earnings in Table 3, specifically the change in the industry’s share of U.S. employment, and the change in the log of the industry average wage, both measured over the interval 1976 to 1991 (Appendix Table 1).

The seven columns of Table 3 permute among combinations of these three groups of industry controls: sector indicators, industry-level controls for production structure, and industry-level controls for pre-trends. Column 1 replicates results from column 3 of Table 2, to serve as a benchmark. Among the additional groups of covariates, only one has a substantial impact on the point estimates: accounting for broad sector dummies reduces the estimated relationship between (instrumented) import penetration and employment by about 40 percent. We infer that growth in import exposure is correlated with broader sectoral trends that are in turn absorbed by the sector dummies. With these sector dummies included, the Table 3 models indicate that neither the production nor the pre-trend variables has any appreciable effect on the magnitude or precision of the coefficient of interest. Inclusion of sector dummies also markedly increases the precision of the import penetration coefficient, so significance is essentially unaffected by adding these many controls (this is also the case when all controls are included simultaneously in column 7).²¹

As a further robustness test, Appendix Table 2 summarizes a simple falsification exercise in which we regress changes in industry employment in earlier decades of manufacturing data on the instrumented change in industry import exposure during the 1991 through 2011 period. It would be problematic for our identification strategy if *future* growth in Chinese import exposure predicted industry employment declines in the era *prior* to China’s trade opening.²² The estimated relationship between our China trade exposure measure and industry employment is statistically insignificant and close to zero in both the 1970s and 1980s (1971–1981 and 1981–1991). The point estimate only becomes economically large and statistically significant after 1990. This pattern of results is consistent with the hypothesis that the within-industry correlation between rising import penetration

²¹In unreported results, we explore the consistency of these estimates among three time intervals: 1991 to 2011, 1999 to 2007, and 1999 to 2011. Across all time periods and among all specifications with sector dummies included, we find a consistently precise and highly robust point estimate for the impact of import exposure on industry employment on the order of -0.7 , meaning that a one percentage point rise in import penetration is found to reduce industry employment by approximately seven-tenths of one percent.

²²To carry the analysis back to 1971, we employ the NBER-CES data, which covers a longer time horizon than the County Business Patterns data that it used in our main estimates. A disadvantage of the NBER-CES database is that it is currently only updated through 2009, which is two years less current than the CBP. To improve comparability, we use the NBER data in *all* columns of Appendix Table 2, including for the post-1990 period (unlike in Tables 2 and 3, where we use CBP data). The Appendix Table 2 regressions also include 10 broad sector dummies since the Table 3 estimates suggest that they may address an important confound. These estimates also differ from those in Tables 2 and 3 in that the import exposure variable corresponds to the long 1991–2011 change in all columns.

and declining manufacturing employment in the 1990s and 2000s emanates from contemporaneous trade shocks rather than longstanding factors driving industry decline, whose origin predates these shocks.

Returning to the results in Table 3, we develop a sense of the economic magnitude of these estimates by constructing counterfactual changes in employment that would have occurred absent increases in import penetration from China. That is, we compare the actual level of manufacturing employment in a given year with the level that our estimates imply would have obtained with zero subsequent growth in Chinese imports, either from 1991 forward or 1999 forward. Using equation (3), we write the difference between actual and counterfactual manufacturing employment in year t as

$$\Delta L_t^{cf} = \sum_j L_{jt} \left[1 - e^{-\hat{\beta}_1 \Delta IP_{jt}} \right] \quad (4)$$

where $\hat{\beta}_1$ is the 2SLS coefficient estimate from (3) and ΔIP_{jt} is the observed increase in import penetration from China for industry j between 1991 (or 1999) and year t .²³ In constructing these counterfactuals we assume that all other factors, including observed covariates and unobserved shocks captured by the error term in (3), would be unaffected by the artificially imposed reduction in the growth of import penetration from China.

Table 7 reports counterfactual employment differences implied by the specifications in Table 3 (as well as those for subsequent tables), where we evaluate changes for 1991 to 1999, 1999 to 2011, and the entire 1991 to 2011 time frame. Using coefficient estimates from column 2, which include controls for the 10 manufacturing sectors, had import penetration from China remained unchanged between 1991 and 2011, manufacturing employment would have fallen by 429,000 fewer jobs over the full 1991 to 2011 span, and by 284,000 fewer jobs during the employment sag era of 1999 to 2011. Observed manufacturing employment changes over these time periods were minus 5.6 million workers (11.4 million - 17.0 million) and minus 5.8 million workers (11.4 million - 17.2 million), respectively. The larger quantity for the second period is indicative of the modest growth in manufacturing employment of 200,000 workers that occurred between 1991 and 1999. By shutting down China's

²³Following Autor, Dorn and Hanson (2013a), we discount the coefficient estimate used in (4) to account for the fact that the *observed* growth in import competition from China includes components that from the perspective of the U.S. industry are exogenous (e.g., growth in China's exports to the United States that result from exogenous enhancements in its TFP) and components that are endogenous (e.g., growth in China's U.S. exports that result from U.S. product demand shocks). We wish to include the former and exclude the latter from (4). To determine the appropriate coefficient "discount" we take the partial R squared from the first stage regression of (1) on the instrument in (2), with no other variables in the regression. This value is 0.62, which we multiply by $-\hat{\beta}_1$ in our application of (4).

import growth, the contraction of U.S. manufacturing employment suggested by our estimates would have been 7.7 percentage points smaller over 1991 to 2011, and 4.9 percentage points smaller for the period after 1999. These counterfactual employment changes are those associated with the *direct* effects of import competition from China on the affected industries. They thus exclude the effects operating through intersectoral linkages, reallocation or aggregate demand spillovers. We subsequently evaluate all three of these general equilibrium effects.

How do our estimates of the direct effect of import competition on manufacturing employment compare with those found the literature? In truth, there are relatively few estimates to consider, as the vast majority of work on the labor-market implications of globalization addresses how trade affects the relative wages and the relative employment of workers by skill level (e.g., Harrison, McLaren, and McMillan, 2011). Trade impacts on *absolute* employment levels are a less common object of study, perhaps reflecting modeling conventions that impose inelastic labor supply and full employment.

In one of the first treatments of how U.S. manufacturing has fared in response to import competition from China, Bernard, Jensen, and Schott (2006) estimate that import penetration from low-income countries (with China being the largest member of this group by far) accounts for 14% of the total decline in manufacturing employment of 675,000 workers that occurred between 1977 and 1997.²⁴ Their specification differs from ours, making a direct comparison of the two sets of results difficult to perform. In particular, they regress the change in log employment at the level of the manufacturing *plant* (rather than industry) on the initial *level* (rather than change) of the *share* of low income countries in industry imports (rather than the import penetration rate). Despite these differences, it would appear to be the case that Bernard, Jensen, and Schott find a relatively high sensitivity of employment to import competition. Over their period of study, the annual increase in import penetration from low income countries in U.S. manufacturing was only 0.09 percentage points,²⁵ whereas over our sample period the annual increase in import penetration from China alone was 0.50 percentage points (Table 1). Had their much lower level of import growth obtained over our sample period, the reduction in manufacturing job loss implied by our coefficient estimates would have been only one-fifth as large.²⁶ One reason why our approach may produce comparatively low

²⁴In related work, Artuc, Chaudhuri, and McLaren (2010) evaluate how costs to workers of moving between sectors dampens the employment response to changes in trade barriers and Muendler and Becker (2010) and Harrison and McMillan (2011) estimate the responsiveness of employment in multinational companies to changes in foreign wages. This work, and related studies, tends to emphasize the elasticity of employment with respect to changes in trade barriers or foreign production costs, rather than producing estimates of aggregate impacts of foreign competition on employment.

²⁵This figure comes from information provided in Table 2 of Bernard, Jensen, and Schott (2006).

²⁶This ratio is based on the calculation, $(1 - e^{-0.75 \times .09}) / (1 - e^{-0.75 \times .50}) = 0.21$, where the value -0.75 is the coefficient from column 2 of Table 3.

sensitivity of employment to imports is that our data are aggregated to the industry level, whereas Bernard, Jensen, and Schott's are at the plant level. Aggregating across plants within an industry effectively allows for within-industry reallocation to occur, as some workers may exit declining plants to take jobs with establishments in their same sector, as found by Autor, Dorn, Hanson and Song (2013). The presence of within industry reallocation effects would tend to generate employment responses to imports that are weaker at the industry level than at the plant level.

A second important study on the employment effects of Chinese trade is Pierce and Schott (2012). Their paper explores whether manufacturing employment growth after 2001 (a business cycle peak year) is low relative to employment growth following previous business cycle peaks (in 1981 and 1990) for plants that faced a larger potential increase in import competition from China. They measure this potential increase in China trade using the difference between the U.S. MFN (most favored nation) tariff and the U.S. non-MFN tariff—to which China was potentially subject prior to becoming a WTO member and whose level was substantially higher than the mean MFN duty. Pierce and Schott thus identify the growth in China trade after 2001 using the notional reduction in U.S. trade barriers confronting China. The complication with this approach is that the U.S. granted China MFN status on a renewable basis in 1980, two decades prior the country's WTO accession. The U.S. non-MFN tariff is only a meaningful predictor of China's pre-2001 trade to the extent that there was a genuine risk the U.S. government would choose not to renew China's MFN privileges, an eventuality that never materialized (though it could have in theory). Pierce and Schott's estimate that China's WTO accession reduced U.S. manufacturing employment by 17.8 log points between 2001 and 2007. Our estimates, which identify the impact of growth in China's imports based on the common component of the country's export expansion across high-income markets, imply that had there been no increase in import penetration from China after 1999, the 2011 level of employment would have been 2.5 percentage points higher (284,000/11,400,000) than it otherwise would have been. Comparing our results summarized in Tables 2 and 3 to Bernard, Jensen, and Schott (2006) and to Pierce and Schott (2012) suggests that our estimates for the direct industry-level employment effects of China trade are if anything on the low side.

3.3 Additional Labor Market Outcomes

We have so far focused exclusively on the effects of trade exposure on industry employment. Numerical employment is only one margin along which industries may adjust, however. Others may include the wage bill, establishment size, establishment shutdown, and production versus non-production employment and earnings. Studying the effects of greater trade or exposure on these additional

labor market outcomes is also useful as a reality check on our employment results. Employing a combination of CBP and NBER-CES data, we explore these outcomes for manufacturing in Table 4.

Many of the results in Table 4 are in line with expectations, given our findings on how import penetration affects employment in Tables 2 and 3. Stronger import competition reduces the count of establishments (column 2), average employment per establishment (column 3), and total industry wage payments (column 4). Production employment (column 6) declines slightly more than non-production employment (column 7), indicating a larger sensitivity to Chinese import competition on the part of lower skilled labor, a result consistent with China’s strong comparative advantage in labor-intensive sectors.

The table also contains some informative surprises. Trade exposure predicts a *rise* in real industry log wages for production workers (column 8)—that is, the real production worker wage bill divided by the production worker headcount. The impact on non-production workers (column 9) is negative but small and not statistically significant. Joining these two effects produces the positive but insignificant coefficient estimate for average real wages (column 5). The results for production workers that combine strongly negative employment effects and mildly positive average wage effects are suggestive of trade-induced changes in the composition of employment. Less highly paid workers may be those most likely to be laid off within the subgroup of production employees, leading to an upward shift in wages among those still employed as a result of unobserved changes in composition. This interpretation is consistent with Autor, Dorn, Hanson, and Song’s (2013) finding that lower wage workers are the most adversely affected by greater import competition.

4 Accounting for sectoral linkages

A contribution of our paper is that we are able to explore both the direct and the indirect effects of trade shocks on industry employment, the latter of which accrue in part through sectoral linkages that connect manufacturing industries to both other manufacturing industries and to non-manufacturing industries.²⁷ For example, the chemical and fertilizer mining industry—which is in non-manufacturing—sells 85% of its output to the manufacturing sector. Its largest single manufacturing customer is the phosphatic fertilizer industry, which accounts for 26% percent of its sales. Similarly, the iron and ferroalloy ores industry sells 92% of its output to the manufacturing sector,

²⁷Pierce and Schott (2012) also examine upstream and downstream linkages within manufacturing. An important feature of the current paper is that we measure the impact of these linkages outside of manufacturing as well, whereas they consider only linkages within manufacturing.

two thirds of which goes to the blast furnace and steel mill industry. Accordingly, a shock to the demand for a given domestic manufactured good may indirectly impact demand for, and reduce employment in, industries that supply inputs to the affected industry, which typically includes both manufacturing and non-manufacturing sectors. We refer to such linkages as a *downstream trade shock*, which affects an industry through import competition in sectors that are located downstream to it in input-output space.

Conversely, a trade shock to the suppliers of a given industry (e.g., the upstream suppliers of tires to the automobile industry) may also affect the industries that are its customers. This effect is generally ambiguous. On the one hand, from the perspective of purchasing industries, the trade shock—by expanding input supply and putting downward pressure on input prices—may constitute a decline in the cost of purchased inputs, and thus would tend to expand employment in the industries that consume these inputs (Goldberg, Khandelwal, Pavcnik and Topalova, 2010).²⁸ On the other hand, the trade shock may destroy existing long-term relationships for specialized inputs as domestic input suppliers are driven out of business, thus creating a force towards contraction in the industries that were their customers. We refer to such linkages as an *upstream trade shock*, as an industry is affected by import competition in the industries that are located upstream to it in the production chain.

To study these inter-industry linkages, we envisage an economy along the lines of that studied by Long and Plosser (1982) and Acemoglu, Carvalho, Ozdaglar and Tahbaz-Salehi (2012), where each industry uses with different intensities the output of other industries as inputs. We apply this methodology to the Bureau of Economic Analysis’ input-output table for 1992. We choose the 1992 input-output table since it largely predates the China trade shock and hence the linkages observed there are unlikely to be endogenous to the subsequent shock. To estimate the change in import penetration that a given industry faces due to linkages with its *downstream* buyers, we calculate the following quantity for each industry j ,

$$\Delta IP_{j\tau}^D = \sum_g w_{gj}^D \Delta IP_{g\tau}, \quad (5)$$

which is equal to the weighted average change in import penetration during time interval τ across

²⁸Consistent with this reasoning, De Loecker, Goldberg, Khandelwal, and Pavcnik (2012) find substantial negative domestic product price effects from trade liberalization in India and Goldberg, Khandelwal, Pavcnik, and Topalova (2010) document that greater availability of imported intermediate inputs is associated with more rapid introduction of new product varieties by domestic firms, also in the Indian context.

all industries g that purchase from industry j . These weights w_{gj}^D are defined as

$$w_{gj}^D = \frac{\mu_{gj}^U}{\sum_{g'} \mu_{g'j}^U}, \quad (6)$$

where μ_{gj}^U is the 1992 “use” value in the BEA input-output matrix for the value of industry j 's output purchased by industry g , such that the weight in (6) is industry g 's share of total inputs purchased from industry j . Thus, (5) is a weighted average of the trade shocks faced by the downstream purchasers' of j 's output.²⁹ When industry j 's purchasers—that is, its downstream buyers—suffer a negative trade shock they are likely to reduce demand for j 's output. Similarly, to compute the upstream shock faced by each industry j —that is, the average of the trade shocks faced by the industries from which j purchases inputs—we make the same calculation after reversing the j and g indexes in the input-output table. We instrument both the upstream and downstream trade shocks analogously to our main import shock measure: using contemporaneous changes in China imports in eight other high income countries to calculate *predicted* upstream and downstream shocks for each industry, where these predictions serve as instruments for the measured domestic values.

Upstream and downstream exposure measures are summarized in Appendix Table 3. As expected, the indirect exposure measures are substantially smaller in magnitude, and have far less cross-industry variation, than the direct exposure measures. In the average manufacturing industry, the direct trade shock is five times larger than the upstream shock and over three times larger than the downstream shock.

Table 5 presents instrumental variables estimates of the effects of import exposure on industry employment akin to those in column 2 (without broad sector dummies) and column 7 (with broad sector dummies) from Table 3, here augmented with the upstream and downstream import exposure measures, $\Delta IP_{j\tau}^D$ and $\Delta IP_{j\tau}^U$. We present results with and without the ten manufacturing sector dummies introduced earlier. We exclude the industry production and pre-trend controls used in Table 3 since these were shown to have little effect conditional on sector dummies—but they do absorb degrees of freedom, which is problematic in a setting with three instrumented endogenous variables that are themselves correlated.

Columns 1-4 in Table 5 consider the impact of upstream and downstream linkages on employ-

²⁹Since our *direct* shock variable only reflects manufacturing trade, all downstream shocks to a sector emanate by definition from shocks to their downstream manufacturing purchasers. These shocks affect both manufacturing and non-manufacturing industries to the degree that they supply inputs to manufacturers g that are directly shocked. Similarly, upstream shocks—that is, shocks to the suppliers of goods to a given sector—emanate from trade shocks to these industries' *manufacturing* sector suppliers, though again both manufacturers and non-manufacturers may have upstream suppliers in manufacturing.

ment in the 392 manufacturing industries; columns 5-7 consider these impacts on employment in the 87 non-manufacturing industries; and columns 8-11 present results for manufacturing and non-manufacturing pooled together. All regressions use the stacked first differences specification, encompassing the time periods 1991 to 1999 and 1999 to 2011. For manufacturing industries, upstream industry effects are never statistically significant and further are unstable in sign, showing up as negative when excluding downstream linkages in the regression (column 1) and positive with the downstream effects are added (column 3). Upstream effects are also imprecisely estimated for non-manufacturing industries (columns 5 and 7) and for manufacturing and non-manufacturing industries pooled together (columns 8 and 10).³⁰ The imprecision of the upstream effects may be a consequence of their being an aggregate of reduced supply emanating from domestic U.S. manufacturing industries curtailing their delivery of inputs to customers because of increased import competition and the increased availability of foreign input supply. Given the instability of effects working through upstream linkages, we focus our attention on the downstream effects, which in contrast to the upstream case are stable across specifications and are qualitatively similar in impact for manufacturing and non-manufacturing sectors.

Consistent with our reasoning above, growth in an industry’s downstream trade exposure is found to reduce industry employment. For manufacturing industries alone, the downstream linkage effect is quite large without broad sector dummies in the regression (column 2), and of similar magnitude as the direct trade shock and more precisely estimated when sector dummies are added in column 4. For non-manufacturing industries, downstream linkages are also negatively and statistically significant, while being larger in magnitude (column 6). Pooling manufacturing and non-manufacturing together, coefficients on downstream linkages are negative and statistically significant either with (column 11) or without (column 9) broad sector dummies included in the regression.³¹

Quantitatively, accounting for downstream linkages substantially increases the impact of trade shocks on employment. Using estimates from the regression that pools manufacturing and non-manufacturing together and that controls for broad sector dummies (column 11), we evaluate the counterfactual change in employment analogous to the exercise in equation (4), again shown in Table 7. This new exercise combines the employment impacts of trade shocks working through direct effects and indirect effects associated with downstream linkages. Had import penetration

³⁰Note that there is no ‘direct’ trade exposure effect in non-manufacturing since our trade measures are confined to manufactured goods.

³¹The non-manufacturing estimates do not include sector dummies (unlike the manufacturing estimates) since our non-manufacturing industry scheme is already highly aggregated and, moreover, does not collapse down readily to a 1 or 2 digit scheme since we had to extensively modify the SIC to concord it with the input-output scheme used by the BEA.

from China remained unchanged between 1991 and 2011, our estimates imply that there would have been 938,000 additional workers employed in manufacturing and 733,000 additional workers employed in non-manufacturing, for a total employment gain of 1.7 million workers. Examining just the 1999 to 2011 period, the corresponding counterfactual employment additions are 657,000 in manufacturing and 597,000 in non-manufacturing, for a total of 1.3 million additional workers employed. These combined direct and indirect effects of trade exposure are substantially larger than the direct effects alone, which naturally are only present in manufacturing. To recap earlier results, the counterfactual employment gains from direct trade effects are 429,000 workers for 1991 to 2011, and 284,000 workers for 1999 to 2011. Thus, accounting for downstream linkages more than doubles the estimated employment effects for the manufacturing sector.

5 Local General Equilibrium Effects of Trade on Employment

As explained above, the estimates presented so far include the direct effect of rising import competition from China and its indirect (“general equilibrium”) effect working through input-output linkages. However, they exclude other general equilibrium impacts, in particular, reallocation and aggregate demand effects. The *reallocation effect* corresponds to the standard reallocation of factors of production away from industries experiencing declining relative prices towards others. The *aggregate demand effect* captures the impact of Keynesian-type multipliers operating through local or national shifts in consumption and investment.

On a priori grounds, both of these effects could be of the same order of magnitude as, or even larger than, the direct and indirect effects we have focused on so far. In a full-employment neoclassical economy, the reallocation effect will necessarily be of the same order as the direct and indirect effects, as ultimately full employment will be restored by the expansion of other sectors. Naturally, this reallocation effect will tend to offset the estimated industry-level employment losses stemming from rising Chinese import competition. Conversely, the aggregate demand effect will tend to amplify the direct effects, and may be large if employment and earnings are significantly depressed in heavily trade-exposed locations, as suggested by the results on local labor markets in Autor, Dorn and Hanson (2013a).

5.1 Empirical approach

In this section, we attempt to quantify the reallocation and aggregate demand effects. Since our industry-level analysis focuses on the behavior of some industries relative to others, it compares

relative employment among industries with differing levels of trade exposure and is not well-suited to identifying these aggregate general equilibrium impacts. We therefore turn to an alternative strategy, focusing on the implications of rising import competition from China on local labor markets. Following Autor, Dorn, and Hanson (2013a), we will examine local labor markets at the level of commuting zones.

Consider reallocation effects first. Local labor markets are a plausible unit of analysis for the study of this channel. If a particular commuting zone experiences a loss of jobs when local industries contract in response to rising import competition, there should be an adjustment of quantities *within the same labor market*, despite the fact that prices are, at least in part, determined in the national or the international equilibrium. If the extent of worker migration between local labor markets in response to these labor market shocks is modest, as suggested by the evidence in Autor, Dorn and Hanson (2013a) and Notowidigdo (2013), this adjustment will take the form of reallocation from declining industries to others within this locale.³²

An important component of aggregate demand effects also plausibly takes place within local labor markets. Mian and Sufi (2013), for instance, show that during the Great Recession, U.S. counties suffering large wealth losses because of particularly severe declines in housing values also saw large declines in employment, consistent with local transmission of shocks to aggregate demand. Components of the aggregate demand effect that operate at the national level will not be captured by our analysis as they will be common across locations.

Our empirical strategy seeks to identify the combined impact of reallocation and aggregate demand effects by quantifying how trade-induced shocks impact a commuting zone's employment in *non-exposed industries*—defined as industries that are not exposed to imports from China either through direct product market competition or through inter-industry purchases of intermediate inputs.

To see the logic of this approach, consider a simplified setting in which each commuting zone houses up to three sectors that, notionally, have no input-output linkages: toys, footwear, and construction. Toys and footwear experience a (non-trivial) increases in imports from China, so we label these sectors as *exposed*. Construction does not experience this shock and we label it *non-exposed*. If a particular commuting zone has many workers employed in toys prior to the rise of import competition from China, it will experience significant worker displacement as this sector

³²Autor, Dorn and Hanson (2013b) study the impact of trade and technology shocks on employment by sector and occupation, as well as on unemployment and non-participation at the level of local labor markets. Different from their analysis, the innovation of this section is to use the distinction between exposed and non-exposed sectors to estimate general equilibrium effects, and to incorporate input-output linkages to correctly trace out the degree of exposure among sectors.

contracts.³³ Due to the reallocation effect, we would expect displaced workers to gain employment in another sector. This sector is unlikely to be footwear, however, since it is simultaneously facing rising import competition. In this simple setting labor within the commuting zone should therefore reallocate towards construction. Estimating by how much employment in construction expands in this commuting zone as toys and footwear decline can help us to assess the positive general equilibrium effects resulting from reallocation.

Employment in construction may be affected by a second channel as well: the potentially negative Keynesian aggregate demand multiplier, stemming from reductions in local economic activity. In our simple example, the initial reduction in employment in exposed industries will reduce local incomes and, via this channel, may depress local demand for construction services, e.g., new home and business construction, renovation, and maintenance, thus further depressing employment.³⁴ The net effect of these reallocation and aggregate demand effects on employment in construction thus may be positive or negative.

Now suppose that the third industry in this economy is not construction but chemicals, which unlike construction, is tradable within the United States across local labor markets and, as it happens, has not been subject to significant increases in import competition from China. To make progress in this case, suppose that our local labor markets can be thought of as small open economies within the United States, so that prices of tradables are determined at the U.S. level (or on world markets). This does not change the nature of the reallocation effect, but it may alter the aggregate demand effect. Even if aggregate demand for non-tradables in the local labor market is depressed, there might be an increase in local employment in chemicals, the output of which is then sold to residents in other commuting zones. This is simply a reflection of the fact that the component of the negative aggregate demand effect working at the national level will not be easily identified from variation across local labor markets. An implication of this observation is that our strategy will tend to underestimate the aggregate demand effect (to the degree it operates nationally rather than locally), but we believe that this does not invalidate our strategy. In particular, to the extent that consumption of most goods is higher near where they are produced, we will be able to detect some portion of the aggregate demand effect with our strategy.

Alongside reallocation and aggregate demand, import competition may also affect local labor

³³This discussion also makes it clear that empirically, it is appropriate to combine the shocks of all of the local industries using weights related to their local employment shares, which is the strategy employed in Autor, Dorn and Hanson (2013a) and applied here.

³⁴As footnote 4 discusses, it is possible for trade-induced price declines to simultaneously contribute to aggregate demand by spurring additional consumption or investment. Our empirical approach does not directly account for any employment effects operating through this channel, but we view these effects as likely to be second order.

market outcomes via the indirect effects working through input-output linkages. We have so far found these effects to be non-trivial, so it is important to allow for them at the level of local labor markets—all the more so because industries that have substantial trade linkages tend to co-locate (e.g., Ellison, Glaeser and Kerr, 2010). Thus, when considering exposed and non-exposed sectors, we will account both for direct and indirect exposure channels.

This discussion makes it clear that our empirical strategy has the potential shortcoming that it will only provide a lower bound on the sum of the full reallocation and aggregate demand effects. It will not enable us to separate the reallocation and aggregate demand effects, nor does it allow to have an exact estimate of the sum of the two. Nevertheless, this strategy is useful inasmuch as it provides an estimate (albeit incomplete) of the general equilibrium effects of rising import competition on employment.

5.2 Estimates

The local labor market analysis is based on 722 commuting zones (CZs) that cover the entire U.S. mainland. Commuting zones are clusters of counties with strong internal commuting ties (see Tolbert and Sizer, 1996, and Autor and Dorn, 2013).

To operationalize our exploration of trade-induced employment changes in exposed and non-exposed sectors, we estimate stacked first-difference models for changes in commuting zone employment to population rates of the following form:

$$\Delta E_{ik\tau} = \alpha_{k\tau} + \beta_1 \Delta IPW_{i\tau} \times 1[\text{Exposed}_k] + \beta_2 \Delta IPW_{i\tau} \times (1 - 1[\text{Exposed}_k]) + \gamma X_{ik0} + e_{ik\tau}. \quad (7)$$

Here, the dependent variable $\Delta E_{ij\tau}$ is equal to 100 times the decadal change in employment over working age population in CZ i in sector k (exposed, non-exposed) over time period τ ; X_{ik0} is a set of CZ by sector start of period controls (specified later); $\alpha_{k\tau}$ is a sector-specific constant; and e_{ikt} is an error term. The key explanatory variable in this model is $\Delta IPW_{i\tau}$, which measures a CZ's decadal change in exposure to Chinese imports (in \$2007) per worker. We interact this measure with indicator variables for exposed and non-exposed sectors (defined below). Following the empirical specification derived by Autor, Dorn, and Hanson (2013a) for imports per worker, imports are apportioned to regions according to their share of national industry employment:

$$\Delta IPW_{i\tau} = \sum_j \frac{L_{ij\tau}}{L_{uj\tau}} \frac{\Delta M_{j\tau}^{china-us}}{L_{i\tau}}. \quad (8)$$

In this expression, $\Delta M_{j\tau}^{china-us}$ is the observed change in U.S. imports from China in industry j between the start and end of period τ , $L_{i\tau}$ is total start of period employment in CZ i , and $L_{ij\tau}/L_{uj\tau}$ is CZ i 's share in national employment of industry j .

In equation (8), the difference in $\Delta IPW_{j\tau}^{china-us}$ across local labor markets stems entirely from variation in local industry employment structure at the start of period τ .³⁵ As with our industry-level estimates above, a concern for our subsequent estimation is that realized U.S. imports from China in (8) may be correlated with industry import demand shocks. To identify the supply-driven component of Chinese imports, we instrument for growth in Chinese imports to the U.S. using the contemporaneous composition and growth of Chinese imports in eight other developed countries as above.³⁶

Table 6 presents our estimates. In the first set of specifications, each industry is assigned to one of two mutually exclusive sectors, exposed or non-exposed. The former category includes all manufacturing industries for which predicted import exposure rose by at least 2 percentage points between 1991 and 2011. The latter includes all of non-manufacturing plus the balance of manufacturing.³⁷

Consistent with the reasoning above, the column 1 estimate finds a strongly negative effect of import exposure on local labor market employment in trade-exposed industries. The point estimate of -0.72 (t=8.0) implies that a \$1,000 increase in import exposure per worker reduces the share of a CZ's working age population employed in exposed industries by 0.72 percentage points, which is economically sizable. Mean import exposure per worker rose by \$2,600 between 1999 and 2011, while employment in exposed industries dropped by 2.4 percentage points of working age population. The estimate in column 1 implies that 1.4 percentage points (60 percent) of this fall can be explained by rising trade exposure.³⁸ While the specification and the coefficient estimates are similar to those in Autor, Dorn, and Hanson (2013a), the present results differ in an important dimension by separating the effects of import competition on exposed versus non-exposed industries within commuting zones.

As our conceptual discussion above anticipates, the column 1 estimate also detects offsetting

³⁵This variation arises from two sources: differential concentration of employment in manufacturing versus non-manufacturing activities and specialization in import-intensive industries within local manufacturing. Differences in manufacturing employment shares are not the primary source of variation, however; in a bivariate regression, the start-of-period manufacturing employment share explains less than 25% of the variation in $\Delta IPW_{j\tau}^{china-us}$. In our main specifications we control for the start-of-period manufacturing share within CZs (interacted with initial sector shares) so as to focus on variation in exposure to Chinese imports stemming from differences in industry mix within local manufacturing sectors.

³⁶Our expression for *non*-U.S. exposure to Chinese imports differs from the expression in equation (8) in one key respect: in place of realized U.S. imports by industry ($\Delta M_{j\tau}^{china-us}$), we use realized imports from China to other high-income markets ($\Delta M_{j\tau}^{china-other}$).

³⁷Predicted import exposure is computed from first stage estimates of equation (3)

³⁸This calculation again discounts the 2SLS point estimate by the partial R-squared of 0.75 of the first stage regression: $1.38 = 2.56 \times 0.72 \times 0.75$

employment growth in non-exposed industries, which captures the net impact of reallocation and local Keynesian effects. The estimated offsetting employment effect is, however, substantially smaller than the employment reduction in exposed industries, suggesting that the general equilibrium employment effect of rising trade exposure is in net negative in our sample period.

We refine the estimates and explore robustness in the next pair of columns by flexibly allowing employment in both exposed and non-exposed industries to evolve differently according to both initial local labor market manufacturing intensity (column 2) and regional manufacturing intensity (column 3). Adding these covariates modestly decreases the estimated negative impact of import exposure on the share of the working age population employed in exposed industries and modestly increases the positive impact on employment in non-exposed sectors. Nevertheless, the offsetting effect on non-exposed employment remains statistically insignificant and only one-third as large as the direct effect on exposed employment, which continues to be large and significant at -0.59 for each \$1,000 per worker of exposure in column 3.

Our analysis in Table 5 above reveals that industries that are not directly exposed to rising import competition nevertheless experience substantial employment losses when their domestic downstream purchasers contract. To incorporate these downstream effects (at least partially), we next expand the definition of the exposed sector to include industries whose predicted downstream import exposure increased by at least 2 percentage points over 1991 through 2011. These indirect linkages add to the exposed sector a number of additional manufacturing industries, as well as a set of industries outside of manufacturing that sell an important portion of their outputs to manufacturing firms. These include, for example, forestry, wholesale trade, equipment rental and leasing, miscellaneous repair services, and advertising.³⁹ Notably, this broader classification of exposed industries does not change the qualitative pattern of results. Employment impacts in exposed industries remain large and negative, while offsetting gains in non-exposed industries are only weakly positive.

Quantitatively, the estimates in column 6 of Table encompass three impacts of Chinese trade competition on local labor market employment: direct employment effects in exposed industries, local reallocation effects, and local aggregate demand effects. As summarized in Table 7, the coefficients estimates imply that had import competition from China not increased after 1999, trade-exposed industries in local labor markets would have avoided the loss of 718,000 jobs. Comparing this quantity to the outcome of our national-industry analysis, it is three times as large as the employment

³⁹This exercise only partially captures the indirect effects working through input-output linkages we directly estimated previously. Even though, as we have already noted, pairs of industries linked through input-output relationships tend to co-locate (e.g., Ellison, Glaeser and Kerr, 2010), many firms purchase and sell inputs beyond the boundaries of their commuting zone, and thus any local strategy will exclude a potentially sizable fraction of these indirect effects.

effect derived from Table 3—which captures the direct effect of trade exposure on manufacturing industries only and suggested a trade-induced loss of 284,000 manufacturing jobs since 1999—and modestly larger than the estimate derived from Table 5—which added the effect of inter-industry linkages within manufacturing and raised employment reductions to 657,000, with both projections summarized in Table 7. The fact that employment effects on exposed industries in commuting zones are larger than the direct and indirect effects of import competition in national industries is suggestive of negative local aggregate demand spillovers. Such spillovers imply that multipliers operating at the local level will suppress demand for all industries, including those initially exposed to the trade shock, inducing further employment declines.

Our estimates also imply modest, though imprecisely estimated, positive employment effects of trade exposure on non-exposed industries. Absent further increases in import penetration from China after 1999, the results summarized in Table 7 show that 127,000 fewer jobs in non-exposed industries would have been created. Combining the numbers from exposed and non-exposed industries, the overall local impact is 591,000 jobs whose loss would have been averted through the absence of further increases in Chinese import competition after 1999. We view this as a lower bound estimate both because aggregate demand spillovers at the national level are excluded and because this number further excludes much of the indirect effects working through input-output linkages. This estimate compares to the 1.25 million jobs lost based on our industry-level estimates in Table 5 (and shown in Table 7), which combine both direct competition effects and inter-industry linkages with non-manufacturing sectors. The latter estimate excludes reallocation and aggregate demand effects. Since our analysis in this section indicates that reallocation effects are limited, especially compared to local aggregate demand effects, this suggests that the industry-level estimate is itself a lower bound, and we can take it as our central (lower bound) estimate, concluding that the rapid increase in import competition from China from 1999 to 2011 led to upwards of a 1.25 million net employment reduction in the U.S. economy. Alternatively, one might take the range between our estimates from the local analysis and from the industry-level analysis incorporating input-output linkages, of 0.6 to 1.25 million fewer workers employed, as a more conservative range of (lower bound) estimates.

The remaining three columns of Table 6 follow our schematic example of construction versus chemicals as non-exposed sectors and subdivide non-exposed sectors into tradables (akin to chemicals) and non-tradables (akin to construction). In our nomenclature, tradable industries are those that produce tradable goods or commodities, and specifically comprise the manufacturing, agriculture, forestry, fishing, and mining sectors. We classify all other sectors, including services, as non-tradable, though we acknowledge that this approach is imperfect since some services are also

traded to varying degrees. We modify our regression model so that this subdivision provides an exact decomposition of the impact of trade-exposure on non-exposed industry employment (columns 4 through 6 of Table 6) into two additive components: employment changes in non-exposed tradables, and employment changes in non-exposed non-tradables.

Based on our reasoning above, we would anticipate that most of the offsetting employment impact detected in earlier columns would stem from employment growth in non-exposed tradables, which face elastic national demand, with the remaining (potentially negative) quantity accruing to non-tradables. Our estimates do not support this prediction. In all three columns, we detect either zero or slightly negative employment changes in non-exposed tradables. Thus, the entirety of the offsetting gains in employment in non-exposed employment stems from labor reallocation into non-traded industries. Though we can only speculate at present on why reallocation does not appear to accord with the simple reasoning above, three considerations seem most relevant. One is that these estimates are fairly noisy. We cannot, for example, reject that the effect on non-tradables and non-exposed tradables are the same or that the former is greater than the latter. Second, our measure of “non-exposure” is imperfect: even the “non-exposed” industries in our classification have some modest growth in exposure on average, and some of these industries might anticipate rising trade competition in the near future, which would curtail their reabsorption of displaced workers.

Third, and perhaps more substantively, the small increase in employment in non-tradable sectors may be related to the rapid rise in the U.S. trade deficit during our sample period (Figure 2), a substantial part of which reflects the growing trade deficit with China. A small open economy facing stiffer import competition will normally shift resources out of tradable industries in which it is weaker and into tradable industries in which it is stronger. That prediction, however, assumes balanced trade. Consider instead a setting where the trade shock is accompanied by a short-run increase in the trade deficit. In that case, the shift from exposed tradables into non-exposed tradables may be delayed, and instead, the increase in the trade deficit may shift employment into non-tradables—that is, the deficit fuels increasing expenditure in the domestic economy, part of which falls on non-tradable consumption. This reasoning cannot of course provide a long-run explanation for the lack of reallocation towards non-exposed tradables, as the trade deficit increase must eventually reverse itself. Moreover, this reasoning is silent on why a rising U.S. trade deficit coincided with China’s growing import penetration. This discussion nevertheless underscores that shifts in global imbalances may complicate the simple adjustment mechanism posited above.

6 Conclusion

Even before the Great Recession, overall U.S. employment growth was slow and manufacturing employment experienced a steady and rapid contraction. In this paper, we investigate the contribution of the rise in import competition from China on this employment “sag” in the U.S. labor market during the last decade.

We first estimate the *direct* effect of trade competition on employment in manufacturing industries that are differentially exposed to growing Chinese import penetration. To isolate changes in imports from China that are generated from developments in the Chinese economy, and thus are plausibly exogenous to economic conditions of industries in the United States, we follow the instrumental-variable strategy of Autor, Dorn and Hanson (2013a). Our estimates show substantial industry-level employment losses, corresponding to approximately 5 percent of the realized job losses in the U.S. manufacturing sector during the same period.

These direct effects do not necessarily capture to the full impact of growing Chinese imports on U.S. employment because of multiple general equilibrium channels are likely operative. First, other sectors might be impacted because they are related to the affected sectors through *input-output linkages*. Second, a neoclassical economy without labor market or other frictions would create jobs in other sectors by *reallocating* workers away from trade-exposed industries. Third, and pointing in the opposite direction, Keynesian-type *aggregate demand spillovers* can significantly multiply the direct effect.

The bulk of our paper investigates these general equilibrium effects. We first extend our industry-level analysis by constructing upstream and downstream trade shocks for manufacturing and non-manufacturing industries. Theoretically, we expect downstream shocks to contribute to further job losses, while the impact of upstream shocks is theoretically ambiguous. These results are broadly borne out in our estimates. We find large negative employment responses to trade exposure in downstream industries and unstable effects of exposure in upstream industries. Incorporating input-output linkages, we observe a larger impact of the rise in import competition from China, now accounting for an employment reduction of 1.3 million jobs (in manufacturing and non-manufacturing combined) between 1999 and 2011.

Our final strategy turns to the impact of Chinese trade shocks on local labor markets, proxied by U.S. commuting zones (as in Autor, Dorn and Hanson, 2013a), to jointly estimate reallocation and aggregate demand effects at the local level. Theoretically, if an industry contracts in a local labor market because of Chinese competition, then some other industry in the same labor market

should expand—enabling us to study quantity adjustments at the local level. In addition, part of any aggregate demand spillovers will also take place in the local labor market. Thus, by looking at Chinese trade-induced shocks to local labor markets and the responses of *exposed* industries (which are directly affected by increasing Chinese competition) and *non-exposed* industries (which are not), we can estimate the combined reallocation and aggregate demand effects at the local level. Our estimates show sizable job losses in exposed industries, and modest job gains in non-exposed industries.

We see our results as a first step in quantifying the employment impact of increasing import competition on the U.S. labor market. Several questions remain unanswered by our study and constitute fruitful directions for future research. These include:

1. A finer distinction between tradable and non-tradable industries could enable both a sharper test of the implications of local general equilibrium interactions and also a separate quantification of reallocation and aggregate demand effects. We should in particular see employment declines in non-tradables due to local aggregate demand spillovers, but no differential decline in tradables except through geographically-concentrated input-output linkages. This approach could thus shed greater light on how local and national labor markets respond to growing import competition.
2. If firms co-locate with their downstream customers and upstream suppliers (as the evidence in Ellison, Glaeser and Kerr, 2010, suggests) and engage in substantial relationship-specific investments, then shocks to these industries will propagate locally. In contrast, if these relationships are not local, input-output linkages should exhibit themselves at the national, but not at the local level. This general observation then might constitute the basis of an investigation of input-output linkages depending on the degree of co-location of various pairs of industries.
3. Our study, as with most other analyses of the impact of the rise in import competition from China, has been silent on mechanisms. An important area for future research is an investigation of what labor and product market characteristics slow the adjustment to such trade shocks.

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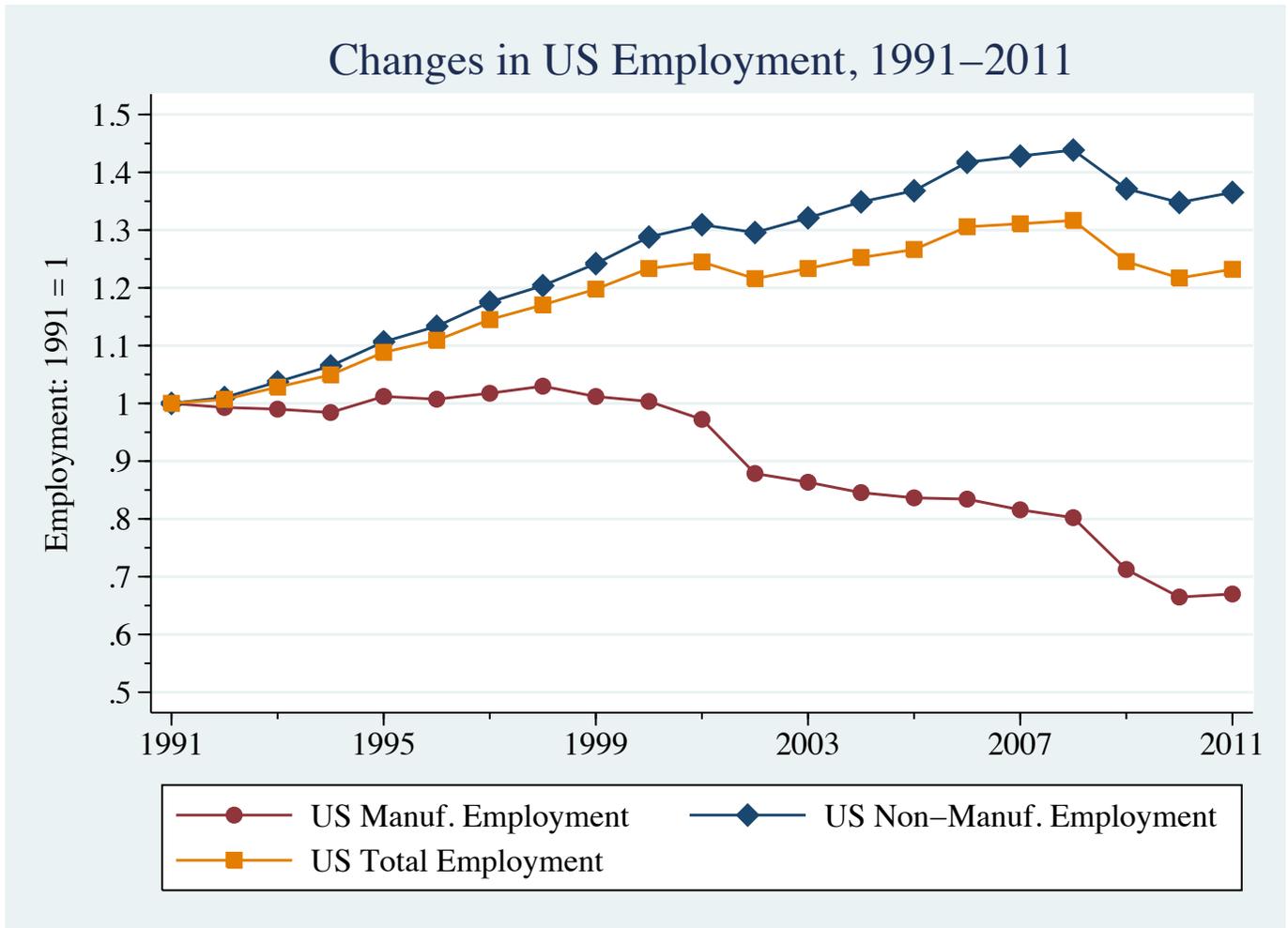
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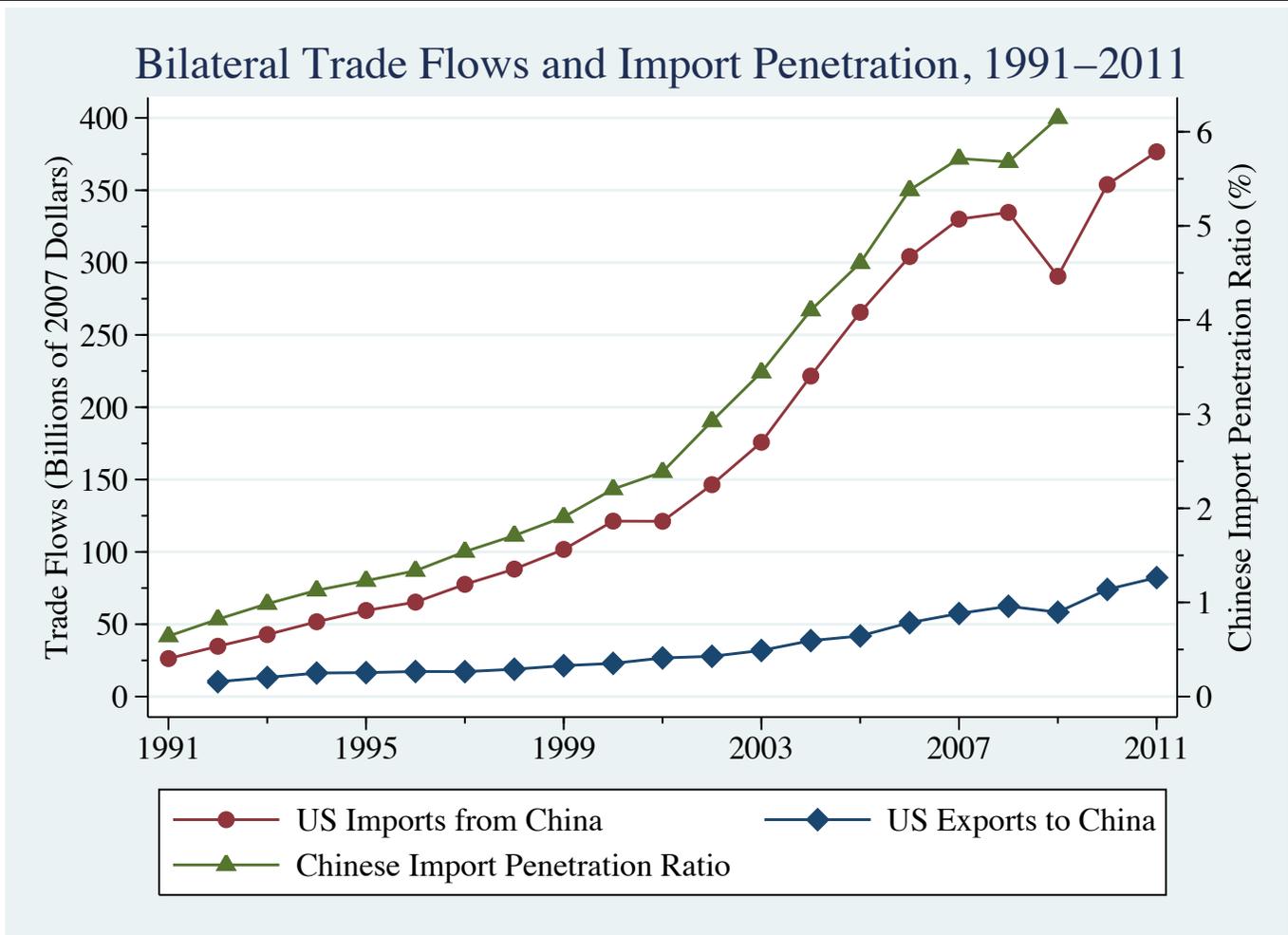
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Figure 1. Changes in US Manufacturing and Non-Manufacturing Employment, 1991-2011.



Notes: Employment is computed in the County Business Patterns. Employment counts are normalized to unity in 1991.

Figure 2. Bilateral US-China Trade Flows and Chinese Import Penetration, 1991-2011.



Notes: Trade data are taken from the UN Comtrade Database. Imports and exports are deflated to 2007 US\$ using the Personal Consumption Expenditure price index. Chinese import penetration is constructed by dividing US manufacturing imports from China by US domestic manufacturing absorption, defined as US domestic manufacturing output plus imports less exports. Export data are available only from 1992 onwards. The import penetration ratio series ends in 2009 because computing the denominator requires use of the NBER-CES Manufacturing Industry Database, which ends in 2009.

Table 1. Industry-Level Changes in Chinese Import Exposure and Manufacturing Employment.

	N	Mean/SD	<u>1991-2011</u>			<u>1991-1999</u>	<u>1999-2011</u>	<u>1999-2007</u>	<u>2007-2011</u>
			Median	Min	Max	Mean/SD	Mean/SD	Mean/SD	Mean/SD
100 x Annual Δ in US Exposure to Chinese Imports	392	0.50 (0.94)	0.14	-0.02	10.93	0.27 (0.75)	0.66 (1.33)	0.84 (1.61)	0.30 (1.68)
Instrument for Δ in US Exposure to Chinese Imports	392	0.44 (0.76)	0.15	-0.52	8.59	0.18 (0.44)	0.60 (1.07)	0.60 (1.07)	0.62 (1.32)
100 x Annual Log Δ in Employment (Manufacturing Industries)	392	-2.71 (3.07)	-2.05	-38.32	4.62	-0.30 (3.49)	-4.32 (3.85)	-3.62 (4.15)	-5.73 (5.02)
100 x Annual Log Δ in Employment (Non-Manufacturing Industries)	87	1.33 (1.46)	1.02	-5.73	5.75	2.46 (2.38)	0.57 (1.56)	1.54 (1.59)	-1.37 (2.83)

Notes: For each manufacturing industry, the change in US exposure to Chinese imports is computed by dividing 100 x the annualized increase in the value of US imports over the indicated period by 1991 US market volume in that industry. The instrument is constructed by dividing 100 x the annualized increase in imports from China in a set of comparison countries by 1988 US market volume in the industry. The quantities used in these computations are deflated to constant dollars using the Personal Consumption Expenditures price index. Employment changes are computed in the County Business Patterns. All observations are weighted by 1991 industry employment.

Table 2. Effect of Import Exposure on Employment in Manufacturing Industries: OLS and 2SLS Estimates.
Dep. Var: 100 x Annual Log Δ in Employment

	Stacked Differences (N = 784)			Separately By Period (N = 392)			
	(1)	1991-2011 (2)	(3)	1991-1999 (4)	1999-2011 (5)	1999-2007 (6)	1991-2011 (7)
100 x Annual Δ in US Exposure to Chinese Imports		-0.81*** (0.16)	-1.30*** (0.41)	-2.30** (1.12)	-1.16*** (0.37)	-1.12*** (0.34)	-1.49*** (0.47)
1{1991-1999}	-0.30 (0.37)	-0.08 (0.36)	0.05 (0.36)				
1{1999-2011}	-4.32*** (0.37)	-3.79*** (0.33)	-3.46*** (0.33)				
Constant				0.32 (0.43)	-3.55*** (0.34)	-2.68*** (0.39)	-1.96*** (0.27)
Estimation Method	OLS	OLS	2SLS	2SLS	2SLS	2SLS	2SLS

Notes: Columns (1)-(3) report results from stacking log employment changes and changes in US exposure to Chinese imports over the periods 1991-1999 and 1999-2011 (N = 784 = 392 4-digit manufacturing industries x 2 periods). Columns (4)-(7) report results from regressing the employment change over the indicated period on the change in US exposure to Chinese imports over the same period. Employment changes are computed in the County Business Patterns and are expressed as 100 x annual log changes. In 2SLS specifications, the change in US imports is instrumented as described in the text. In all specifications, observations are weighted by 1991 employment. Standard errors in parentheses are clustered on 135 3-digit industries in all specifications. * p<0.10, ** p<0.05, *** p<0.01.

Table 3. 2SLS Estimates Including Industry-Level Controls.
Dep. Var.: 100 x Annual Log Δ in Employment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
100 x Annual Δ in US	-1.30***	-0.75***	-1.10***	-1.26***	-0.80***	-0.75***	-0.73***
Exposure to Chinese Imports	(0.41)	(0.22)	(0.35)	(0.41)	(0.25)	(0.22)	(0.23)
1{1991-1999}	0.05	-0.09	0.00	0.04	-0.08	-0.10	-0.10
	(0.36)	(0.32)	(0.37)	(0.35)	(0.30)	(0.31)	(0.29)
1{1999-2011}	-3.46***	-3.82***	-3.59***	-3.49***	-3.79***	-3.83***	-3.84***
	(0.33)	(0.27)	(0.35)	(0.33)	(0.28)	(0.26)	(0.27)
1-Digit Mfg Sector Controls	No	Yes	No	No	Yes	Yes	Yes
Production Controls	No	No	Yes	No	Yes	No	Yes
Pretrend Controls	No	No	No	Yes	No	Yes	Yes

Notes: Each column reports results from stacking log employment changes and changes in US exposure to Chinese imports over the periods 1991-1999 and 1999-2011 ($N = 784 = 392$ 4-digit manufacturing industries \times 2 periods). The dependent variable is 100 x the annual log change in each industry's employment in the County Business Patterns (CBP) over the relevant period. The regressor is 100 x the annual change in US exposure to Chinese imports over the same period; it is instrumented as described in the text. Sector controls are dummies for 10 1-digit manufacturing sectors. Production controls for each industry include production workers as share of total employment, log average wage, and the ratio of capital to value added (in 1991); and computer investment as share of total investment and high-tech equipment as share of total investment (in 1990). Pretrend controls are changes in the log average wage and in the industry's share of employment over 1976-1991. Observations are weighted by 1991 employment. Standard errors in parentheses are clustered on 135 3-digit industries. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4. 2SLS Estimates of Import Effects on Industrial Outcomes.
Dep. Var.: 100 x Annual Log Δ in Indicated Outcome

	A. 2SLS Estimates								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Emp	Num Estabs	Emp Per Estab	Real Wage Bill	Real Wage	Prod. Emp	Non-Prod. Emp	Real Prod. Wage	Real Non-Prod. Wage
Source Dataset	CBP	CBP	CBP	CBP	CBP	NBER	NBER	NBER	NBER
100 x Annual Δ in US	-0.75***	-0.23***	-0.52***	-0.67***	0.08	-0.86***	-0.69***	0.23**	-0.05
Exposure to Chinese	(0.22)	(0.09)	(0.17)	(0.21)	(0.06)	(0.26)	(0.25)	(0.11)	(0.08)
1{1991-1999}	-0.09	0.48**	-0.57**	1.53***	1.63***	0.13	-0.52	1.13***	1.79***
	(0.32)	(0.19)	(0.26)	(0.30)	(0.08)	(0.37)	(0.37)	(0.06)	(0.09)
1{1999-2011}	-3.82***	-1.51***	-2.31***	-3.42***	0.40***	-4.84***	-3.61***	0.20	0.32***
	(0.27)	(0.19)	(0.18)	(0.30)	(0.10)	(0.36)	(0.31)	(0.13)	(0.11)
1-Digit Mfg Sector Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	B. Dependent Variable Means by Time Period								
1{1991-1999}	-0.30	0.41**	-0.71***	1.35***	1.65***	-0.09	-0.70*	1.19***	1.77***
	(0.32)	(0.19)	(0.26)	(0.31)	(0.07)	(0.37)	(0.38)	(0.06)	(0.08)
1{1999-2011}	-4.32***	-1.67***	-2.66***	-3.87***	0.46***	-5.41***	-4.07***	0.35**	0.29**
	(0.25)	(0.17)	(0.17)	(0.29)	(0.08)	(0.33)	(0.31)	(0.13)	(0.13)
1-Digit Mfg Sector Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Each column stacks changes in the indicated outcome and changes in US exposure to Chinese imports over the periods 1991-1999 and either 1999-2011 (for County Business Pattern outcomes) or 1999-2009 (for NBER-CES outcomes) ($N = 784 = 392$ 4-digit manufacturing industries \times 2 periods). In each column, the dependent variable is 100 x the annual log change in the indicated quantity over the relevant period. Panel A reports 2SLS estimates including the annual change in US exposure to Chinese imports over the relevant period; it is instrumented as described in the text. Panel B reports OLS estimates from a regression including only time effects and sector controls. Sector controls are dummies for 10 1-digit manufacturing sectors. They are demeaned in all specifications. Observations are weighted by 1991 employment in the relevant dataset. Standard errors in parentheses are clustered on 135 3-digit industries. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5. 2SLS Estimates Incorporating Input-Output Linkages.
Dep. Var.: 100 x Annual Log Δ in Employment

	Manuf. Only (N = 784)			Non-Manuf. Only (N = 174)			Pooled (N = 958)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Direct Trade Shock	-1.24** (0.48)	-1.16*** (0.42)	-1.26*** (0.48)	-0.72*** (0.22)				-1.14** (0.48)	-1.13*** (0.42)	-1.09** (0.48)	-0.70*** (0.22)
Upstream Trade Shock	-1.23 (1.88)		2.14 (2.90)		-5.64 (6.83)		-6.00 (7.43)	-3.05 (3.23)		-1.01 (3.92)	
Downstream Trade Shock		-2.33* (1.21)	-2.48** (1.19)	-1.04** (0.42)		-6.18** (2.82)	-6.45** (3.00)		-2.69** (1.27)	-2.63** (1.32)	-1.58** (0.69)
1{1991-1999} x Manufacturing	0.09 (0.37)	0.18 (0.36)	0.12 (0.37)	-0.03 (0.32)				0.15 (0.38)	0.20 (0.36)	0.23 (0.38)	0.00 (0.32)
1{1999-2011} x Manufacturing	-3.35*** (0.37)	-3.06*** (0.34)	-3.23*** (0.41)	-3.63*** (0.30)				-3.19*** (0.44)	-3.00*** (0.34)	-2.92*** (0.48)	-3.52*** (0.32)
1{1991-1999} x Non-Manufacturing					2.56*** (0.39)	2.54*** (0.34)	2.65*** (0.41)	2.52*** (0.36)	2.50*** (0.34)	2.51*** (0.36)	2.48*** (0.34)
1{1999-2011} x Non-Manufacturing					0.77*** (0.30)	0.81*** (0.30)	1.02*** (0.38)	0.68*** (0.23)	0.67*** (0.24)	0.71*** (0.22)	0.63*** (0.23)
1-Digit Mfg Sector Controls	No	No	No	Yes	No	No	No	No	No	No	Yes

Notes: Each column stacks changes in log employment and changes in direct, upstream, and downstream import exposure over the periods 1991-1999 and 1999-2011. In each specification, the dependent variable is 100 x the annual log change in employment over a given period, as computed in the County Business Patterns. The direct trade shock to industry i is defined as the annual change in US exposure to Chinese imports in that industry. The upstream trade shock to i is a weighted average of the direct trade shocks to upstream industries j , where the weight on industry j equals j 's share of i 's material purchases. The downstream trade shock to i is a weighted average of the direct trade shocks to downstream industries k , where the weight on industry k equals k 's share of i 's sales. The direct, upstream, and downstream trade shocks are instrumented using share-weighted changes in comparison countries' exposure to Chinese imports in own, upstream, and downstream industries; see text for details. Purchase and sales shares are taken from the Bureau of Economic Analysis's 1992 benchmark input-output table. Observations are weighted by 1991 industry employment, and standard errors in parentheses are clustered on 3-digit industry (with each non-manufacturing industry constituting its own cluster). * p<0.10, ** p<0.05, *** p<0.01.

Table 6. 2SLS Estimates of Import Effects on Commuting Zone Employment-to-Population Ratios.
Dep. Var.: $100 \times \Delta$ in (Local Employment in Sector / Local Working-Age Population)

	<u>Direct Exposure</u>			<u>Direct/Downstream Exposure</u>			<u>Direct/Downstream Exposure</u>		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(Δ in Imports Per Worker) x (Exposed Sector)	-0.72***	-0.62***	-0.59***	-0.76***	-0.54***	-0.50***	-0.76***	-0.54***	-0.50***
(Δ in Imports Per Worker) x (Non-Exposed Sector)	0.07	0.20	0.18	0.11	0.12	0.09			
(Δ in Imports Per Worker) x (Non-Exposed Tradable Goods)							-0.04	0.00	0.00
(Δ in Imports Per Worker) x (Rest of Non-Exposed Sector)							(0.03)	(0.04)	(0.04)
							0.15	0.12	0.09
							(0.20)	(0.16)	(0.18)
Sector x Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector x Mfg Emp Share at Baseline	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Sector x Census Division	No	No	Yes	No	No	Yes	No	No	Yes
N	2888	2888	2888	2888	2888	2888	4332	4332	4332

Notes: Each column reports results from stacking changes in commuting zone employment-to-population ratios and changes in commuting zone exposure to Chinese imports over the periods 1991-1999 and 1999-2011. In each specification, the dependent variable is $100 \times$ the change in the ratio of sector employment to working-age population, where sectors are defined on the basis of trade exposure and tradability. Columns (1) to (6) partition employment into exposed and non-exposed sectors ($N = 2888 = 722$ commuting zones \times 2 sectors \times 2 periods); the remaining columns further decompose the non-exposed sector into tradable goods industries and all other non-exposed industries ($N = 4332 = 722$ commuting zones \times 3 sectors \times 2 periods). In columns (1)-(3), "exposed" industries are defined as manufacturing industries for which predicted import exposure rose by at least 2 percentage points between 1991 and 2011; the remaining manufacturing industries, together with all non-manufacturing industries, are "non-exposed". In columns (4)-(9), we expand the definition of industry exposure to include industries both inside and outside of manufacturing for which predicted downstream import exposure rose by at least 2 percentage points. Tradable industries include manufacturing, agriculture, mining, and air transportation; all other industries are coded as non-tradable. The change in Chinese imports per worker (expressed in \$2007K) is instrumented as described in the text. Manufacturing employment share at baseline is the percentage of commuting zone employment in manufacturing industries in 1991. Census division dummies control for 9 Census divisions. Observations are weighted by commuting zone population as of 1991. Standard errors in parentheses are clustered on commuting zone.

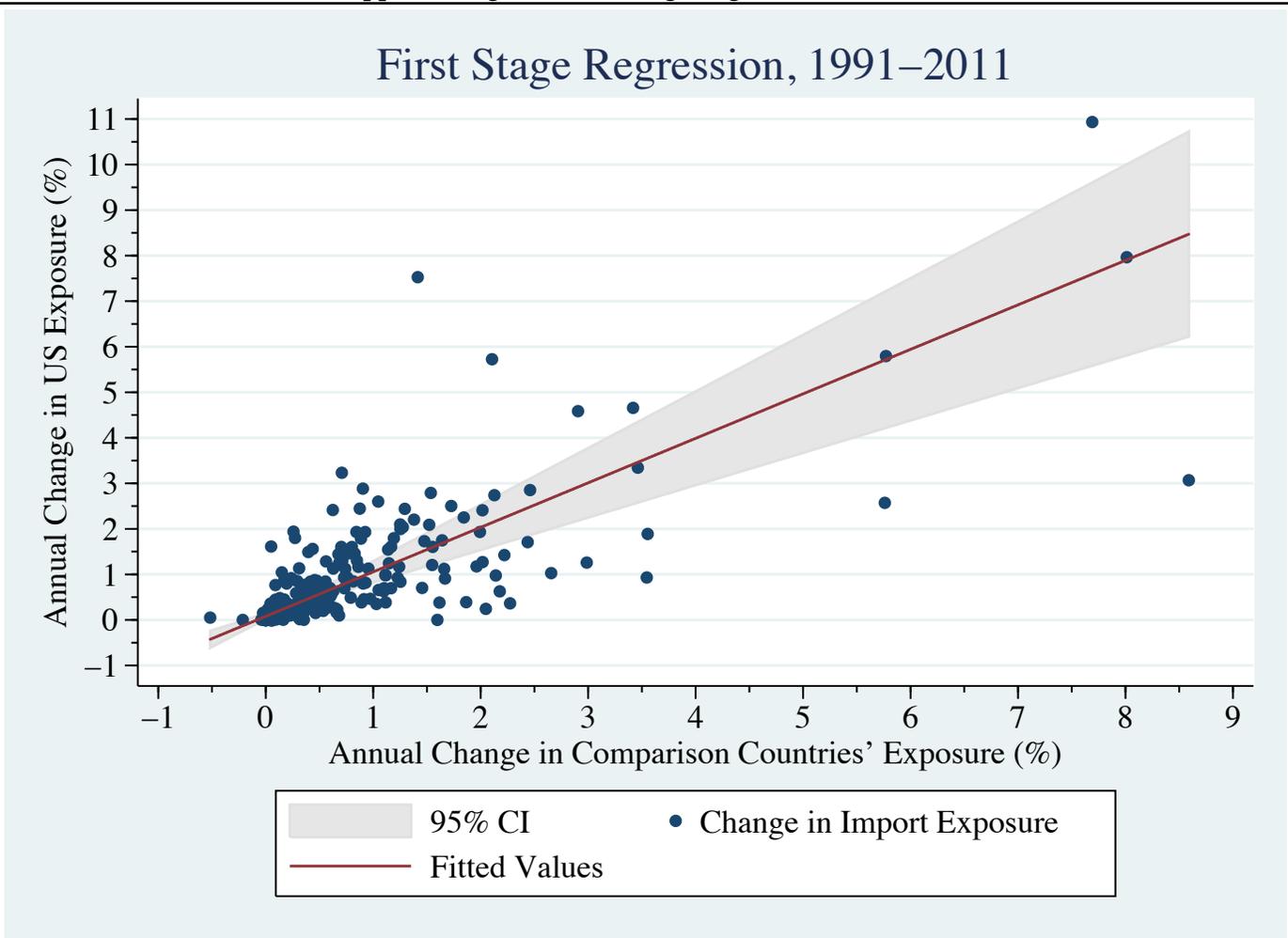
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7. Implied Employment Changes Induced by Changes in Import Exposure.

Specification	Unit of Analysis	Description	Affected Sector(s)	Implied Employment Changes		
				1991-1999	1999-2011	1991-2011
Table 3, Column 2	Industry	Direct effect of import exposure, controlling for 1-digit manufacturing sectors	Manufacturing	-145k	-284k	-429k
Table 5, Column 11	Industry	Direct and downstream effects of import exposure, controlling for 1-digit manufacturing sectors	Total	-418k	-1,254k	-1,672k
			Manufacturing	-281k	-657k	-938k
			Non-manufacturing	-136k	-597k	-733k
Table 6, Columns 6/9	Commuting Zone	Effect of local import exposure on CZ employment, controlling for baseline manufacturing share of employment and for Census divisions	Total	-180k	-591k	-770k
			Exposed industries	-218k	-718k	-936k
			Non-exposed tradables	+1k	+4k	+6k
			Non-exposed non-tradables	+37k	+123k	+161k

Notes: Reported quantities represent the change in employment attributed to instrumented changes in import exposure in each of our preferred specifications, where negative values indicate that import exposure is estimated to have reduced employment. For industry-level analyses, we first use the estimated coefficients to predict the change in each industry's log employment induced by changes in import exposure. Concretely, we multiply the coefficient of interest by the observed change in import exposure, then multiply this product by the partial R-squared from the corresponding first-stage regression. This computation yields estimates of the change in each industry's log employment induced by instrumented changes in import exposure over the periods 1991-1999 and 1999-2011. We then use each industry's observed end-of-period employment to convert these estimates from logs into levels. Downstream effects are handled similarly. For commuting-zone analyses, we first use observed changes in imports per worker—again discounted by the partial R-squared of the first-stage regression—to predict the trade-induced change in each commuting zone's employment-to-population ratio within the indicated sectors over

Appendix Figure 1. First Stage Regression, 1991-2011.



Notes: Each point represents a 4-digit manufacturing industry (N = 392). Lines are fitted by OLS regression, weighting by each industry's 1991 employment in the County Business Patterns. The 95% confidence interval is based on standard errors clustered on 135 3-digit industries. The slope coefficient is .98 with standard error .14; the regression has an R-squared of .62.

Appendix Table 1. Industry-Level Control Variables.

	Mean	SD	Min	Max
Production Workers' Share of Employment, 1991	68.43	15.50	18.72	97.62
Ratio of Capital to Value Added, 1991	0.92	0.55	0.19	3.52
Log Real Wage (2007 US\$), 1991	10.54	0.29	9.78	11.09
Computer Investment As Share of Total, 1990	6.56	6.07	0.00	43.48
High-Tech Equipment As Share of Total Investment, 1990	8.24	4.84	1.20	18.25
Intermediates As Share of Total Imports, 1990	13.18	7.77	0.00	65.97
Change in Industry Employment Share, 1976-1991	0.10	0.40	-1.49	1.27
Change in Log Real Wage, 1976-1991	3.57	9.94	-32.01	48.06

Notes: N = 392 4-digit manufacturing industries. Observations are weighted by industry employment in 1991, as measured in the County Business Patterns. Production workers' share, the ratio of capital to value added, log real wage, and the changes in industry employment share and in log real wage are computed in the NBER-CES Manufacturing Industry Database. The remaining control variables are taken from Autor, Dorn, Hanson, and Song (2012).

Appendix Table 2. Effect of Import Exposure on Employment Changes over 1971-2009.
Dep. Var.: 100 x Annual Log Δ in Employment

	(1)	(2)	(3)	(4)	(5)
	1971-1981	1981-1991	1991-1999	1999-2009	1991-2009
100 x Annual Δ in US Exposure to Chinese Imports	0.19 (0.26)	0.03 (0.26)	-0.56* (0.31)	-0.90*** (0.31)	-0.75*** (0.22)
Constant	-0.05 (0.32)	-0.08 (0.74)	0.52 (0.63)	-0.98** (0.45)	-0.32 (0.48)
Sector Controls	Yes	Yes	Yes	Yes	Yes

Notes: N = 392 4-digit manufacturing industries. The dependent variable in each specification is 100 x the annual log employment change over the indicated period. The regressor in each specification is 100 x the annual change in US exposure to Chinese imports over 1991-2011, instrumented as described in the text. Sector controls are dummies for 10 1-digit manufacturing sectors. Employment changes are computed in the NBER-CES Manufacturing Industry Database, and observations are weighted by 1991 employment. Standard errors in parentheses are clustered on 135 3-digit industries. * p<0.10, ** p<0.05, *** p<0.01.

Appendix Table 3. Direct, Upstream, and Downstream Import Shocks, 1991-2011.

	<u>Manufacturing Industries (N = 392)</u>				<u>Non-Manufacturing Industries (N = 87)</u>			
	Mean/SD	Median	Min	Max	Mean/SD	Median	Min	Max
Direct Trade Shock	0.50 (0.94)	0.14	-0.02	10.93				
Instrument for Direct Trade Shock	0.44 (0.76)	0.15	-0.52	8.59				
Upstream Trade Shock	0.09 (0.10)	0.06	0.00	0.83	0.03 (0.04)	0.02	0.00	0.21
Instrument for Upstream Trade Shock	0.09 (0.08)	0.07	-0.02	0.47	0.02 (0.03)	0.02	0.00	0.13
Downstream Trade Shock	0.16 (0.28)	0.04	0.00	2.10	0.03 (0.04)	0.01	0.00	0.20
Instrument for Downstream Trade Shock	0.12 (0.20)	0.03	0.00	1.72	0.02 (0.03)	0.01	0.00	0.23

Notes: The direct trade shock to industry i is defined as the $100 \times$ the annual change in US exposure to Chinese imports in that industry over 1991-2011. The upstream trade shock to i is a weighted average of the direct trade shocks to upstream industries j , where the weight on industry j equals j 's share of i 's material purchases. The downstream trade shock to i is a weighted average of the direct trade shocks to downstream industries k , where the weight on industry k equals k 's share of i 's sales. Instruments for the direct, upstream, and downstream trade shocks are constructed as share-weighted changes in comparison countries' exposure to Chinese imports in own, upstream, and downstream industries; see text for details. Observations are weighted by 1991 industry employment in the County Business Patterns.

Appendix Table 4. Commuting-Zone Changes in Chinese Imports Per Worker and Industrial Employment.

	1991-1999				1999-2011			
	Mean/SD	Median	Min	Max	Mean/SD	Median	Min	Max
<u>Changes in Exposure to Chinese Imports</u>								
Δ in Imports Per Worker (\$2007K)	0.88 (0.80)	0.69	0.00	22.05	2.56 (2.30)	2.00	-0.18	36.28
Instrument for Δ in Imports Per Worker (\$2007K)	0.61 (0.48)	0.52	-0.60	7.86	3.26 (2.17)	2.94	-0.26	29.66
<u>Changes in Emp/Working-Age Population</u>								
100 x Δ in Directly Exposed Industries' Emp/Pop	-0.47 (1.09)	-0.52	-16.94	9.04	-2.40 (1.66)	-2.09	-15.21	5.96
100 x Δ in All Exposed Industries' Emp/Pop	-0.44 (1.33)	-0.46	-15.71	9.34	-3.63 (2.06)	-3.44	-20.78	6.08
100 x Δ in Non-Exposed Tradable Goods Industries' Emp/Pop	-0.43 (0.79)	-0.37	-6.39	12.54	-0.87 (1.01)	-0.92	-10.66	21.48
100 x Δ in Other Non-Exposed Industries' Emp/Pop	5.75 (2.62)	6.03	-3.82	25.02	-0.98 (3.74)	-1.02	-23.24	16.66

Notes: N = 722 commuting zones. The change in Chinese imports per worker is an weighted average of changes in US imports from China in 392 4-digit manufacturing industries, where the weights are 1991 commuting-zone-level employment shares. The instrument is constructed by replacing US imports from China with imports from China by a set of comparison countries, and by using 1988 commuting-zone employment shares as weights. Imports are deflated to \$2007K using the Personal Consumption Expenditures price index. In the second panel, each variable describes the change in 100 x sector employment divided by the commuting-zone population between the ages of 16 and 64. Directly exposed industries are manufacturing industries for which the predicted increase in Chinese import penetration exceeds 2 percentage points between 1991 and 2011. All exposed industries extend this definition to include industries for which the predicted downstream increase in Chinese import penetration exceeds 2 percentage points over 1991-2011. We define agriculture, forestry, fishing, mining, and manufacturing as tradable goods industries. Employment is computed in the County Business Patterns. Population is computed using the 1990 and 2000 5% IPUMS Census extracts (for years 1991 and 1999, respectively) and using the 2005-2007 and 2009-2011 pooled 3-year IPUMS American Community Survey extracts (for years 2007 and 2011). Observations are weighted by total 1991 commuting-zone population.