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Trade Adjustment: Worker Level Evidence

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Trade Adjustment: Worker Level Evidence

Abstract

We analyze the effect of exposure to international trade on earnings and employment of U.S. workers from 1992 through 2007 by exploiting industry shocks to import competition stemming from China's spectacular rise as a manufacturing exporter paired with longitudinal data on individual earnings by employer spanning close to two decades. Individuals who in 1991 worked in manufacturing industries that experienced high subsequent import growth garner lower cumulative earnings, face elevated risk of obtaining public disability benefits, and spend less time working for their initial employers, less time in their initial two-digit manufacturing industries, and more time working elsewhere in manufacturing and outside of manufacturing. Earnings losses are larger for individuals with low initial wages, low initial tenure, and low attachment to the labor force. Low-wage workers churn primarily among manufacturing sectors, where they are repeatedly exposed to subsequent trade shocks. High-wage workers are better able to move across employers with minimal earnings losses, and are more likely to move out of manufacturing conditional on separation. These findings reveal that import shocks impose substantial labor adjustment costs that are highly unevenly distributed across workers according to their skill levels and conditions of employment in the pre-shock period.

JEL-Code: F160, H550, J230, J310, J630.

Keywords: trade flows, labor demand, earnings, job mobility, social security programs.

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Introduction

Among the most significant recent changes in the global economy is the rapid emergence of China from a technologically backward and largely closed economy to the world's third largest manufacturing producer in the space of just two decades. Between 1990 and 2000, the share of world manufacturing exports originating in China increased from 2% to 5%, and then accelerated to 12% in 2007 and to 16% in 2011 (Figure I). For U.S. manufacturing, China's expanding role in global trade represents a substantial competitive shock. Not only is China's export growth concentrated in manufacturing—the sector that still accounts for the majority of U.S. trade—but its growth in imports, in particular from the United States and other high income countries, has been sluggish, thus leading to large trade imbalances. During the last decade, China's average current account surplus was 5% of GDP, the mirror image of the U.S. current account deficit over the period. As Chinese imports to the United States surged, U.S. manufacturing employment underwent a historic contraction. Although the level of employment in U.S. manufacturing had been declining modestly since the start of the 1980s, this trend gained pace in the mid-1990s and accelerated sharply in the 2000s: the number of workers employed in U.S. manufacturing fell by 9.7 percentage points between 1991 and 2001 and by an additional 16.1 percentage points between 2001 and 2007.[1]

In this paper, we examine how exposure to rising competition from China affects the employment and earnings trajectories of U.S. workers over the medium to long run. We define trade exposure as the growth in U.S. imports from China over 1991 to 2007 that occurred in a worker's initial industry of affiliation. By categorizing workers according to their sector of employment at the time the shock commences, we isolate the extended consequences of exposure to import competition and avoid selection problems arising from the post-shock re-sorting of workers across industries.[2] The choice of the outcome period is dictated on the front end by the availability of bilateral trade data that can be matched to U.S. manufacturing industries and on the back end by the onset of the Great Recession, which severely battered U.S. manufacturing. These years span much of China's export boom, as the 1990s and especially the early 2000s—following China's entry into the WTO in 2001—were the years when the country's export growth accelerated.

Using individual-level, longitudinal data from the U.S. Social Security Administration, we estimate the impact of exposure to Chinese import competition on cumulative earnings, employment, movement across sectors, movement across regions, and receipt of Social Security benefits over the

[1] Using 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.

[2] Our approach using longitudinal data is comparable to Walker (2012) and Hummels, Jorgensen, Munch, and Xiang (2013), and is also related to Menezes-Filho and Muendler (2011).

period 1992 to 2007. The data permit us to decompose worker employment spells by firm, industry, and place of residence, and to examine variation in trade impacts according to worker and firm characteristics.[3] To account for possible correlation between industry imports and industry domestic demand or productivity shocks, we instrument for the change in U.S. imports from China using import growth in other high income countries within 397 harmonized manufacturing industries.[4]

Key to our identification strategy is that China's growth over the period appears to be driven by rapid improvements in industrial production resulting from rising TFP, capital accumulation, migration to urban areas, and enhancements in infrastructure, each of which was a consequence of its transition to a more market-oriented economy (Naughton [2007]; Hsieh and Klenow [2009]; Hsieh and Ossa [2011]).[5] Brandt, van Biesebroeck and Zhang (2012) estimate that over the period 1998 to 2007, China had average annual TFP growth in manufacturing of 8.0%. In the same time frame, China accounted for an astonishing three quarters of worldwide growth in manufacturing value added that occurred in low and middle-income nations (Hanson [2012]).

Our work contributes to the rapidly developing literature on the labor market consequences of globalization, much of which focuses on the consequences of international competition for wages and employment at the firm, industry, or region level.[6] Concerning China's impact on U.S. labor markets, recent findings imply that greater import exposure results in higher rates of plant exit and more rapid declines in plant employment (Bernard, Jensen, and Schott [2006]), larger decreases in manufacturing employment and increases in unemployment and labor force non-participation rates in regions that specialize in industries in which China's presence is strong (Autor, Dorn, and Hanson [2013a]), and larger employment declines in industries in which the threat of reversion to high import barriers was erased by China's joining the WTO (Pierce and Schott [2013]).

The current paper extends the literature on labor market impacts of trade by shifting the focus from aggregate market level reactions to adjustments at the worker level. By estimating the difference in outcomes among workers who ex ante are observationally similar except for their industry of employment, our analysis captures variation in the incidence of trade-induced disruptions to earnings and employment caused by proximity to the shock.[7] Implicitly, this variation in incidence arises

[3] Limitations of the SSA data include not recording hours worked, within-year spells of unemployment, or receipt of government benefits other than through Social Security.

[4] Our identification strategy follows Autor, Dorn, and Hanson (2013a) and Bloom, Draca, and Van Reenen (2011).

[5] China's export growth is the culmination of a sequence of reforms that began in the 1980s. Naughton (1996) marks 1984 as the year that China's tilt toward exports initiated. In 1992, China launched a further wave of reforms that welcomed foreign direct investment and promoted Special Economic Zones. China's 2001 WTO entry solidified its most-favored-nation status in the United States, though it had enjoyed de facto MFN status since 1980.

[6] See Amiti and Davis (2012) and Hummels, Jorgensen, Munch, and Xiang (2013) on trade and firms; Artuc, Chaudhuri, and McLaren (2010) and Ebenstein, Harrison, McMillan, and Phillips (2011) on trade and industries; and Chiquiar (2008), Topalova (2010), and Kovak (2013) on trade and regions.

[7] For structural analyses of trade shocks and labor market dynamics in the presence of search frictions and entry

from frictions to moving workers between jobs, since, absent such frictions, wages would equalize for similar workers at all moments of time and we would detect no earnings differences across workers either in the short or long run. Though our approach prevents us from estimating the impact of trade on equilibrium employment or wages for entire skill groups, it allows us to quantify the distribution of incidence among workers along four margins of worker adjustment: the change in earnings at the initial employer (intensive margin), the change in earnings associated with job loss (extensive margin), the change in earnings associated with uptake of government benefits (transfer margin), and the change in earnings associated with moving between employers, industries, and/or regions (reallocation margin). Decomposing changes in earnings across these margins reveals where in the adjustment process frictions arise and which types of workers face larger adjustment burdens.

The research we present also relates to an influential literature on the long run consequences of job loss. In pioneering work, Jacobsen, LaLonde, and Sullivan (1993) draw on administrative data to identify episodes in which plants engage in mass layoffs, meaning that they dismiss a substantial fraction of their employees within a short time span.[8] While we follow this literature in using administrative data to examine the long-run effects of shocks on worker outcomes, we break from it by focusing on the specific shock of China's export growth. It is by identifying the source of the shock that we see worker adjustment along intensive, extensive, transfer and reallocation margins.

To preview the results, we find that workers more exposed to trade with China exhibit lower cumulative earnings and employment and higher receipt of Social Security Disability Insurance (SSDI) over the sample window of 1992 through 2007. The difference between a manufacturing worker at the 75th percentile of industry trade exposure and one at the 25th percentile of exposure amounts to cumulative earnings reductions of 46% of initial yearly income and to one-half of an additional month where payments from SSDI are the main source of income. Trade exposure increases job churning across firms, industries, and sectors. More exposed workers spend less time working for their initial employer, less time working in their initial two-digit manufacturing industry, and more time working elsewhere in manufacturing and outside manufacturing altogether.

The magnitudes of job churn and adjustment in earnings and employment differ substantially across demographic groups. Workers with lower labor force attachment, shorter tenure, and lower earnings incur larger losses in subsequent earnings and employment, while losses for workers with

and exit costs, see Helpman, Itskhoki, and Redding (2010), Helpman, Itskhoki, Muendler, and Redding (2012), Coşar (2011), Dix-Carneiro (2014), and Coşar, Guner and Tybout (2011).

[8]See also Sullivan and von Wachter (2009), von Wachter, Song, and Manchester (2009), and Couch and Placzek (2010) for recent work that uses administrative data, and see Neal (1995), Parent (2000), and Chan and Stevens (2001) for representative work on job loss using survey data. An alternative approach to study job loss uses the CPS Displaced Workers Survey (DWS) (e.g., Addison, Fox, and Ruhm [1995]; Kletzer [2000]; Farber [2005]).

high initial earnings are modest.[9] Distinct from their high-wage counterparts, low-wage workers churn primarily among manufacturing industries, where they remain exposed to trade shocks.

Import competition is but one of the forces impinging on U.S. manufacturing. Technological progress has been rapid in computer and skill intensive sectors (Doms, Dunne, and Troske [1997]; Autor, Katz, and Krueger [1998]), and to the degree this is correlated with industry trade exposure, it poses a potential confound for our identification strategy.[10] To capture industry exposure to technical change, we control for capital and technology intensity, as well as industry pre-trends in employment and wages. We further perform falsification tests to verify that future increases in trade exposure do not predict past changes in worker outcomes. These robustness tests support the interpretation that our identification strategy isolates industry level shocks caused by rising import competition rather than other temporal confounds. Our results are also robust to a broad set of alternative measures of trade exposure to China.

Our analysis complements Autor, Dorn, and Hanson (2013a), who estimate changes in employment and average earnings across U.S. local labor markets resulting from regional exposure to import competition from China. Because that work uses repeated cross sections on geographic localities, it cannot address how individuals adjust to trade shocks. We are able to measure worker-level consequences by focusing on the substantial differences in trade exposure that derive from the initial industry of employment. In alternative specifications, we also control for trade exposure operating through workers' regions of residence, although variation in geographic exposure to trade is less well measured in our data. Consistent with Autor, Dorn, and Hanson (2013a), we find little evidence that geographic mobility is an important mechanism through which trade adjustment operates.

We begin by documenting our approach to estimating the effects of exposure to trade shocks and describing the data. Section 2 provides estimates of the impact of trade shocks on cumulative earnings, employment, and benefit receipts for high-attachment workers. Section 3 examines heterogeneity in the consequences of trade shocks by individual characteristics and conditions of initial employment. Section 4 explores alternative measures of trade exposure, and section 5 concludes.

1 Motivation, Identification and Data

We examine changes in outcomes for workers over the 1992 to 2007 period that are associated with exposure to growing imports from China. The context for our analysis is one in which China

[9] These results contrast with earlier literature, which finds that earnings losses for affected workers are relatively uniform across worker type (e.g., Jacobson, LaLonde and Sullivan [1993]; von Wachter, Manchester and Song [2009]).

[10] Reassuringly, Autor, Dorn and Hanson (2013b,c) find that across U.S. local labor markets, exposure to import competition and exposure to computerization are essentially uncorrelated.

experiences productivity growth, factor accumulation, and reductions in trade costs, which lead its exports to expand. Trade theory predicts how such shocks affect wages in China, the United States, and the rest of the world (e.g., Hsieh and Ossa [2011]; di Giovanni, Levchenko, and Zhang [2011]). Our interest here is reduced form and relatively narrow in focus: we seek to capture the changes in earnings and employment that workers in exposed industries encounter when adjusting to the shock.

1.1 Industry Trade Shocks

As theoretical motivation, consider an economy with two sectors, one that is directly exposed to trade shocks in the rest of the world and one that is not.[11] In the long run, but not necessarily the short run, labor is mobile between sectors, equalizing wages for similarly skilled workers. Implicitly, non-labor factors are immobile across sectors, as in the specific factors model (Feenstra [2004]). Suppose that productivity growth abroad causes product demand to fall for the economy's trade exposed industry. The immediate impact is to reduce the industry's demand for labor, causing its nominal wages to fall and inducing some of its workers to relocate to the unexposed sector. If there are frictions in moving labor between industries, adjustment will be slow, forcing nominal wages in the exposed industry to remain below those in the non-exposed industry during the transition. Over time, labor will continue to exit the exposed sector until inter-industry wages are again equilibrated. Summing worker earnings over the pre-shock, shock, and post-shock periods, nominal and real cumulative incomes for workers *initially employed* in the exposed sector will be less than for workers initially employed in the unexposed sector. The resulting earnings differences, attributable entirely to the transitional phase, are increasing in the extent of labor immobility across sectors in both the short and medium run. This effect on cumulative earnings, and the associated churning in workers across employers, industries and possibly regions, are the focus of our empirical analysis.

Empirically, we capture shocks to foreign export supply using changes in China's presence in the U.S. market. Our baseline measure of trade exposure is the change in the import penetration ratio for a U.S. industry over the period 1991 to 2007, defined as

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

where for U.S. industry j, $\Delta M_{j\tau}^{UC}$ is the change in imports from China over the period 1991 to 2007 and $Y_{j0} + M_{j0} - E_{j0}$ is initial absorption (measured as industry shipments, Y_{j0}, plus industry imports, M_{j0}, minus industry exports, E_{j0}). We choose 1991 as the initial year as it is the earliest

[11] An online theoretical appendix provides the formal analysis underlying this discussion.

period for which we have disaggregated bilateral trade data for a large number of country pairs that we can match to U.S. manufacturing industries.

A natural concern with equation (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. Even if the factors driving China's export growth are internal supply shocks, U.S. industry import demand shocks may still contaminate observed bilateral trade flows. To capture the China supply-driven component in U.S. imports from China, we instrument for trade exposure in (1) with the variable

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

where $\Delta M_{j,\tau}^{OC}$ is the change in imports from China from 1991 to 2007 in non-U.S. high income countries, based on the industry in which the worker was employed in 1988, three years prior to the base year.[12] We use industry of employment in 1988, rather than 1991, to account for worker sorting across industries in anticipation of future trade with China. The motivation for the instrument in (2) is that high income economies are similarly exposed to growth in Chinese imports that is driven by supply shocks originating in China.[13] Thus, the identifying assumption is that industry import demand shocks are weakly correlated across high-income economies. In an online appendix, we regress the value in (1) on the value in (2), which is equivalent to the first-stage regression in the estimation without controls. The coefficient is 0.855 and the t-statistic and R-squared are 9.20 and 0.34, indicating the strong predictive power of import growth in other high income countries for U.S. import growth from China.

A potential threat to our identification strategy is that product demand shocks are correlated across high-income countries, implying that our IV estimates may be contaminated by correlation between import growth and unobserved components of product demand. This would tend to bias a negative impact of trade exposure on earnings and employment toward zero. To help address this concern, we alternatively measure the change in trade exposure using a gravity-based strategy, which captures changes in China's industry productivity relative to changes in U.S. industry productivity, akin to the change in China-U.S. comparative advantage. The gravity approach neutralizes demand conditions in importing countries by using the change in China's exports relative to U.S. exports within destination markets, helping isolate supply and trade-cost-driven changes in China's export

[12] These countries are Australia, Denmark, Finland, Germany, Japan, New Zealand, Spain, and Switzerland, which are the high income countries for which we can obtain disaggregated bilateral HS trade data back to 1991.

[13] An alternative identification strategy would be to consider specific policy shocks that may have contributed to China's export growth, as in Bloom, Draca and Van Reenen (2011), who exploit the end of the Multifibre Arrangement (MFA), or Pierce and Schott (2012), who exploit China's accession to the WTO.

performance. Our gravity and IV estimates end up being very similar, suggesting that correlated import demand shocks across countries are not driving our results.

An additional threat to identification is that growth in imports from China may be due to technology shocks affecting all high-income countries that have shifted employment away from apparel, footwear, furniture, and other labor-intensive industries. We address this issue in the estimation by employing an extensive set of initial-year industry controls that potentially account for confounding technology shocks. We discuss additional robustness tests in the sections that follow.[14]

1.2 Measuring Trade Exposure

There is immense variation in import growth across industries. We use data on trade flows from UN Comtrade, concorded from HS product codes to 397 four-digit SIC manufacturing industries (see the Data Appendix). A combination of these data with information on shipments by U.S. four-digit industry from the NBER Productivity Database (Bartelsman, Becker, and Gray [2000]) yields the industry-level trade exposure measure of equation (1). Figure II plots on the horizontal axis the change in industry import penetration from China from 1991 to 2007 and on the vertical axis the share of production workers in industry employment in 1991—meant to capture industry dependence on less-skilled labor. Each four-digit industry is a point on the graph. We use common symbols for industries that fall within each of ten broad sectors, where each sector consists of industries that have relatively similar production-worker employment shares.

Focusing first on changes in import penetration at the sector level, which are reported in the legend to Figure II, the sectors with the largest increase in exposure from 1991 to 2007—whose component industries include points located on the far right of the figure—tend to be those intensive in the use of production workers. These highly trade exposed sectors include toys, sports equipment, and other products (whose industries appear as squares), with a 32.6 percentage point increase in import penetration; apparel, leather (footwear), and textiles (shown as hollow diamonds), with a 16.7 percentage point increase; and furniture and wood products (shown as triangles), with a 15.2 percentage point increase. The four digit industries within each of these broad sectors are located relatively far up the vertical axis, indicating a high level of production worker intensity. Also exposed to trade is machinery, electrical machinery, and electronics where import penetration grew by 15.2 percentage points. In the United States, this sector contains both more-skill and less-skill intensive industries (e.g., semiconductors in the former and computer peripherals in the latter group),

[14] Recent evidence (e.g., Bloom, Draca, and Van Reenen [2011]; Autor, Dorn, and Hanson [2013c]) suggests that automation and related changes in technology are not what is behind rising import penetration from China.

evident in the wide vertical range of the plus plotting symbols in Figure II. In China, the dominant industries within this sector include finished computers and telecommunications equipment (e.g., cell phone handsets), within which the country specializes in the processing of components and final assembly. The least exposed sectors in Figure II—food products, beverages, and tobacco; chemical and petroleum products; and transportation equipment—each have changes in import penetration of less than two percentage points and thus their industries are clustered vertically close to the y-axis. These sectors have in common intensive use of natural resources or physical capital. Overall, the broad patterns of sectoral import growth are consistent with China's strong comparative advantage in labor-intensive activities (Amiti and Freund [2010]; Huang, Ju, and Yue [2011]).

Notwithstanding the differences in trade exposure by broad sector, factor intensity is not the whole story behind China's export growth. Visible in Figure II is variation in the change in industry import penetration *within* broad sectors. The location of the hollow diamonds high on the vertical axis confirms the apparel and textile industries' dependence on production workers. Yet, within the sector, the most exposed industries see changes in import penetration of over 90 percentage points, whereas the least exposed see changes of less than 10 percentage points. Within sector variation in trade exposure is consistent with the idiosyncratic nature of comparative advantage (Schott [2004]). Factor intensity determines high level patterns of specialization (Romalis [2004]), with other factors shaping which goods countries produce. In China's case, the factors affecting within broad sector export performance include the ease of offshoring (Feenstra and Hanson [2005]), proximity to suppliers or buyers (Koopman, Wang, and Wei [2012]), and the phase-out of rules favoring state-owned firms in exporting (Khandelwal, Schott, and Wei [2013]). In the empirical analysis, we include controls for the ten broad sectors indicated in Figure II, meaning that our identification strategy exploits variation in import growth among industries with similar skill intensities.

It is worthy of note that China's export production also relies heavily on imported inputs. During the sample period, approximately half of China's manufacturing exports were produced by export processing plants, which import parts 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 gross value of its exports overstates actual value added in the country. Recent evidence suggests, however, that the domestic content of China's exports is substantial and rising. 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 highly specialized export processing sector, domestic value added rose from 32% of gross exports in 2000 to 46% in 2006 (Kee and Tang [2012]). Our instrumental variable strategy does not require that China is the sole producer of the goods it ships

abroad but rather that the growth of its manufacturing exports is driven largely by factors internal to China. To account for how input trade may affect the transmission of trade shocks in China to U.S. industries, we use six alternative measures of changes in import competition, alongside our principal measure in equation (1), discussed in section 4.

1.3 Worker Level Data

We draw on the Annual Employee-Employer File (EE) extract from the Master Earnings File (MEF) of the U.S. Social Security Administration to study longitudinal earnings histories for a randomly selected one percent of workers in the United States. Most of our analysis explores the impact of import competition on workers' career outcomes during the years 1992 and 2007, while using data since 1972 as control variables and for robustness checks. For each worker and year, we observe total annual earnings, and an employer identification number (EIN) and detailed industry code (SIC) for the worker's main employer.[15] We augment the EE data using additional Social Security Administration data files that provide basic demographic characteristics of workers, their income obtained from Social Security benefits and from self-employment, and information on total employment and payroll for each firm represented in the data.[16] The data lamentably do not contain information on hours worked or on spells of unemployment less than one calendar year in duration.

From 1993 forward, we also observe an individual's county of residence and can therefore match the worker to the commuting zone in which he resides.[17] Measuring trade exposure in the local labor market is complicated by a lack of geographic information for earlier years and for workers without employment in a given year; further, the one percent extract of the SSA data provides an imprecise measurement of local industry composition.[18] In light of these limitations, we examine the regional dimension of worker exposure to trade shocks in extensions to the main results but not in the baseline specification. Since the correlation between industry-level and region-level trade exposure is small in the data (correlation coefficient of 0.12), the main results for worker adjustment to industry-level trade shocks are not sensitive to controlling for variation in geographic trade exposure.

We focus on workers who were born between 1943 and 1970 and study their outcomes over the period 1992 to 2007, during which these individuals were between 22 and 64 years old. We use two samples in the estimation. Our primary sample of 508,129 workers consists of workers with

[15] For workers who have multiple jobs in a given year, we aggregate earnings across all jobs and retain the EIN and SIC of the employer that accounted for the largest share of the worker's earnings.

[16] We lack information on receipt of other forms of government benefits.

[17] The 722 commuting zones, which cover the entire U.S. mainland, are clusters of counties that share strong within-cluster and weak between-cluster commuting ties in the 1990 Census.

[18] In order to mitigate these problems, we impute a worker's 1991 residential location (see Data Appendix) and incorporate tabulations of industry employment by county from the 1990 County Business Patterns.

high labor force attachment in each year from 1988 to 1991 (i.e., prior to the outcome period), with earnings that equal or exceed the equivalent of 1,600 annual hours of work at the real 1989 Federal minimum wage. The full sample, containing 880,465 workers, adds workers with low labor force attachment and comprises all working-age individuals who had positive earnings (and a valid industry code) for at least one year each during 1987 through 1989 and 1990 through 1992.[19]

2 Impacts of Trade Exposure on Earnings and Employment

We begin by examining the impact of trade exposure on total earnings and employment, and next consider worker adjustment to trade shocks through transitions between jobs, regions, and receipt of benefits. We study five main worker outcomes over the sample period: total labor earnings, the number of years with positive labor earnings, earnings per year for years with non-zero earnings, total self-employment income, and total Social Security Disability Insurance (SSDI) benefits received.[20] Table I describes variation in these outcomes across workers. For the main sample of workers with with high labor force attachment, the average worker had positive labor earnings in 14.2 of the 16 years, cumulatively earned 19.2 times his initial average annual wage (measured as the average of the annual wage between 1988 and 1991), earned an average of 1.3 initial annual earnings in years in which earnings were non-zero, and spent 0.3 years (4 months) in which SSDI benefits were the main income source. Among individuals initially employed in manufacturing, the average increase in import penetration from China was 7.7 percentage points.

Our baseline model takes the form:

$$\tilde{E}_{ij\tau} = \beta_0 + \beta_1 \Delta IP_{j\tau} + \beta_2 IP_{j,91} + X'_{ij,0}\beta_3 + Z'_{j,0}\beta_4 + e_{ij\tau}, \tag{3}$$

where $\tilde{E}_{ij\tau} = \sum_{t=92}^{t=07} E_{ijt}/\bar{E}_{it_0}$ is cumulative earnings over 1992 to 2007, normalized by average annual earnings over 1988-1991, for worker i employed in industry j in 1991. Cumulative earnings embody the sum of labor market activity over the sample period. Normalizing cumulative earnings by workers' initial (pre-shock) earnings $\bar{E}_{it_0}$ provides a natural metric for assessing the effect of shocks on the evolution of earnings. Relative to the conventional approach of taking the logarithm of earnings to provide a proportional scale, this normalization has two virtues: baseline earnings are constructed with *pre*-shock data only and so are not contaminated by post-shock outcomes; and

[19] Observations from the first period are necessary to construct (2) and for the second period to construct (1).

[20] Because the sample is individuals of working age, the vast majority of workers who report Social Security benefits receive them in the form of SSDI, rather than Social Security Retirement Income (whose primary recipients are aged 65 or older) or SSI, whose primary recipients do not have sufficient prior work history to qualify for SSDI.

scaling post-shock earnings by the pre-shock baseline circumvents the problem that log earnings are undefined when income from some period or source is zero.

We model the cumulative shock due to trade exposure in equation (3) as a function of import penetration in 1991 ($IP_{j,91}$) plus the growth in import penetration from 1991 to 2007, which is equivalent to the initial condition plus the average annual change ($\Delta IP_{j\tau}$, as defined in equation (1)). The vector X_{ij0} contains controls for the worker's gender, birth year, race, and foreign-born status, average log annual earnings over 1988 to 1991 and its interaction with worker age, lagged earnings growth from 1988 to 1991, indicators for labor market experience and for tenure as of 1991 in the worker's primary firm, the level and growth of the primary firm's average wage between 1988 and 1991, and indicators for the size of the primary firm.The vector $Z_{j,0}$ controls for economic conditions in industry j in 1991, discussed in more detail below. While trade exposure and industry characteristics vary at the level of workers' 4-digit industries in 1991, standard errors are clustered at the level of 3-digit industries, thus allowing for correlation in error terms among workers who are initially employed in the same or in closely related industries.

Implicitly, our analysis compares workers with similar demographic characteristics, employment histories, and average firm and industry characteristics, some of whom work in industries subject to import competition from China and some of whom do not. If labor markets are frictionless, such that workers can costlessly change industries and obtain identical compensation in alternative lines of work, we will see no earnings or employment impacts from exposure to China trade—though we should still be able to detect inter-firm and inter-industry mobility induced by trade exposure. If growing imports from China cause wages to change for entire groups of similarly skilled workers, our approach would also fail to identify such adjustments in earnings or employment, since in this case the wage effects would not be firm or industry-specific. Conversely, we will find that trade impacts worker outcomes if trade shocks induce exposed firms to cut wages and employment, and either firm or industry-specific human capital make it costly for workers to change employers or industries (Neal [1995]), or search and matching frictions reduce the gains from changing jobs in the event of separation (Helpman, Itskhoki, and Redding [2010]; Rogerson and Shimer [2011]).

A further consideration is that individuals will be exposed to trade not just through their initial industry of employment but also through their region of residence. Regions more vulnerable to import competition from China—by virtue of being specialized in sectors in which China has a strong comparative advantage—have undergone larger reductions in overall employment and earnings (Autor, Dorn, and Hanson [2013a]). We also address how workers are affected by an import shock to the industries of other workers in their local labor market, in addition to the own-industry trade

shock. The local labor market trade exposure for worker i is measured by averaging the value of (1) across all other workers in the same initial commuting zone of residence, while the instrument for local labor market import exposure is the corresponding average of other workers' values of (2).

2.1 Cumulative Earnings, Years Worked, and Earnings per Year

Table II presents baseline estimates of equation (3) using the sample of individuals with high labor force attachment for the outcome period 1992 to 2007. We initially include only the Chinese import penetration measure and a full set of birth year dummies to account for life cycle variation in earnings. The regression in column 1 is estimated by OLS, whereas the regression in column 2 is estimated by two-stage least squares, using the variable described in (2) as an instrument for the change in import penetration given in (1). In both cases, there is a negative and statistically significant relationship between the change in import penetration and cumulative earnings over 1992 and 2007. Greater exposure to imports from China based on a worker's initial industry of employment is associated with lower total earnings over the subsequent 16-year period.

To interpret the coefficient estimates, we compare a manufacturing worker at the 75th percentile of the change in trade exposure (7.30 percentage points) with a manufacturing worker at the 25th percentile (0.62 percentage points, see Table I).[21] The implied differential reduction in earnings over the 16-year outcome period for the worker at the 75th percentile is 20% ($-2.94 \times (7.30 - 0.62)$) of initial annual earnings in column 1, and 38% ($-5.73 \times (7.30 - 0.62)$) of initial annual earnings in column 2. The 2SLS estimate is roughly twice the magnitude of the OLS estimate, which is consistent with there being a positive correlation between U.S. industry import demand shocks and U.S. industry labor demand, which would bias the OLS estimate towards zero.[22]

In column 3, we add dummies for female, non-white and foreign-born; column 4 controls for individuals' work history by adding dummies for tenure at the 1991 firm (0-1, 2-5, 6-10 years), experience (4-5, 6-8, 9-11 years), and size of the 1991 firm (1-99, 100-999, 1000-9999 employees); and column 5 controls for worker earning histories, including the annual log wage averaged over 1988-1991, an interaction of initial wage with age, the change in log wage between 1988 and 1991, and the level and trend of the 1991 firm's log mean wage for 1988 to 1991.[23] These additional controls modestly increase the magnitude and precision of the coefficient of primary interest.

[21] Non-manufacturing workers are not a useful comparison group since by definition they have zero trade exposure.

[22] A second difference between these specifications is that the OLS model uses 1991 industry affiliation in its exposure measure while the the 2SLS model uses 1988 industry affiliation for the instrument. Since the first stage relationship will be tighter for workers who remain in the same industry in 1988 and 1991, differential effects of trade shocks by worker attachment to the initial industry may also contribute to the greater magnitude of the 2SLS point estimates.

[23] Data on firms' total wage bill and total employment is drawn from the full SSA Master Earnings File instead of the 1% sample.

Industries that are subject to greater import competition may also be exposed to other economic shocks that are confounded with China trade. To capture overall industry exposure to trade, column 6 includes controls for initial trade penetration by Chinese and non-Chinese imports in the worker's industry. Column 7 adds dummies for 10 manufacturing sectors, meaning that the regression models compare outcomes for manufacturing workers who are initially employed in different sub-industries of the same sector. To address differential rates of technological progress across manufacturing industries, in column 8 we include controls for the 1990 level of computer investment, the share of investment allocated to high-tech equipment, the capital/value added ratio, and the 1991 employment share and log average hourly wage of production workers. This column further includes the share of imported intermediate inputs in material purchases (from Feenstra and Hanson [1999]) to capture overall industry exposure to offshoring. To account for pre-existing trends in industry growth, column 9 adds measures of changes in industry employment shares and log average wage levels during the preceding 16 years, 1976 to 1991.

The additional controls in columns 6 through 9 have little substantive impact on the estimated impact of import penetration. The coefficient of -6.86 on the import penetration in the final column is about 20 percent larger than in the initial 2SLS specification (column 2). This suggests that conditional on demographic measures, workers with somewhat higher potential earnings are initially employed in industries that subsequently experience sharper rises in trade exposure. Accounting for these sources of heterogeneity thus leads to a slightly larger estimate of the earnings losses that workers experience due to trade exposure. To gauge the economic magnitude of this point estimate, we again compare the implied impact on earnings of a manufacturing worker at the 75th versus 25th percentile of the change in trade exposure. Multiplying by the point estimate in column (9), we find a reduction of cumulative earnings by approximately one half of an initial annual wage for the more exposed worker ($-6.86 \times (7.30 - 0.62) = 45.8$).

The upper panel of Table III considers two additional labor market outcomes. Column 2 estimates the impact of trade exposure on the number of years between 1992 and 2007 in which the worker has non-zero labor earnings. This measure of the extensive margin of employment is coarse: an individual who works a single day in a year will have non-zero earnings, so even prolonged periods of non-employment will go undetected unless they span a full calendar year. The point estimate of -0.53 in column (2) is negative, suggesting that increases in industry trade exposure reduce subsequent years of employment. But this coefficient is not statistically significant and it implies only a modest effect of trade exposure on years with positive earnings.[24] The third column of Table III

[24] The drop in employment years for a manufacturing worker at the 75th percentile of exposure relative to a worker

considers the impact of trade exposure on earnings per year of employment (in multiples of the initial annual wage) for years in which labor earnings are non-zero. The point estimate of -0.39 ($t = 2.8$) suggests that trade exposure depresses future earnings: specifically, earnings are differentially reduced by 2.6% per year (-0.39×6.7) for a worker initially employed in an industry at the 75th percentile of exposure relative to a worker at the 25th percentile of exposure. In combination, the estimates in columns 2 and 3 reveal that the net reductions in cumulative earnings seen in column 9 of Table II (and replicated in Table III column 1) stem primarily from reductions in within-year earnings rather than from additional years with zero earnings. These within-year earnings declines are, in turn, a combination of reduced earnings per hour and reduced hours worked, the relative contributions of which we cannot disentangle with our data.

Could these results merely reflect the secular decline of labor-intensive U.S. manufacturing employment rather than the period-specific effects of exposure to China trade? We explore this concern in panel B of Table III by testing whether the growth in import competition from China in the 1990s and 2000s "predicts" earnings and employment outcomes for an earlier cohort of workers that was *not* directly exposed to Chinese competition.[25] This falsification test provides scant evidence of the hypothesized confound. Column 1B estimates a negative relationship between cumulative earnings and future industry level China trade exposure occurring during the 1990s and 2000s, but the point estimate is insignificant and less than one-tenth the magnitude of the analogous contemporaneous estimate in panel A. Column 2B finds a weakly *positive* relationship between years of non-zero labor income and subsequent industry trade exposure, opposite to panel A. Finally, column 3B finds a small, negative and insignificant relationship between annual wages in years with non-zero earnings and subsequent trade exposure. In net, future trade exposure is a poor predictor for past earnings and employment outcomes for workers, suggesting that our main findings are not plausibly attributable to industry-specific trends that predate the rise of import competition from China.

Figure III provides a dynamic view of these findings by plotting the estimated effect of import exposure on worker cumulative outcomes calculated on a rolling annual basis for each year from 1991 to 2007. The estimating equations underlying the top panel of the figure are identical to those in our baseline regression (Table III, column 9) except that in place of workers' cumulative earnings over the entire period 1992 through 2007, we use cumulative earnings up through the year indicated

at the 25th percentile is 3.6% of a year (-0.54×6.7), or about two weeks, during the 16-year outcome period.

[25] We draw on an extended version of the Social Security data to construct cumulative earnings from 1976 to 1991 for workers who were between 22 and 64 years of age during this earlier period, and use these data to examine whether their employment outcomes during 1976 through 1991 are correlated with later, post-1991 changes in Chinese import penetration that subsequently occurred in their initial industries. The sample for the analysis of the 1976-1991 period uses the same sampling criteria as our main sample, and hence comprises the workers who earned at least the equivalent of $8,193 at 2007 values in each of the four years preceding the outcome period.

on the horizontal axis. Trade exposure remains the *total change* over the 1991 to 2007 period, such that the figure depicts how the impact of trade exposure amasses over time. The figure reveals a significant adverse effect of trade exposure on cumulative earnings in every year between 1992 and 2007. The impact coefficients become progressively more negative over the 1990s and then grow even more rapidly after 2001; the 2001-2007 total decrease is nearly twice that for 1992-2001.

The path of earnings evident in the upper panel of Figure III encompasses multiple possible channels of adjustment. If workers' initial sectoral affiliations are relatively durable, the monotonic decrease in earnings may be a consequence of extended exposure to the rise in import competition. Alternatively, trade shocks may increase churning across jobs, impairing workers' ability to find secure positions or to obtain equivalently high quality matches with new employers, as would be consistent with labor market scarring effects. We present initial evidence of the connection between import competition and job churn in the bottom panel of Figure III, which follows the structure of the top panel but replaces the dependent variable with workers' cumulative number of changes in employers and employment to non-employment transitions as of a given year. From 1992 forward, the coefficients are uniformly positive and are significantly so for all years after 1997. More trade exposed workers have a larger number of job changes, where the sum of these changes steadily grows as the trade shock becomes fully expressed. We subsequently explore whether these more frequent job changes also entail greater mobility across sectors or regions.

The time pattern in the top panel of Figure III highlights an important nuance in interpreting our impact estimates: the rise in China trade exposure is an ongoing process that builds momentum in the early 1990s as China embraces export-led development, and then accelerates after 2001 as the country further opens its markets. Thus, the time pattern of coefficients in Figure III does not constitute an "event study" as in traditional mass-layoff analyses—that is, a discrete shock followed by a time path of adjustments—but rather depicts the interaction between two economic forces, rising import penetration and ongoing worker adaptation. We similarly find that at the industry-level, increases in trade exposure exhibit strong serial correlation: no sizable industry experiences a large increase in trade competition in the 2000s that did not also experience one in the 1990s, or vice versa. Industries that are in the top tercile of trade exposure in one decade but the bottom tercile in the other account for just 1% of all manufacturing workers in our sample. These attributes of the data motivate our parameterization of the rise in China's import penetration in equation (3) as a single long change over the period 1991 through 2007.

2.2 Worker Mobility across Firms, Industries and Sectors

A strength of the SSA longitudinal data is that they permit us to observe the earnings, employment, and job reallocation margins by which workers and, indirectly, their employers, adjust to changes in import penetration. We analyze this reallocation process by decomposing the total worker-level effect of trade exposure seen in Table III into a set of additive, mutually exclusive channels that include: employment observed at the worker's initial employer; employment at other firms within the worker's initial two-digit industry; employment at firms within manufacturing but outside the worker's initial industry; employment outside of manufacturing entirely; and employment at new firms whose industry is unrecorded in the data. This analysis encompasses the direct impact of rising import competition on workers' tenure and earnings at their initial employers as well as any subsequent, potentially offsetting effects of moves across employers, across sub-sectors of manufacturing, and between the manufacturing and non-manufacturing sectors.[26]

Table IV presents the results, beginning in panel A with cumulative earnings. The first column (1A) replicates our main estimate for the impact of trade exposure on cumulative earnings among high attachment workers, while columns 2 through 6 decompose this net earnings effect into its constituent additive parts: initial firm; new firm in same industry and sector; new industry in same sector; new sector; and sector missing.[27] The negative and significant coefficients in columns 2A and 3A reveal that workers initially employed in industries that undergo substantial increases in trade exposure experience both sharply reduced earnings at their initial employers and lower subsequent income from other firms in the same two-digit industry. Do these reductions stem from changes at the extensive margin (reduced years of work), the intensive margin (reduced earnings per year), or both? The estimates in columns 2B and 3B, which consider employment rather than earnings, indicate that the answer is some of both. Comparing across panels, cumulative earnings fall by about 50% more than cumulative employment at both the initial employer and in the initial industry. Columns 2C and 3C confirm this implication: trade exposure significantly reduces earnings per year of employment at the initial firm and at subsequent firms in the same industry.

These impacts at the initial firm and industry may of course be offset by gains in other sectors. Indeed, we know from the small and insignificantly negative *net* estimate of trade exposure on

[26] Prior to the year 2000, industry information is available for 96-97% of all workers is a given year. However, industry codes are missing for most firms that were incorporated in or after the year 2000. The Social Security data very rarely record changes in firms' industry affiliation, and worker outcomes at the initial firm (column 2 of Table IV) thus correspond to outcomes in the initial industry.

[27] In panels A and B (cumulative earnings and cumulative years of employment), summing the coefficients in columns 2 through 6 produces the value in column 1. This adding-up property does not apply to panel C because the outcome variable, earnings per year employed, is a conditional value.

years of employment (column 1B) that employment losses are almost entirely offset: trade-impacted workers make back their employment losses in the initial firm and industry through employment outside of the original two-digit industry. Column 4B indicates that trade-exposed workers spend more years employed at firms that belong to a different two-digit industry within their initial sector of employment. But these offsetting employment gains from reallocation to other two-digit industries within manufacturing are only just over half as large as the losses incurred with the original employer and two-digit industry ($4.65/(6.20 + 2.04) = 0.56$), indicating that trade exposure in a worker's initial firm reduces the worker's total manufacturing employment net of mobility within the sector.[28] Columns 5B and 6B complete the employment picture by considering employment outside of the worker's initial sector and at firms whose industry could not be identified. Workers who are initially employed in trade-exposed industries experience offsetting employment gains in both categories, though results for employment outside of manufacturing are imprecisely estimated.

While trade-exposed workers appear to offset most of their *employment* losses in the initial firm and two digit industry through employment further afield, they do not fully offset lost *earnings* in subsequent employment. In particular, panel A demonstrates that earnings gains in other manufacturing industries are only half as large as the losses incurred with the original employer and industry ($5.91/(9.11 + 3.00) = 0.49$), while earnings gains outside of manufacturing are on net close to zero. Thus, to the degree that trade-impacted manufacturing workers succeed in offsetting initial earnings losses, this primarily occurs through subsequent earnings gains with other manufacturing firms outside of the immediate two-digit industry. This result is surprising since U.S. manufacturing is a comparatively small and *rapidly* contracting sector throughout the time period of our study (see footnote 1). Panel C finally demonstrates that the discrepancy between the large trade-induced reduction in cumulative earnings and the insignificant trade-induced reduction in employment years is explained by lower earnings per year of employment both at the initial firm and at subsequent employers within and outside of manufacturing.[29]

Why don't employment transitions allow initially trade exposed workers to fully recoup declines in earnings with the initial employer? The literature on job loss provides one potential answer (e.g., Neal [1995]): displacement destroys industry specific human capital, leaving affected workers in positions for which they are poorly suited relative to non-displaced workers. A parallel explanation

[28] Column 6B shows moderate employment gains at firms with a missing industry code, a large majority of which were incorporated in the years 2000 to 2007, when a new data collection process no longer recorded information on industry. Even if one assumes that the new firms that employ former manufacturing employees all operate in the manufacturing sector, there is still a sizable negative effect of trade exposure on manufacturing employment or earnings, which may be seen by summing the coefficients across columns 2, 3, 4 and 6 of Panel A or B.

[29] The results in panel C must be interpreted with care, however, since the earnings-per-year effects combine variation stemming from changes in weeks worked, hours worked per week, and earnings per hour of work.

is that workers' specific skills cause them to seek out positions in which they remain exposed to import competition, notwithstanding the predilection of trade impacted workers to exit their original two digit sector. Figure IV provides insight into this latter mechanism by depicting the correlation between workers' trade exposure at their initial employers and at their current employers for each year between 1991 and 2007.[30] In the years immediately following 1991, few workers have yet separated from their original firms, and hence the correlation remains close to one. Over time, the correlation between initial and current firm trade exposure falls, as job transitions proceed apace, but remains strongly positive, leveling off at 0.43 in the final year (2007). As a benchmark against which to evaluate the persistence of trade exposure, Figure IV also plots counterfactual correlations in which trade exposure at any *new* employer is set to zero, such that the reported series summarizes the cumulative likelihood of having left the initial firm as of a given year. Logically this counterfactual correlation also declines over time, reflecting the rising likelihood of having departed from the original place of work. But the counterfactual decline is far more rapid than the actual series and ends up at the much lower level of 0.17 in 2007. By implication, were trade-exposed workers to exit manufacturing immediately after the first job separation, their net subsequent exposure would be 60% lower than in the actual data. Thus, even after changing employers, initially trade-exposed workers appear likely to remain in high exposure industries which are subject to further trade shocks.

2.3 Do Workers Adjust to Trade Exposure through Geographic Mobility?

Transitions across employers and industries are one mechanism by which workers adapt to the consequences of import competition. Moving between geographic locations is another. The literature provides mixed evidence on mobility responses to labor market shocks. The flow of labor across U.S. cities and states following changes in regional labor demand appears to be sluggish and incomplete (Topel [1986]; Blanchard and Katz [1992]; Glaeser and Gyourko [2005]). This sluggishness is most pronounced among less educated workers, who make up a disproportionate share of manufacturing employment (Bound and Holzer [2000]; Notowidigdo [2013]). Consistent with limited mobility responses, Autor, Dorn, and Hanson (2013a) find little impact of regional trade exposure on changes in regional population. We revisit the issue of geographic relocation by extending our analysis to consider whether workers initially employed in more trade exposed industries are more likely to change their place of residence during the sample period.

The SSA data provides a county code for the residence address associated with each individual

[30] The correlations compare the 1991-2007 growth of import penetration between the industry that employed a worker in 1991 and the industry that employed a worker in the subsequent year indicated on the y-axis. This correlation is 1.0 by construction in 1991.

record in a given year. Since individuals may reside in one location and work in another, residence may be a noisy indicator of the employment location. However, because we designate geographic units to be commuting zones—which are defined precisely to be the regions within which individuals usually both live and work—there is a built in buffer against such noise. Other limitations of individual addresses are that they do not appear in the data until 1993, are not available for all workers, and are never observed for individuals who are not employed in a given year.[31]

We match a worker's county of residence in 1993 to the corresponding commuting zone and define a worker to have changed locations if the commuting zone of residence subsequently changes. Despite its limitations, the SSA data appear to accord well with other sources in capturing the frequency of location changes. Molloy, Smith and Wozniak (2011) use the Census to calculate that 12.9% of workers changed their commuting zone between 1995 and 2000; in our SSA sample over the same time frame, the mobility rate is 14.4%. Because geographic information is not available until 1993, when analyzing regional mobility we define the outcome period to be 1994 to 2007 instead of 1992 to 2007. As above, we define the change in import penetration using (1) and continue to use the instrument defined in (2).

Table V presents results on the regional dimension of adjustment to trade shocks. Column 1 repeats the baseline specifications for the shorter outcome period 1994 to 2007, which causes estimates to differ slightly (but not qualitatively) from those in panel A of Table III. We examine the consequences of trade exposure on geographic mobility in columns 2A through 4A by decomposing the earnings that a worker accumulated from 1994 to 2007 according to whether the earnings were accrued in the initial commuting zone, in a different commuting zone, or, in 6% of cases, in locations that are missing a commuting zone identifier.

If workers respond to trade shocks by moving between regions, import exposure will have a negative effect on total earnings in the initial commuting zone in which a worker resides—shown in column 2—which would indicate reduced labor supply in the location where a worker is employed when trade exposure starts to rise. But there would be a positive effect on total earnings in future commuting zones of residence—shown in columns 3 and 4—indicating a shift in labor supply across regions in response to the shock. This pattern is nowhere present in the data. In panel A, the impact of trade exposure on cumulative earnings as a share of initial period earnings is negative not just for workers' initial commuting zones (column 2A) but also for cumulative earnings in other commuting zones (column 3A), and for cumulative earnings in commuting zones that we cannot classify because information on a worker's initial or subsequent location is missing (column 4A). More trade exposed

[31] We are able to determine the 1993 county code of residence for 94% of workers in our main sample.

workers thus receive less in total earnings in all local labor markets in which they reside, suggesting that geographic mobility is not a primary mechanism for adjusting to trade shocks.

Results for cumulative years of non-zero earnings in panel B also fail to indicate that trade exposure causes geographic mobility to increase. Workers initially employed in industries subject to greater import competition have lower cumulative years with non-zero earnings not just in their initial commuting zone (column 2B) but also in other (column 3B) and in unidentified commuting zones (column 4B), though none of these effects is significant. The decline in cumulative earnings by location in panel A is instead driven largely by reduced earnings per year of employment in all commuting zones in which a worker resides (columns 2C-4C). In sum, the results of Table V give further indication that regional mobility is of limited import as a mechanism through which workers adjust to changes in trade exposure.

2.4 Social Security Benefits as a Channel of Adjustment

Alongside changes in employment and earnings, a complementary channel by which workers may adjust to employment shocks is through job search, retraining and transfer programs, such as the federal Trade Adjustment Assistance (TAA) program, state unemployment insurance programs, and numerous need-based transfer programs. One such adjustment program that is observable in our data is the federal Social Security Disability Insurance (SSDI), which provides income transfers and Medicare coverage to workers who have developed a physical or mental disability that prevents them from being gainfully employed.[32] Since workers cannot obtain SSDI if they are employed, it is plausible that the trade-induced declines in employment and earnings seen in Table III may have a counterpart in increased SSDI participation. We explore this possibility in Table VI by analyzing the impact of trade exposure on SSDI enrollment along four margins: the number of years receiving SSDI as a primary income source, cumulative income from SSDI, the probability of receiving SSDI at any point, and the number of years with positive SSDI income for those who receive any benefits.

The first panel of Table VI shows the effect of trade exposure on the *primary* source of income during each year that is observed in our data: labor income (column 1); self-employment income (column 2); SSDI income (column 3); and no recorded income (column 4). Echoing the results in Table III, column 2A shows a negative but insignificant relationship between trade exposure and years with labor earnings as the main source of income: among the workers in our main sample

[32] To become insured by the SSDI program, an individual must have worked in at least five of the ten most recent years in covered employment. Prior literature has established that enrollment in the SSDI program is generally countercyclical, and that local economic shocks can induce sharp rises in SSDI applications and subsequent awards (Black, Daniel and Sanders [2002]; Autor and Duggan [2003]; Autor, Dorn and Hanson [2013a]).

(with strong initial labor force attachment), spending a full calendar year out of work is uncommon. In column 2A of Table VI, trade exposure is also negatively but not significantly correlated with total years in which self-employment is the primary income source, indicating that transitions into self-employment are not an important mechanism for worker adjustment to trade shocks. However, column 3A finds that trade exposure predicts a significant increase in years receiving SSDI as the primary income source. Applying our 75th and 25th percentile comparison among manufacturing workers, the more trade-exposed worker spends an additional half month receiving SSDI benefits as the primary income source during the 16 year outcome window. This is a modest effect. By way of context, the average manufacturing worker spends approximately five months (0.43 years) over the sample period with SSDI benefits as his or her main income source.[33]

In untabulated results, we repeat the analysis above while replacing receipt of SSDI with receipt of any type of Social Security benefit, which includes SSDI, Social Security Retirement Income, and Supplemental Security Income. The results are nearly identical to those Table VI, consistent with our main sample containing working-age individuals with high-attachment to the labor force who are unlikely to qualify for other types of Social Security payments.

Panel B of Table VI studies more closely the impact of trade exposure on income (rather than employment) by considering self-employment and SSDI income alongside wage income. Column 2B finds a negligible impact of trade exposure on self-employment income. Commensurate with the increased duration of SSDI benefit receipts documented in column 3A, column 3B shows a positive and statistically significant effect of trade exposure on receipt of SSDI income (measured in percentage points of the initial average wage). The point estimate of 0.35 implies that a manufacturing worker at the third quartile of exposure receives an additional 2.3% of initial annual earnings in SSDI benefits relative to a manufacturing worker at the first quartile of exposure. Thus, SSDI benefits only replace a small fraction—about 5 percent—of the income lost to trade exposure.[34]

Panel C decomposes the increased duration of SSDI benefit receipts into intensive and extensive margins. While trade exposure significantly increases the likelihood that a worker receives SSDI at some point in the next 16 years, the impact is modest. Comparing the 75th and 25th percentile manufacturing worker, the increment to the probability of *any* SSDI receipt over 16 years is only 0.6 percentage points, with no significant effect on years of receipt conditional on receiving SSDI. This pattern is also evident in the bottom panel of Online Appendix Figure A.2, which shows that the

[33]Workers may exit the labor force and obtain SSDI in the same calendar year without having both sources of income concurrently. In addition, SSDI recipients are permitted to work up to a Substantial Gainful Activity threshold (currently $1,010 per month for non-blind adults) without jeopardizing their SSDI benefits.

[34]Our data indicate that SSDI payments average 47 percent of initial average labor earnings for years in which workers in our sample receive SSDI.

effect of trade exposure on the incidence of SSDI receipt cumulates slowly over the 16 year outcome window. Thus, disability plays an important role on the extreme extensive margin—among workers who exit the labor force altogether—but the majority of trade-exposed workers with an initial strong labor force attachment remain attached to the labor market, albeit at reduced earnings. As subsequent analysis shows, SSDI is a more important adjustment margin for less attached workers.

3 Heterogeneity in Worker Adjustment to Trade Exposure

We have so far followed the literature on mass layoffs by limiting our sample to workers with high labor force attachment. This exclusive focus on high-attachment workers may miss an important dimension of heterogeneity in adjustment to adverse shocks. If workers with weaker attachment are at greater risk of job displacement or face fewer outside employment options, they may be differentially harmed by adverse trade shocks. Alternatively, if these workers are particularly likely to exit the labor market regardless of circumstance, adverse trade shocks may not alter their career trajectories. We assess these differences by comparing results from Table VI to estimates for the full sample that includes workers with low labor force attachment. We then extend the analysis to explore heterogeneity in adjustment according to workers' firm tenure, age, and earnings levels.

3.1 High versus Low Labor Force Attachment Workers

Table VII expands our sample to include workers who had *any* labor income in at least one year during 1987-1989 and one year during 1990-1992, which brings our sample size from 508,129 to 880,465. The additional workers of the extended sample either had zero earnings, or earned less than the salary of a full-time minimum wage job in at least one of the years 1988 to 1991. While our data do not contain information on hours worked, it is likely that the expanded sample contains many more part-time and intermittent workers.[35] For consistency with the broadened sample definition, trade exposure is now measured as the average exposure of the industries that employed a worker during the years 1990 to 1992 while the instrument is based on industry affiliation in 1987 to 1989. All firm- and industry-specific control variables are also averaged over 1990 through 1992, and outcomes are measured over the subsequent period of 1993 to 2007.

We begin in panel A of Table VII by replicating the main specification of Table VI for the original high labor force attachment sample, using suitably modified variable definitions. These changes in

[35]The minimal pre-period earnings of workers in the extended sample are likely a poor proxy of their earnings potential, and they complicate an analysis of future earnings that are expressed in multiples of initial earnings as in Table II. We therefore focus on employment outcomes, as in Table 5.

variable definitions have no substantive effect on the main estimates. Combining high and low labor force attachment workers in panel B magnifies trade's negative impact on years worked and positive impact on SSDI reliance. In column 1B of Table VII, the negative coefficient on total years with main income from labor earnings is sixty percent larger in absolute value than the high attachment coefficient in panel A (and is now marginally statistically significant), implying that among low attachment workers, adjustment at the (extreme) extensive margin of full-year non-employment is comparatively common. In column 2, the reduction in years with main income from self-employment is larger in absolute value terms in the full sample than in the high attachment sample.

Columns 3 and 5 capture the differential responsiveness of SSDI take-up in the two samples. Extending the sample to include low attachment workers increases the coefficient on cumulative years with SSDI as the main income source by 160% (column 3) and the coefficient on ever receiving SSDI income by 120% (column 5). Because low attachment workers are more likely to exit the labor force after a trade shock, as seen in column 1, they are also more likely to take up SSDI, which is unavailable while workers are gainfully employed. Thus, greater usage of SSDI benefits and larger extensive margin employment adjustments go hand-in-hand.

3.2 High versus Low Tenure Workers, Younger versus Older Workers

Low tenure workers comprise a second segment of the labor market omitted by mass layoff studies. Seniority-based employment rules may insulate older workers from external shocks while exposing younger workers to greater risk of career disruption (Oreopoulos, von Wachter and Heisz [2012]). Alternatively, workers with higher tenure may suffer greater losses from trade exposure since their ability to adapt to new employers may be limited (Jacobsen, LaLonde, and Sullivan [1993]).

In the first two panels of Table VIII, we compare the impact of trade exposure on employment and earnings for workers with low job tenure at their initial firms (defined as less than five years as of 1991) to those with high initial tenure (five-plus years in 1991).[36] Condensing the specification in Table IV, we disaggregate worker outcomes according to three mutually exclusive employment venues: the initial employer (column 2), subsequent employers in manufacturing (column 3), and employers outside manufacturing or with a missing industry code (column 4).[37] For reference, the online appendix displays the average trade exposure of manufacturing workers in both high and low tenure subsamples, as well as the exposure for other subsamples that we explore subsequently.

[36] The low and high-tenure groups are drawn from our primary sample with high-attachment workers, and the 5-year tenure cutoff splits this sample roughly in half.

[37] For workers initially employed in manufacturing, 'same sector' and 'other sector' denote manufacturing and non-manufacturing, respectively.

While average trade exposure for low-tenure workers is about one-fourth larger than for high-tenure workers, there is little difference in the timing of exposure within the 1991 to 2007 period. In each subsample that we consider, about one quarter of the increase in trade competition occurs 1991 to 1999, and three quarters in 1999 to 2007, when import growth from China accelerates strongly. The different coefficient estimates for trade impacts on earnings and employment across subsamples of workers cannot therefore be explained by a differential timing of import shocks.

Akin to the Table VII estimates for low-attachment workers, panels A1 and A2 of Table VIII reveal that the negative impacts of trade exposure on cumulative earnings and on earnings per year worked are substantially larger for the low tenure group. In panel A1, the effect of trade exposure on cumulative earnings for low-tenure workers is 8.7 times as large as the estimated effect for high-tenure workers (panel A2). The difference between low and high tenure workers begins at the initial employer. Low-tenure workers experience more than twice the reduction in employment years as high-tenure workers, and more than three times the loss in earnings at the initial firm (panels A1 and A2, column 2). Low tenure workers make up little of this loss through earnings from other employers (panel A1, columns 3 and 4). The comparatively modest but still negative and significant cumulative earnings losses for high tenure workers at the initial firm are offset—by a factor of nearly two-thirds—through gains at employers outside the initial sector (panel A2, column 4). Earnings losses for low-tenure workers are not explained by lost years of employment; in fact, the estimated cumulative employment effect is weakly positive. It appears instead that their annual earnings in subsequent employment lies substantially below their earnings in the original firm.

One reason low tenure workers may be more affected by trade is simply that they are young, with employers preferring to sever ties first with those having less labor-market experience. Panels B1 and B2 of Table VIII separate workers by age, with the younger cohort being 22 to 35 years old in 1992 and the older cohort being 36 to 49 years old in that year. Coefficient estimates are modestly larger for the younger workers, but the difference between the two groups is slight and statistically insignificant. Thus, the larger impacts of trade on low tenure workers in panels A1 and A2 appear to be driven more by their brief attachment to their initial employer than by their youth.

3.3 Differences in Adjustment by Earnings Capacity

The clear pattern emerging from Tables VII and VIII is that workers who have a weaker foothold in the labor market suffer the largest proportionate earnings losses from trade shocks. This suggests more broadly that the adverse effects of trade shocks may be greatest for workers with low earnings capacity, a possibility that we explore in Table IX by separately estimating the impact of trade

on workers subdivided into terciles of average annual pre-exposure earnings (1988 through 1991) *relative* to others in their age cohort. By making within-cohort comparisons, this sample split captures differences in earnings capacity that are likely to stem from factors such as education and ability—not directly observable in our data—rather than experience and seniority.

Table IX confirms that the adverse impacts of trade exposure on worker outcomes are inversely monotone in initial earnings. Column 1 of the top panel finds a large and highly significant negative estimate of the impact of trade exposure on cumulative earnings of bottom-tercile workers. Scaling by the 75/25 metric, the point estimate implies that a low-wage worker in manufacturing at the 75th percentile of exposure loses 1.2 (-18.3×6.7) additional years of initial annual earnings over the subsequent sixteen years relative to a worker at the 25th percentile of exposure. This effect is nearly three times as large as the impact for the full sample (Table II, column 9). In comparison, the estimated impact for middle-tercile workers (panel B) is only half as large as the impact for bottom tercile workers, while the estimated impact for top-tercile workers (panel C) is essentially zero.

Why are the adverse impacts larger for low-wage than for high-wage workers? One possibility is that import competition differentially reduces firms' demand for lower skill workers while leaving high-wage workers relatively unscathed. The subsequent rows of Table IX do not support this conjecture. High, middle and low-wage workers experience similarly large declines in earnings obtained from the initial employer (column 2). What differs between these groups is their subsequent labor market adjustment. High-wage workers recover from initial shocks by moving out of the impacted sector. Middle and low-wage workers are less able to offset those losses through sectoral mobility. High-wage workers on average make up one-fourth of their loss with the initial employer through additional earnings from other firms in the same sector (column 3), and they recoup most of the remaining three-fourths at employers outside of manufacturing (column 4). Middle-wage workers, by contrast, replace around one-third of earnings lost with the initial employer through earnings elsewhere in manufacturing, and they suffer further losses outside of the original sector. At the other extreme, low-wage workers experience no offsetting increase in earnings within the same sector, and they accrue even larger earnings declines outside of the original sector.

The second rows of each panel in Table IX offer further insight into the adjustment process by focusing on years of employment rather than cumulative earnings. Workers at all wage levels experience substantial reductions in years of employment at the initial employer. However, the magnitude of this reduction is nearly twice as great for high-wage relative to middle or low-wage workers. While all three groups appear to largely offset lost earnings *years* (though not lost earnings) at the initial firm through additional employment, their subsequent employment venues differ substantially.

Low-wage workers primarily offset lost employment at the initial firm with employment elsewhere in the manufacturing sector; middle-wage workers offset losses with extra employment both inside and outside manufacturing; and high-wage workers appear primarily to obtain new employment outside manufacturing—highlighting that these workers are particularly mobile across industries. Thus, while workers at all earnings levels exhibit heightened job churning as a consequence of trade shocks, workers at different earnings levels differ substantially in how they adjust to these shocks.

The third rows of each panel in Table IX reveal an additional contrast among earnings groups: low and middle-wage workers experience substantial declines in earnings per year both at the initial firm and at subsequent employers. High-wage workers, by contrast, exhibit no adverse earnings effects, even as they move across firms and sectors.[38] What explains the contrast in earnings consequences among skill groups? One proximate explanation focuses on the differences in their sectoral mobility identified in the second row of Table IX. High-wage workers primarily offset losses at their initial firm by moving out of manufacturing. Low-wage workers, however, disproportionately remain in manufacturing, where their subsequent earnings are subject to rapidly accelerating trade pressure throughout the 1990s and 2000s. A potential cause of this low rate of inter-sectoral mobility is that low-wage workers may be earning rents in manufacturing—that is, wages or net surplus that exceed their alternatives opportunities outside of manufacturing (Katz and Summers, 1989; Gittleman and Pierce, 2011). As trade pressure erodes these rents, workers may therefore choose to accept lower pay in manufacturing rather than seek employment outside of it.

An online appendix investigates whether these differences in reallocation of workers across firms and sectors also operate through differential geographic mobility. Import exposure does indeed shift the employment of high-wage workers from the initial commuting zone toward other regions, while the opposite pattern is observed for workers with middle or low wages. The greater geographic mobility response of high-wage workers is consistent with previous research on U.S. domestic migra-

[38] Among low-wage workers, the implied 75/25 differential loss in earnings per year amounts to 7.8% (-1.2×6.7) annually, while for middle-wage workers, the in-year earnings losses are only approximately half as large. This result appears to stand in contrast with the local labor market evidence from Autor, Dorn and Hanson (2013a), who find that CZ-level trade exposure reduces the log weekly earnings of currently employed college and non-college workers by similar (modest) amounts. Why do the earnings effects of trade exposure measured at the worker level differ substantially by skill group while those measured at the CZ level do not? Noting that our SSA annual earnings data indicate that only a small percentage of primary sample workers has *zero* earnings over the course of a full-year, we hypothesize that the fall in *within-year* earnings detected in the SSA data (Table IX) is reflected primarily in a rise in the odds of non-participation during the survey reference week in the Census and American Community Survey data used in the Autor, Dorn and Hanson (2013a) analysis. Consistent with this supposition, Autor, Dorn and Hanson (2013a, Table 5) find that trade shocks induce a much sharper fall in the probability of labor force participation during the survey reference week among non-college than non-college workers: -0.83 versus -0.30 percentage points per thousand dollars of CZ exposure. The small drop in weekly earnings of low-education workers detected by Autor, Dorn and Hanson (2013a), combined with a large increase in their non-participation, is potentially consistent with the significant decline in the cumulative annual earnings of low-wage workers detected above.

tion (Wozniak [2010]; Notowidigdo [2013]), but the increase in employment years outside the initial commuting zone is not significant either for high-wage workers, or for any of the previously studied tenure and age subsamples. Across all groups of workers, trade exposure induces considerably more mobility across firms and sectors than across space.

In the SSA data, workers with low earnings are differentially impacted by trade shocks. No distinctions between low and high-wage workers appear in the literature on mass layoffs, however, where low and high-skill workers fare equally poorly subsequent to large contractions in their initial firms. In an online appendix, we examine when and how workers separate from their initial employer in response to changes in trade exposure. Not surprisingly, more trade exposed workers are more likely to separate from their initial place of work, with the impact of trade exposure on separation being larger for low-wage workers than for high-wage workers. When we categorize job exits by their proximity to a mass layoff at the initial firm, we find that the contribution of mass-layoff separations to total separations is highest among low-wage and lowest among high-wage workers. Separations from the initial employer immediately *before* a mass layoff have the opposite pattern, being relatively high among high-wage workers. While trade exposure significantly increases the likelihood that a low-wage worker leaves the initial firm during a mass layoff, the only significant effect among high-wage workers is for separations *before* mass layoffs. This difference in pre-mass layoff separations between low and high-wage workers is, naturally, absent in the mass-layoff literature since that work focuses exclusively on workers who have separated during a mass layoff (e.g., Jacobson, LaLonde and Sullivan [1993]; von Wachter, Manchester and Song [2009]). In contrast to existing literature that concludes that mass layoffs have equally scarring effects for workers of all skill levels, our results suggest instead that high-wage workers are less exposed to mass layoffs and are more likely to leave their initial firm in a pre-layoff period when presumably a larger fraction of separations is voluntary.

4 Alternative Measures of Trade Exposure

In this section, we consider alternative measures of workers' exposure to trade with China. We first explore specifications that measure exposure not only to trade competition in the worker's industry, but also in the worker's local labor market of residence. We then re-estimate the regressions for cumulative earnings, cumulative employment years, and earnings per year of employment from panel A of Table III for six alternative measures of industry-level trade shocks.

4.1 Industry-Level and Region-Level Trade Exposure

Our main analysis finds that workers who were employed in subsequently import-exposed industries accumulate substantially lower earnings over their careers than comparable workers in industries with little trade competition, a result consistent with labor market frictions preventing workers from smoothly adjusting to trade shocks. If trade-exposed industries were highly segregated across local labor markets, these results could be consistent with moving frictions inhibiting flows across local labor markets, even while reallocation within these markets is frictionless. This would imply that workers in trade-exposed industries would obtain lower earnings than those in a low-exposure industries primarily because they are located in differentially trade-exposed regions. We explore this hypothesis by testing how our main results are affected by controlling for import exposure in a worker's initial commuting zone of residence, where a CZ's industry exposure is defined as the average growth of Chinese import penetration in the industries of all *other* workers who reside in the individual's initial commuting zone.[39]

Table X follows Table V by analyzing the impact of trade competition on earnings, employment, and geographic mobility during the shortened outcome period of 1994 to 2007. Column 1 shows the impact of industry-level trade exposure on earnings and employment (replicating column 1 of Table V), column 2 regresses the same outcomes on commuting zone-level trade exposure and a set of indicator variables for the nine Census divisions that absorb regional trends, and column 3 combines the two exposure measures.[40] Columns 2 and 3 of panel A show that workers initially residing in CZs with larger increases in trade exposure had significantly lower cumulative earnings over the 1994 to 2007 period. Results for CZ trade exposure are similar either with (column 2A) or without (column 3A) initial own industry trade exposure in the regression; in parallel fashion, results for own industry trade exposure change only modestly when CZ trade exposure is added (columns 1A and 3A). The regions of residence of workers in trade-exposed industries are sufficiently dispersed across space that the correlation coefficient between industry-level and CZ-level trade exposure is only 0.12. The industry-level effects reported earlier are hence not primarily capturing geographic variation in worker's trade exposure. The negative earnings effect of a trade-exposed industry, *conditional* on

[39] To obtain the employment weights of all industries in a commuting zone, we draw on the 1990 County Business Patterns, as in Autor, Dorn, and Hanson (2013a). The CBP provides more precise measures of industry employment structure at the county level than our main data, a one percent random sample of Social Security Administration data. The SSA data provide workers' county of residence as of 1993. We impute 1991 location, taking advantage of the fact that most workers did not change employers, and presumably did not change region, between 1991 and 1993. The Data Appendix provides a detailed description of the imputation procedure.

[40] In combining both industry and regional exposure to trade, our approach complements McLaren and Hakobyan (2010). Though our use of panel data contrasts with their use of Census data on repeated cross-sections of individuals, our results that industry exposure is more consequential than regional exposure are qualitatively similar to theirs.

trade exposure of the local labor market, is consistent with the presence of labor market frictions that prevent a smooth relocation of workers across industries *within* local labor markets.

To interpret the magnitude of the impacts of trade exposure, we use the estimates of column 3A to compare manufacturing workers who are at the 75th versus 25th percentiles of industry trade exposure, or at the 75th versus 25th percentile of regional trade exposure. Over the period 1994 to 2007, the worker in the more exposed industry received 40.5% lower cumulative earnings valued in terms of initial average annual earnings, while the worker in the more exposed local labor market earned 19.7% less than a peer in a less-exposed location.[41] The results on local labor market exposure accord with Autor, Dorn, and Hanson (2013a), who find that commuting zones more exposed to China trade had lower growth in household wage income. To compare with their estimates, we calculate the decline in annual wage income per worker between the start and end of our sample for CZs at the 75th versus 25th percentiles of trade exposure, and use a corresponding calculation based on findings from Autor, Dorn, and Hanson (2013a). From Table X, we estimate that the annual earnings in the more exposed CZs decline by 2.5% of workers' initial annual earnings during the sample period, while we estimate a reduction of average household income per adult of -2.4% between 1990 and 2007 using estimates from Autor, Dorn, and Hanson (2013a).[42]

Panels B and C show the impact of greater regional trade exposure on cumulative years with positive earnings (columns 2B and 3B) and average earnings per year employed (columns 2C and 3C). While earnings per year fall with greater local trade exposure (columns 1A and 1B), the impact on years worked is, surprisingly, positive. Given the large, negative effect of trade exposure on earnings, the slight corresponding increase in total years of employment may be an income effect. It also bears note that these estimates use our main sample of workers with high labor force attachment. While Table VII indicates that industry-level trade shocks particularly reduce employment of less-attached workers, we are unable to include the low-attachment subsample in the Table X analysis since we cannot measure workers' residential locations when they are not employed.

The final three columns of Table X disaggregate the earnings and employment outcomes in col-

[41] These results reflect the fact that trade exposure of manufacturing workers varies much more at the industry level (P75-P25 differential of 6.68) than at the CZ level (P75-P75 differential of 0.83).

[42] We multiply the P75-P25 differential of CZ exposure across all workers with the coefficient in column 2A of Table X to obtain a cumulative earnings loss of $0.86 \times (-20.30) = -17.50$. Assuming that the annual earnings loss increases linearly over time (as roughly suggested by Figure III), we calculate that the final year 2007 contributes 2/14 to the total earnings loss over the 14-year outcome period, corresponding to a decline of annual income by $2/1 \times 4(-17.50) = -2.50$ percentage points of an initial annual income between start and end of the sample period. In Autor, Dorn and Hanson (2013a), the difference between the import exposure of a CZ at the 75th and 25th percentile is 1.11 (with import exposure measured in $1,000 of imports per worker, and averaged over the periods 1990-2000 and 2000-2007), and multiplication with the estimated effect of import exposure on average household wage income per adult yields a differential earnings decline of $1.11 \times (-2.14) = -2.36$ percent of base-year earnings.

umn 3 according to the CZ of residence in which workers accumulated their earnings and employment. Almost all earnings losses due to local labor market exposure occur in the initial, trade-exposed CZ, while losses due to industry exposure are more dispersed across locations (columns 4A to 6A). Workers who are initially located in a trade-exposed region do not appear to spend significantly more employment years in other local labor markets (column 5B).

In summary, the low correlation between industry and local labor market trade exposure allows us to focus on the former shock, which is better observed in our data and contributes more to the variation in career outcomes across manufacturing workers, without confounding it with the latter dimension of exposure that was the focus of Autor, Dorn and Hanson (2013a).

4.2 Alternative Measures of Industry-Level Trade Exposure

In this section, we use alternative measures of industry exposure to import competition to re-estimate regressions from panel A of Table II. Table XI contains the results, with baseline estimates from Table III shown in panel A. The alternative measures of trade exposure are as follows:

(i) *Gravity-based measure of trade exposure.* Our primary strategy for identifying the impact of trade exposure as measured in equation (1) is based on the assumption that growth in imports from China in high income countries is due to supply shocks in China, or global changes in trade policy toward China, rather than import demand shocks in these economies. As an alternative to instrumenting for observed U.S. imports from China with other wealthy countries' imports from China, we determine the supply shock component of import growth from China using the gravity model of trade. With data on bilateral imports by high income countries at the industry level over 1991 to 2007, we estimate a gravity model in which the dependent variable is log industry imports from China minus log industry imports from the United States and the regressors are dummy variables for the importing country, dummy variables for the industry, and standard gravity model controls for trade costs. Taking the China-U.S. difference in log imports removes import demand shocks in the destination market that are common across sources of supply. Changes over time in the residuals from this regression represent the change in China's comparative advantage in an industry relative to the United States. Following the procedure described in the appendix to Autor, Dorn, and Hanson (2013a), we use these residuals to construct an alternative measure of import growth.

The gravity-based approach, shown in panel B of Table XI, allows us to estimate the impacts of trade exposure on cumulative earnings under different identifying assumptions. Since we have neutralized market-level import demand via the gravity estimation, the new identifying assumption is that changes in China-U.S. comparative advantage are uncorrelated with U.S. product demand

shocks. Because the gravity-based measure captures the change in China-U.S. competitiveness across high income markets, it subsumes supply shocks in both countries. Hence, we now allow changes in productivity in either nation to affect cumulative earnings for U.S. workers and no longer assume that U.S. and China supply shocks are uncorrelated. While the gravity-based measure broadens the impact coefficient to reflect China-U.S. relative export growth, the much more rapid pace of productivity growth in China over the sample period suggests that advances in the country's industrial capabilities are likely to be what drives changes in China-U.S. comparative advantage.

(ii) *Other low-income countries.* Changes in import penetration from China may overstate the change in trade exposure for U.S. workers if China competes with other low-wage countries in the U.S. market. One worry is that imports from China simply displace other countries' exports to the United States. To address this concern, we add to imports from China imports from all other low-income countries. Given that China accounts for over 90 percent of recent growth in U.S. imports from low-wage economies, this modification is unlikely to materially affect the trade penetration measure. Results using this measure of trade exposure are shown in panel C of Table XI.

To provide further comparisons with alternative low-wage-country sources of U.S. imports, we replace import penetration from China with import penetration from Mexico and Central America. Results for this outcome are in Panel D of Table XI. Over the sample period, Mexico had minimal industrial productivity growth (Hanson [2011]), making U.S. demand shocks a relatively important driver for growth in U.S. imports from Mexico, especially when compared to China. We would therefore expect our instrumentation strategy to perform poorly for Mexico, as absent strong export supply shocks its shipments to high income countries would be particularly subject to idiosyncratic demand shocks in these markets. Below, we confirm that growth in import penetration from Mexico and Central America has effects that are economically small and statistically insignificant.

(iii) *Other destination markets.* Growth in China's exports affects U.S. industry output not just through intensifying competition in the U.S. consumer market but also in foreign markets in which U.S. firms compete with China. Following this logic, we expand the definition of import penetration in equation (1) to include all destination markets to which U.S. industries export goods. Results using this measure of trade exposure are shown in panel E of Table XI.

(iv) *Net imports.* China's growth causes an increased supply of goods to the U.S. market but may also increase demand for U.S. exports. To account for U.S. exports to China, we also measure trade exposure using *net* imports rather than gross imports, which allows U.S. exports to China to offset some of the loss in production from greater import penetration. Because U.S. manufacturing imports from China are six times larger than U.S. manufacturing exports to China, this change

has a relatively modest effect on the trade exposure measure. Yet, this approach does add the challenge of instrumenting for U.S. net imports from China, requiring that we find an exogenous source of variation in U.S. exports to the country. We use two instruments for U.S. net imports from China. One, given by equation (2), is other high income country imports from China, as in our core specification; the second is the analogous expression to (2) for other high income country exports to China. This instrumentation strategy assumes that growth in high income country exports to China is driven by shocks to China's economy and that high income country exports respond similarly to these shocks. The latter condition may hold imperfectly if high income countries vary widely in their export strengths, an issue of possible concern for the United States given its unusually broad resource base. Results using this measure of trade penetration are shown in panel F of Table XI.

(v) *Factor content of trade.* If the labor content of production varies across China's exports, measuring trade in dollar terms may not accurately capture the impact of import growth on U.S. workers (Borjas, Freeman, and Katz [1997]; Burstein and Vogel [2011]). To account for sectoral differences in labor intensity, we measure net imports in worker equivalent units, using direct and indirect labor usage in the production of industry outputs, based on the 1992 U.S. input-output table. Our measure calculates industry exposure to trade by imputing labor services embodied in net imports using net imports times employment per dollar of gross shipments in U.S. industries ($\tilde{E}_{j0}/Y_{j0}$), where $\tilde{E}_{j0}$ is based on the *direct plus indirect* employment of labor used to manufacture goods in an industry. Results using this exposure measure are shown in panel G of Table XI.

(vi) *Intermediate inputs.* Growth in exports by China represents not just greater competition for U.S. producers but also greater supply of inputs that U.S. industries require, which may positively affect U.S. productivity (Goldberg, Khandelwal, Pavcnik, and Topalova [2010]). To account for input supply effects, we adjust total industry imports for imports of intermediate inputs by netting out the latter, which we estimate based on the 1992 U.S. input-output table. Results using this measure of trade exposure are in panel H of Table XI.

Table XI documents that each of these alternative measures of trade exposure has a negative impact on cumulative earnings of workers over the 16-year sample period, consistent with the main results in Table III. The estimated effects are statistically significant in all specifications except panel D, where import penetration is measured for Mexico and Central America and not for China. Impact coefficients for net imports in panel F are around one third smaller than for the baseline specification in panel A, possibly reflecting difficulties in using other high income countries to instrument for U.S. exports to China or positive effects of growth in U.S. exports to China on worker adjustment to changes in trade exposure. Results for cumulative years with positive earnings and for cumulative

earnings per year worked also reflect the pattern of our main specification in Table III, which documented strong negative effects of exposure to Chinese imports on earnings per year, and more modest effects on employment years. The estimates in Table XI underscore the robustness of our results to alternative specifications of rising import competition from China.

5 Conclusion

China's spectacular export growth in recent decades provides a rare opportunity to examine how workers adjust to trade shocks. Changes in trade flows typically have myriad causes and are jointly determined with other outcomes of interest. In the case of China, its economically rudimentary state at the time the country began to open to foreign trade and investment meant that its subsequent export growth would be driven by the convergence of its economy toward the global technology frontier rather than by idiosyncratic shocks in its trading partners. We exploit this feature of recent Chinese history to examine how U.S. workers adjust to a surge in imports in their initial industries of employment. Data from the Social Security Administration give us a unique longitudinal perspective over an extended period of time to observe how workers respond to greater import competition.

Workers who in 1991—prior to China's rapid growth—were employed in industries that were subsequently exposed to greater import competition from China experienced lower cumulative earnings, weakly lower cumulative employment, lower earnings per year worked, and greater reliance on Social Security Disability Insurance over the 1992 to 2007 period. Exposure to trade induces workers to move between employers and industries but generates little spatial mobility. Workers initially employed in industries with larger increases in import competition were more likely to leave their initial employer, their initial two-digit industry, and manufacturing overall.

There is considerable heterogeneity across workers in adjustment to import competition, which distinguishes our work from previous analyses that examine the labor market consequences of mass layoffs or intensifying import competition. Reductions in cumulative earnings are concentrated among workers with low initial wages, workers with low tenure at their initial firm, and workers with weak attachment to the labor force. Trade competition also affects the careers of high-wage workers, who rapidly separate from their initial employers and move to other firms, often outside manufacturing. Our results are robust to including a large set of worker, firm and industry controls, to using alternative measures of trade exposure, and to falsification tests which verify that future increases in trade exposure do not predict past changes in worker outcomes by industry.

We focus on import growth from China while recognizing that China actively participates in

global production networks. Goods exported by China use inputs produced in other developing economies and in high-income countries. Still, China's enormous size and its rapid rate of technology convergence means that its own growth has been a major impulse for the expansion of global production networks in recent decades. Our findings do not preclude a role for other countries in the recent growth in U.S. imports of labor-intensive manufactures.

Data appendix

Social Security Data

Our main source of data is the Annual Employee-Employer File (EE), an extract from the Master Earnings File (MEF) of the U.S. Social Security Administration that provides longitudinal earnings histories for a randomly selected one percent of workers in the United States. These data provide annual earnings, an employer identification number (EIN), and a Standard Industrial Classification (SIC) code for each job that a worker held. Our analysis draws on information covering the years 1972 through 2007. For workers who have multiple jobs in a given year, we aggregate earnings across all jobs and retain the EIN of the employer that accounted for the largest share of the worker's earnings. Earnings data are inflated to 2007 using the Personal Consumption Expenditure Index, and annual uncapped earnings are Winsorized at the 99th percentile of each year's wage distribution in order to mitigate the impact of outliers on the empirical analysis. We augment the EE data with individual-level information on birth year, sex, race and immigrant status (U.S. or foreign born) from the SSA's NUMIDENT file, which records information from Social Security card application forms. We code race as non-white if the race indicator is missing in the data, which is the case for about 3.5% of all observations. We also add information on annual uncapped self-employment earnings from the MEF (available since 1992), and on Social Security benefit entitlement and benefit amounts from the Master Beneficiary Record (MBR). The Social Security program that is most relevant for our study of working-age individuals is Disability Insurance.

For about 97% of all employees in 1991, we are able to match the EIN of the employer to firm data that provides information on industry and firm size, measured by total employment and payroll in the complete MEF data. The industry classification is based on firms' registration with the Internal Revenue Service (IRS). Coders at the Social Security Administration transform the write-in information from the IRS form to a four-digit SIC code, or to a three-digit or two-digit SIC code if the description of firm activity is not sufficiently detailed to permit a more precise classification. The IRS switched from a paper-based application for obtaining an EIN to an online application

procedure in the year 2000 and the Standard Industrial Classification was replaced by the North American Industry Classification System (NAICS) starting in 1997. For a large portion of new firms that have been incorporated as of these years, we are no longer able to observe industry codes, and the fraction of workers with missing industry information thus grows from 3-4% throughout the 1990s to 20% by 2007.

We are able to observe the county of residence for at least 95% of all employees in each year between 1993 and 2007. Information on residential location is however unavailable prior to 1993, and is never observed when an individual is not employed in a given calendar year. The data also contain county codes for firms, but these correspond to the location where a firm is registered, and not necessarily to an employee's place of work. Since our analysis measures trade exposure in 1991, we impute a worker's residential location in 1991 for the subsection of the analysis that compares the impacts of trade exposure at the industry and local labor market levels. Most workers in our sample did not change employers between 1991 and 1993, and we thus largely rely on the first observed location in 1993 as a proxy for location in 1991.[43] Following Dorn (2009) and Autor and Dorn (2013), we aggregate geographic information to the level of 722 commuting zones that cover the entire mainland of the United States. Commuting zones are clusters of countries that are linked by strong within-cluster commuting ties, and they approximate the concept of local labor markets. Since our one percent sample of Social Security data is too small to provide precise measurement of detailed industry composition at the commuting zone level, we instead draw on tabulations of employment by industry by county from the 1990 County Business Pattern to compute local industry structure.

Our main sample comprises workers who were born between 1943 and 1970. We use this sample to study outcomes during the period 1992 to 2007 when these workers were between 22 and 64 years old. The sample is restricted to workers who were earning at least $8,193 per year in each of the four years 1988 to 1991, prior to the outcome period. The value of $8,193 (in 2007 dollars) corresponds to the earnings of a worker who was employed during 1,600 annual hours at the Federal minimum wage of 1989. The sample size of this main sample is 508,129. We also show additional results for an extended sample that includes workers with a weaker labor force attachment. This alternative

[43] More specifically, the imputation uses the following sequential procedure: (1) use the worker's first observed residential location (usually in 1993) as a proxy for 1991 location if (a) the worker continues to be employed at the 1991 firm, or else if (b) the worker's 1991 firm employs other individuals in the worker's first observed location during any of the years 1993-1997, or else if (c) the worker's 1991 firm is registered in the location where the worker's first residence is observed; (2) otherwise assume that the worker's 1991 location was: (a) the location where, during the years 1993 to 1997, we observe most worker-years for other employees of the worker's 1991 firm, or else (b) the location where the 1991 firm was registered, or else (c) the location where we observe most worker-years for the worker's initial industry during 1993 to 1997. Step (1a) of the imputation assigns a 1991 residential location to 68% of workers in our main sample, with steps (1b)-(1c) and (2a)-(2c) contributing another 18% and 14%, respectively.

sample comprises the 880,465 workers who had positive earnings (and a valid industry code) during at least one year in each of the three-year periods 1987 to 1989 and 1990 to 1992.

Matching trade data to industries

Data on international trade for 1991 to 2007 are from the UN Comrade Database (*http:// comtrade.un.org/db/default.aspx*), which gives bilateral imports for six-digit HS products. To concord these data to four-digit SIC industries, we proceed as follows. First, we take 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 slightly aggregate the four-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. We also aggregate the trade data to three-digit and two-digit SIC industries in order to construct measures of import exposure for firms whose industry is not identified at the four-digit level in the Social Security Administration data. Details on our industry classification are available on request. Second, we combine the HS-SIC crosswalk with six-digit HS Comrade data on imports for the United States (for which Comrade has six-digit HS trade data from 1991 to 2007) and for all other high-income countries that have data covering the sample period (Australia, Denmark, Finland, Germany, Japan, New Zealand, Spain, and Switzerland) and then aggregate up to SIC industries. All import amounts are inflated to 2007 USD using the Personal Consumption Expenditure deflator.

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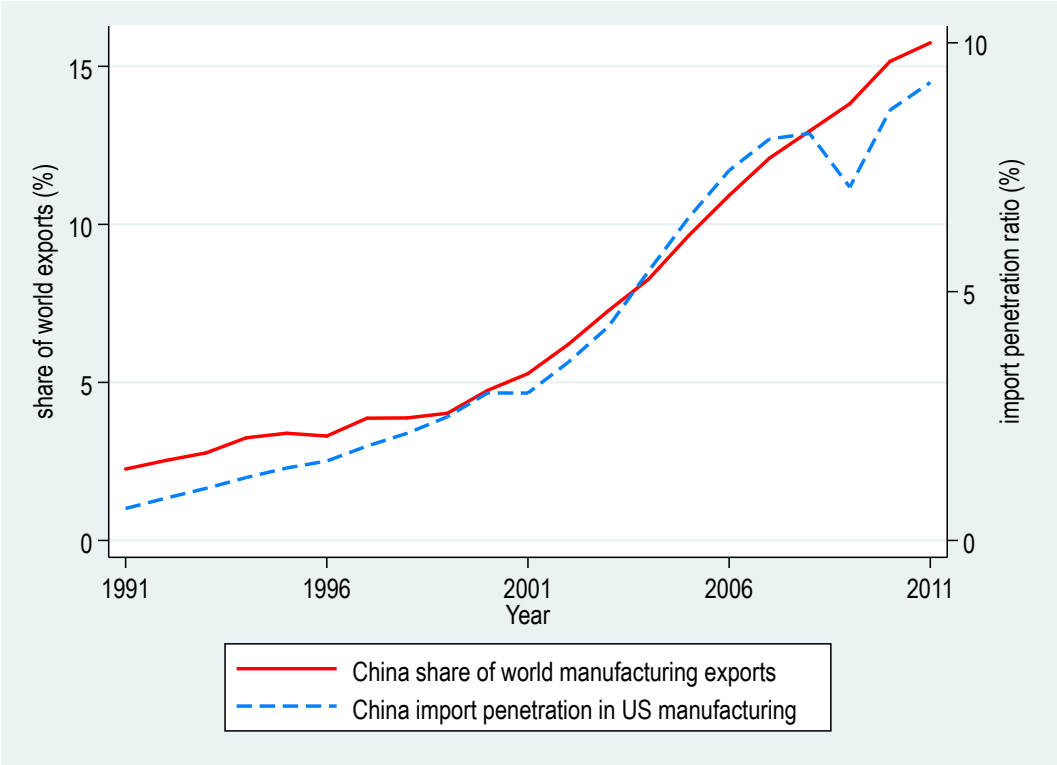

Figure I
China Share of World Manufacturing Exports and China Import Penetration in U.S. Manufacturing, 1991-2011.

Notes: The China share of world manufacturing exports is the ratio of China's total manufacturing exports to world total manufacturing exports as reported in *World Development Indicators* (http://data.worldbank.org/). The China import penetration ratio is U.S. manufacturing imports from China divided by U.S. domestic absorption in manufacturing (shipments plus imports minus exports).

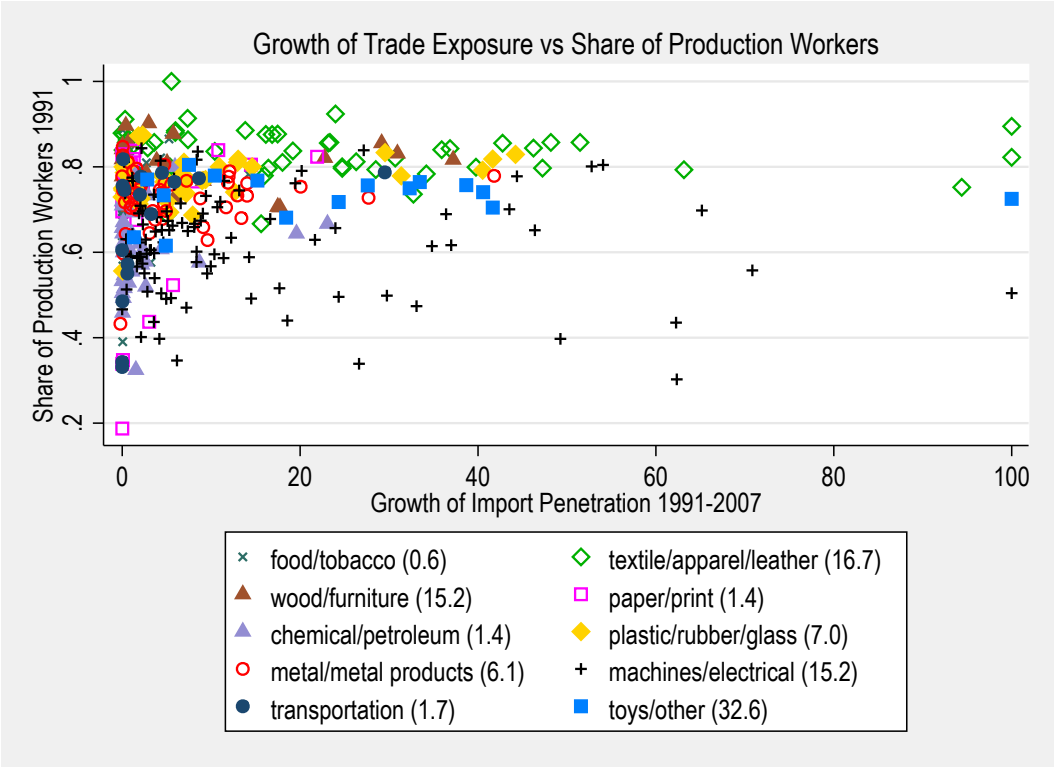

Figure II
Trade Exposure and Production Worker-Intensity by Industry.

Notes: Numbers in parentheses in the legend indicate average growth of import penetration within industry group, weighted by 1991 employment. Values for growth of import penetraton are Winsorized at 100.

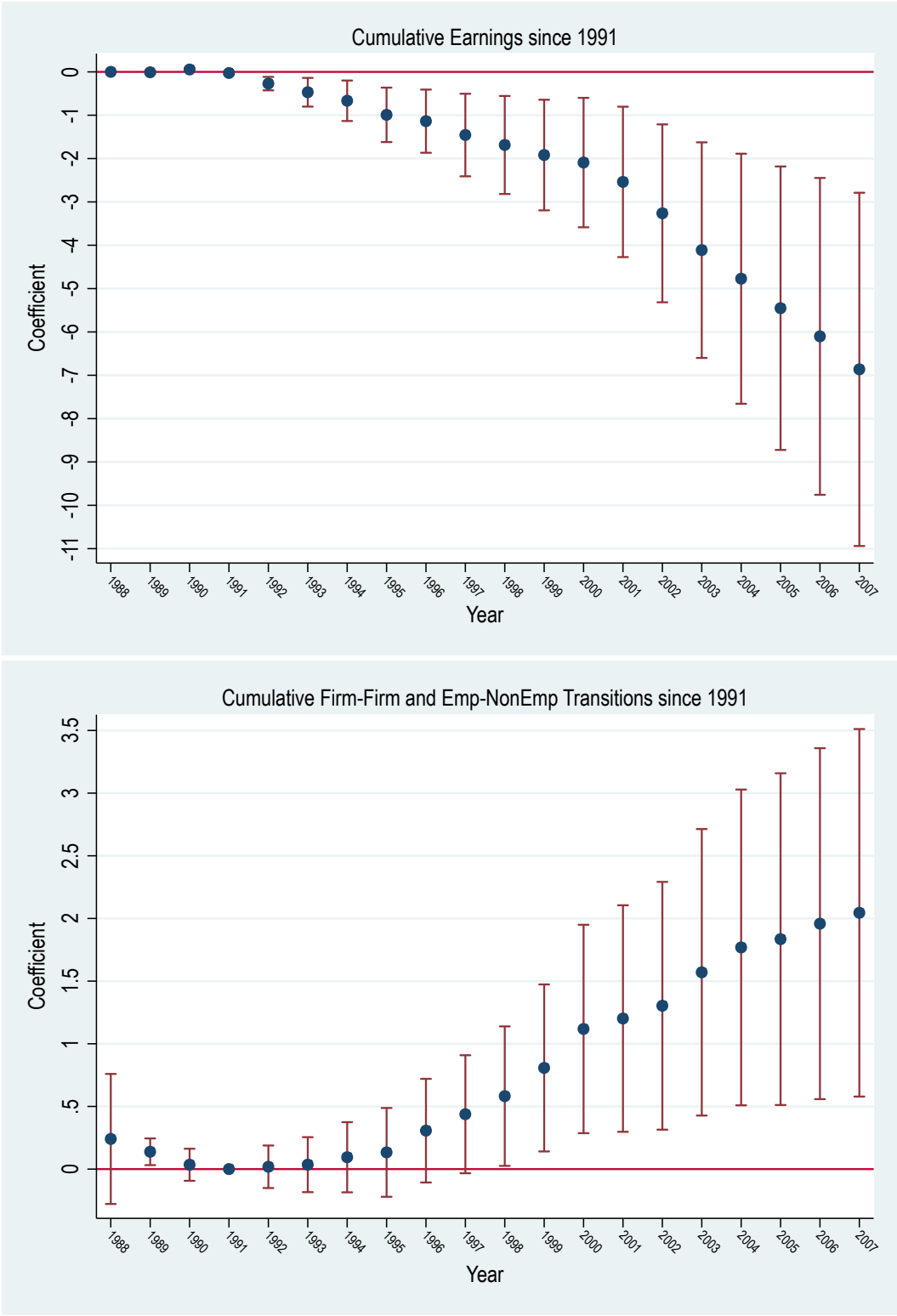

Figure III
Cumulative Earnings and Cumulative Job Churning since 1991

Notes: Each panel plots regression coefficients and 90% confidence intervals obtained from 20 regressions that relate the indicated outcome variables to the 1991-2007 trade exposure of a worker's 1991 industry. The outcome in the top panel is the cumulative earnings that a worker obtained from 1991 through the year indicated on the x-axis, expressed in percentage points of the worker's average annual earnings in 1988-1991. Coefficients for years prior to 1992 refer to cumulative earnings between the year indicated on the x-axis and 1991. The outcome variable in the bottom panel is the cumulative number of times a worker has changed employers or moved between employment and non-employment between 1991 and the year indicated on the x-axis, multiplied by 100. This outcome variable takes negative values prior to 1991, such that positive coefficients pre-1991 indicate lower churning for workers whose 1991 industry was trade-exposed. All regressions include the vector of control variables from column 9 of Table 1.

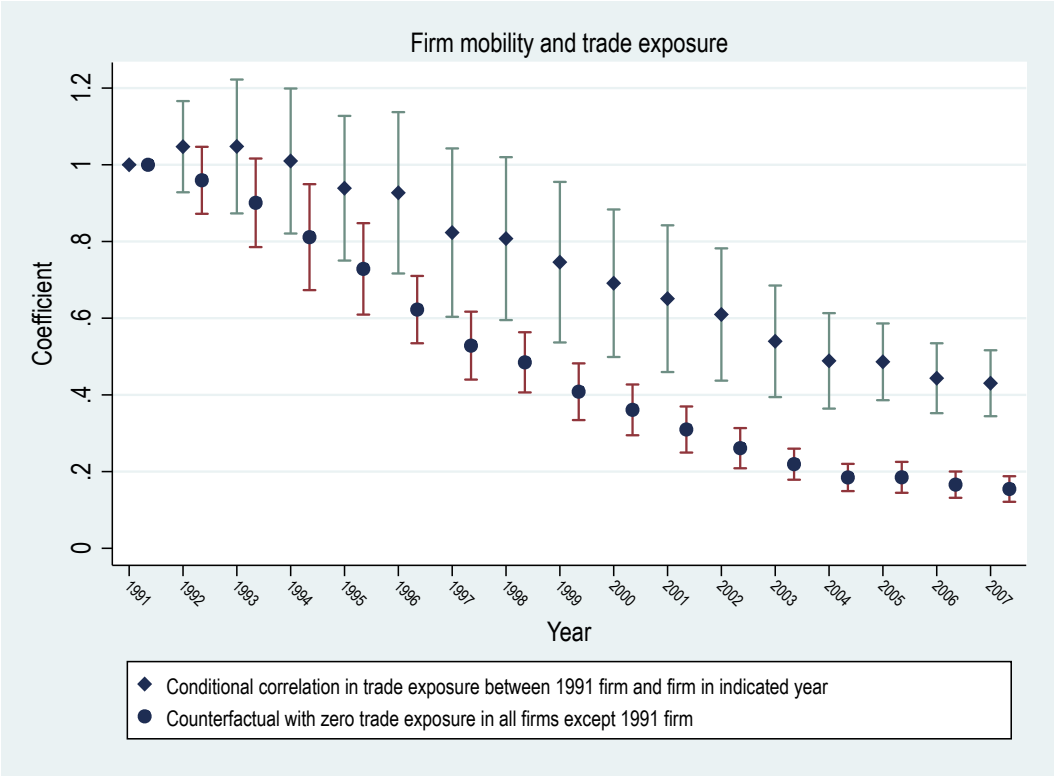

Figure IV
Persistence of Trade Exposure since 1991

Notes: The graph plots regression coefficients and 90% confidence intervals obtained from 2x16 regressions that relate the 1991-2007 trade exposure of a worker's industry in the year indicated on the x-axis to the 1991-2007 trade exposure of the worker's intial 1991 industry. The counterfactual data series sets trade exposure to zero for all firms except the worker's initial employer. It refers to a hypothetical scenario in which no worker joins a trade-exposed firm after separating from their initial firm, and so all persistence in trade exposure is due to workers who have not separated from their initial firm.

Table I
Descriptive Statistics

	Main Sample All Workers	Main Sample: Manuf Workers	Extended Sample: All Workers	Extended Sample: Manuf Workers
		A. Trade Exposure, 1991-2007		
(Δ Imports from China to US)/US Consumption$_{91}$	1.60 (7.05)	7.72 (13.85)	1.30 (5.85)	6.30 (11.59)
P90, P10 Interval P75, P25 Interval	[2.72, 0.00] [0.00, 0.00]	[24.74, 0.06] [7.30, 0.62]	[1.99,0.00] [0.00,0.00]	[18.75, 0.04] [6.28, 0.38]
(1991 Imports from China to US)/US Consumption$_{91}$	0.11 (0.94)	0.54 (2.00)	0.11 (0.88)	0.48 (1.78)
		B. Main Outcome Variables, 1992-2007		
100*Cumulative Earnings (in Mult of Avg Annual Wage 88-91)	1918.4 (1181.7)	1808.9 (1025.7)	n/a	n/a
100*Number of Years with Earnings>0	1422.3 (342.1)	1428.6 (335.7)	1326.0 (428.3)	1355.8 (403.6)
100*Cum Earn/Yrs with Earn>0 (in Mult of Avg Ann Wage 88-91)	130.0 (69.9)	122.4 (59.7)	n/a	n/a
100*Number of Years with Main Income from SSDI	34.3 (168.3)	43.3 (188.6)	44.4 (200.0)	50.9 (211.4)
100*Number of Years with Main Income from Self-Employment	46.4 (175.9)	37.7 (152.2)	59.8 (200.4)	47.0 (170.2)
		C. Worker Characteristics in 1991		
Female	0.431	0.312	0.475	0.359
Non-White	0.207	0.200	0.236	0.235
Foreign-Born	0.077	0.086	0.085	0.097
Employed in Manufacturing	0.208	1.000	0.173	0.836
Tenure 0-1 Years	0.269	0.236	0.418	0.425
Tenure 2-5 Years	0.368	0.355	0.301	0.283
Tenure 6-10 Years	0.169	0.187	0.129	0.134
Tenure 11+ Years	0.194	0.221	0.153	0.158
Firm Size 1-99 Employees	0.231	0.153	0.257	0.199
Firm Size 100-999 Employees	0.237	0.289	0.231	0.285
Firm Size 1000-9999 Employees	0.246	0.290	0.210	0.251
Firm Size 10000+ Employees	0.286	0.267	0.302	0.265
Average Log Wage 1988-1991	10.46	10.55	9.23	9.60
Sample Size	508,129	105,625	880,465	181,900

Notes: The main sample in the first two columns includes all workers who had at least full-time minimum wage earnings during each of the years 1988 to 1991. The extended sample in the second two columns includes all workers who had a positive income in at least one year between 1987 and 1989 and one year between 1990 and 1992. Trade exposure for this sample and control variables for manufacturing employment, tenure and firm size are computed and averaged over all years between 1990 and 1992 during which the worker is employed. Average log wage for this sample is computed based on years with positive earnings between 1988 and 1991. The outcome variables for main income sources are defined for the years 1993-2007 in the extended sample. Column B2 provides statistics for the subset of workers from the extended sample who were employed in manufacturing during at least one year between 1990 and 1992.

Table II
Imports from China and Cumulative Earnings, 1992-2007: OLS and 2SLS Estimates
Dependent Var: 100 x Earnings 1992-2007 (in Multiples of Initial Annual Wage)

	OLS	2SLS								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(Δ China Imports)/ US Consumption$_{91}$	-2.939 *	-5.726 **	-6.017 **	-6.099 **	-6.883 **	-6.436 **	-5.695 *	-6.728 **	-6.864 **
	(1.150)	(1.425)	(1.475)	(1.395)	(1.351)	(2.450)	(2.326)	(2.392)	(2.477)
Birth year dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes
Demographic controls			yes	yes	yes	yes	yes	yes	yes
Employment history				yes	yes	yes	yes	yes	yes
Earnings history					yes	yes	yes	yes	yes
Initial import levels						yes	yes	yes	yes
10 mfg industry dummies							yes	yes	yes
Industry characteristics								yes	yes
Pretrends ind emp and wage									yes

Notes: N=508,129. All regressions include a constant and a full set of birth year dummies. Demographic controls in column 3 include dummies for female, non-white and foreign-born. Employment history controls in column 4 include dummies for tenure at 1991 firm (0-1, 2-5, 6-10 years), experience (4-5, 6-8, 9-11 years), and size of 1991 firm (1-99, 100-999, 1000-9999 employees). Earnings history controls in column 5 include the worker's annual log wage averaged over 1988-1991, an interaction of intial wage with age, and the change in log wage between 1988 and 1991, as well as the level and trend of the 1991 firm's log mean wage for the period 1988-1991. Columns 6-9 add controls for a worker's 1991 manufacturing industry, starting with initial trade penetration by Chinese and non-Chinese imports in column 6 (coefficients indicated in the table). Column 7 adds dummies for 10 manufacturing sub-industries, column 8 adds 1991 levels for employment share of production workers, log average wage, capital/value added, and 1990 levels for computer investment, share of investment allocated to high-tech equipment, and fraction of intermediate goods among imports in 1990, and column 9 additionally controls for changes in industry employment share and log average wage level during the preceding 16 years (1976-1991). Robust standard errors in parentheses are clustered on start-of-period 3-digit industry. ~ $p \leq 0.10$, * $p \leq 0.05$, ** $p \leq 0.01$.

Table III
Imports from China 1992-2007 and Cumulative Earnings, Years with Earnings, and Earnings per Year 1992-2007 and 1976-1991: 2SLS Estimates
Dep Vars: 100 x Cumulative Earnings; 100 x Years with Earnings; 100 x Earnings per Year of Employment (in Multiples of Initial Annual Wage)

	Cumulative Earnings		Years w/ Earnings>0	Earnings/ Year	
	(1)		(2)	(3)	
			A. Treatment Period 1992-2007		
(Δ China Imports)/ US Consumption$_{91}$	-6.864	**	-0.535	-0.393	**
	(2.477)		(0.505)	(0.140)	
			B. Pre-Period 1976-1991		
(Δ China Imports)/ US Consumption$_{91}$	-0.432		0.695	-0.064	
	(1.996)		(0.856)	(0.112)	

Notes: N=508,792 in Panel I and N=301,490 in Panel II, except N=506,339 and N=300,239 in column 3 where the dependent variable is not defined for individuals who are never employed during the entire outcome period. Regressions in Panel I include the full control vector from column 9 of Table 2. Regressions in Panel II include the same controls except tenure, experience and firm size; and industry-level controls are measured either for 1975 or for 1972 (intermediate imports, computer investment and high tech equipment). Robust standard errors in parentheses are clustered on start-of-period 3-digit industry. ~ $p \leq 0.10$, * $p \leq 0.05$, ** $p \leq 0.01$.

Table IV

Imports from China and Earnings and Employment by Firm, Industry and Sector, 1992-2007: 2SLS Estimates

Dep Vars: 100 x Cumulative Earnings; 100 x Years with Earnings; 100 x Earnings per Year of Employment (in Multiples of Initial Annual Wage)

			Same Sector				Other Sect		N/A	
Same 2-digit Industry	All Em-		Yes		Yes		No		N/A	
Same Firm	ployers		Yes		No		No		No	
	(1)		(2)		(3)		(4)		(5)		(6)	
			A. Cumulative Earnings (in Initial Annual Wage*100)									
(Δ China Imports)/	-6.864	**	-9.107	**	-2.998	~	5.914	*	-2.253		1.579	*
US Consumption$_{91}$	(2.477)		(3.395)		(1.671)		(2.326)		(3.049)		(0.800)	
			B. Cumulative Employment (in Years*100)									
(Δ China Imports)/	-0.535		-6.204	*	-2.036		4.654	**	1.451		1.600	*
US Consumption$_{91}$	(0.505)		(2.566)		(1.278)		(1.655)		(1.983)		(0.625)	
			C. Earnings per Year of Emp (in Initial Annual Wage*100)									
(Δ China Imports)/	-0.393	**	-0.283	**	-0.543	~	-0.551	~	-0.655	*	-0.606	*
US Consumption$_{91}$	(0.140)		(0.093)		(0.304)		(0.300)		(0.291)		(0.245)	

Notes: N=508,129 in panels A and B. N=506,339/424,027/155,993/263,158/112,002/119,989 in columns 1-6 of panel C. Column 6 measures employment and earnings in firms with missing industry information. A large majority of these firms are new firms that have been incorporated between the years 2000 and 2007. All regressions include the full vector of control variables from column 9 of Table 2. Robust standard errors in parentheses are clustered on start-of-period 3-digit industry. ~ $p \leq 0.10$, * $p \leq 0.05$, ** $p \leq 0.01$.

Table V

Imports from China and Earnings and Employment by Geographic Location, 1994-2007: 2SLS Estimates

Dep Vars: 100 x Cumulative Earnings; 100 x Years with Earnings; 100 x Earnings per Year of Employment (in Multiples of Initial Annual Wage)

	All CZ		Initial CZ		Other CZ		N/A CZ	
	(1)		(2)		(3)		(4)	
	A. Cum. Earnings (in Initial Annual Wage*100)							
(Δ China Imports)/ US Consumption$_{91}$	-6.649	**	-3.558	*	-2.307	~	-0.785	
	(2.417)		(1.396)		(1.281)		(0.542)	
	B. Cumulative Employment (in Years*100)							
(Δ China Imports)/ US Consumption$_{91}$	-0.653		-0.008		-0.491		-0.154	
	(0.513)		(0.599)		(0.539)		(0.253)	
	C. Earnings/Year (in Initial Annual Wage*100)							
(Δ China Imports)/ US Consumption$_{91}$	-0.418	**	-0.344	**	-0.741	*	-1.010	*
	(0.152)		(0.124)		(0.369)		(0.398)	

Notes: N=508,129, except smaller samples in panel C. Column 1 shows aggregate results for earnings and employment. Columns 2-4 subdivide results into employment and earnings obtained while residing in the 1993 Commuting Zone of residence (column 2), in all CZs other than the 1993 CZ of residence (column 3), and in CZs than cannot be classified because either the 1993 location or subsequent location of the worker is unknown (column 4). All regressions include the full control vector from column 9 of Table 2, and a dummy for the 6% of workers whose 1993 CZ is unknown. Robust standard errors in parentheses are clustered on start-of-period 3-digit industry. ~ $p \leq 0.10$, * $p \leq 0.05$, ** $p \leq 0.01$.

Table VI
Imports from China and Non-Wage Income, 1992-2007: 2SLS Estimates
Dep Vars: 100 x Cumulative Years of Indicated Status or Income 1992-2007

	A. Cumulative Years with Main Income from:				
	Wage Earnings		Self-Emp Income	SSDI Income		No Recorded Income
	(1)		(2)	(3)		(4)
(Δ China Imports)/	-0.493		-0.127	0.562	*	0.057
US Consumption$_{91}$	(0.498)		(0.207)	(0.268)		(0.367)
	B. Cumulative Income (in Initial Annual Wage*100)					
	Wage Earnings		Self-Emp Income	SSDI Income		No Recorded Income
(Δ China Imports)/	-6.864	**	-0.007	0.352	*	n/a
US Consumption$_{91}$	(2.477)		(0.348)	(0.164)		
	C. Years with SSDI Income: Intensive vs Extensive Margin					
			100*Dummy (Yrs SSDI>0)			100*Yrs SSDI if Yrs SSDI>0
(Δ China Imports)/			0.082		*	0.687
US Consumption$_{91}$			(0.035)			(1.298)

Notes: N=508,129, except N=32,426 in the second column of panel C. The dependent variable in the first column of Panel C is a dummy for individuals who received SSDI benefits in at least one year during 1992 to 2007 and the dependent variable in the second column of Panel C is the number of calendar years with SSDI benefits conditional on receiving benefits in at least one year. All regressions include the full vector of control variables from column 9 of Table 2. Robust standard errors in parentheses are clustered on start-of-period 3-digit industry. ~ $p \leq 0.10$, * $p \leq 0.05$, ** $p \leq 0.01$.

Table VII

Imports from China and Cum. Years of Emp and SSDI Receipt by Worker Sample: 2SLS Estimates. Dep Vars: 100 x Cumulative Years with Income from Indicated Sources and 100 x Dummy for SSDI Income, 1993-2007

	Cumulative Years with Main Income from:										
	Wage Earnings		Self-Employmt		SSDI Benefits		No Income		100*Dummy (Yrs SSDI>0)		
	(1)		(2)		(3)		(4)		(5)		
	A. Main Sample: High LF Attachment										
(Δ China Imports)/ US Consumption$_{91}$	-0.613		-0.152		0.438	*	0.327		0.056	*	
	(0.415)		(0.157)		(0.202)		(0.330)		(0.026)		
	N=508,129										
	B. Extended Sample: High and Low LF Attachment										
(Δ China Imports)/ US Consumption$_{91}$	-0.991	~	-0.694	*	1.137	**	0.548		0.125	**	
	(0.569)		(0.301)		(0.431)		(0.426)		(0.043)		
	N=880,465										

Notes: Panel A includes workers who earned at least the equivalent of a full-time minimum wage job in each of the four years 1988 to 1991. Panel B adds workers with low annual incomes or interrupted careers who were employed at least in one year during 1987-1989, and one year during 1990-1992. All regressions include the full vector of control variables from colum 9 of Table 2, except that all industry- and firm-related variables are averaged over those years in which a worker was employed during 1990 to 1992. Robust standard errors in parentheses are clustered on start-of-period 3-digit industry. ~ $p \leq 0.10$, * $p \leq 0.05$, ** $p \leq 0.01$.

Table VIII

Imports from China and Earnings and Employment by Firm Tenure and Age, 1992-2007: 2SLS Estimates. Dep Vars: 100 x Cum Earnings; 100 x Years with Earnings; 100 x Earnings per Year of Emp (in Multiples of Initial Annual Wage)

	Outcomes: Overall and by Employer				Outcomes: Overall and by Employer			
	All Firms	Initial Firm	Same Sector	Oth Sect / NA	All Firms	Initial Firm	Same Sector	Oth Sect / NA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	A1. Workers w/ Firm Tenure <5 Years				B1. Workers Born in 1957-1970			
Cum Earnings	-15.06 **	-15.53 **	-1.28	1.75	-8.71 *	-8.98 **	2.45	-2.18
	(5.53)	(5.77)	(5.02)	(6.76)	(3.52)	(3.40)	(3.37)	(4.09)
Cum Yrs Emp	0.84	-9.03 *	1.99	7.88 ~	0.94	-4.43 *	2.49	2.88
	(0.99)	(3.88)	(3.14)	(4.63)	(0.64)	(2.09)	(1.78)	(2.47)
Cum Earn/Yr	-0.95 **	-0.60 **	-1.65 **	-1.22 *	-0.61 **	-0.56 **	-1.06 *	-0.68 *
	(0.34)	(0.20)	(0.60)	(0.51)	(0.23)	(0.18)	(0.50)	(0.31)
	A2. Workers w/ Firm Tenure ≥5 Years				B2. Workers Born in 1943-1956			
Cum Earnings	-1.74 ~	-4.99 *	0.06	3.20	-5.63 **	-8.39 **	-0.08	2.84
	(0.94)	(2.08)	(0.99)	(1.98)	(2.03)	(3.28)	(1.94)	(2.67)
Cum Yrs Emp	-1.27 *	-4.18 *	0.17	2.74	-1.38 ~	-6.84 *	1.42	4.04
	(0.59)	(1.86)	(0.76)	(1.68)	(0.76)	(2.80)	(1.43)	(2.49)
Cum Earn/Yr	-0.05	-0.07	0.01	0.13	-0.25 **	-0.09	-0.47 *	-0.25
	(0.06)	(0.06)	(0.08)	(0.11)	(0.09)	(0.08)	(0.21)	(0.17)

Notes: N=293,816/214,313/236,136/249,921 for Panels A1/A2/B1/B2, except smaller samples for cumulative earnings per year of employment. Columns 4 and 8 report outcomes at firms outside the initial sector and at firms with missing industry information (most of which have been incorporated between 2000 and 2007). All regressions include a constant and the full vector of control variables from column 9 of Table 2. Robust standard errors in parentheses are clustered on start-of-period 3-digit industry. ~ $p \leq 0.10$, * $p \leq 0.05$, ** $p \leq 0.01$.

Table IX
Imports from China and Earnings and Employment by Subgroup of Workers: 2SLS Estimates
Dep Vars: 100 x Cum Earnings; 100 x Years with Earnings; 100 x Earnings per Year of Emp (in Multiples of Initial Annual Wage)

	Worker Outcomes -- Overall and by Employer							
	All Firms		Initial Firm		Oth Firm, Same Sector		Other Sector/ NA	
	(1)		(2)		(3)		(4)	
	A. Initial Wage in Bottom Tercile of Cohort							
Cum Earnings	-18.27	**	-8.78	*	0.85		-10.34	*
	(5.76)		(3.84)		(5.21)		(4.52)	
Cum Yrs Emp	-0.20		-4.10	~	4.50	~	-0.60	
	(1.30)		(2.23)		(2.73)		(2.68)	
Cum Earn/Yr	-1.16	**	-0.44	~	-2.71	**	-1.34	**
	(0.34)		(0.24)		(0.85)		(0.45)	
	B. Initial Wage in Middle Tercile of Cohort							
Cum Earnings	-9.93	**	-8.50	**	2.73		-4.16	
	(3.65)		(3.27)		(2.38)		(3.17)	
Cum Yrs Emp	-0.37		-4.43	*	2.84	~	1.22	
	(0.65)		(2.03)		(1.65)		(1.88)	
Cum Earn/Yr	-0.61	**	-0.51	**	-0.67	~	-0.67	*
	(0.22)		(0.17)		(0.35)		(0.31)	
	C. Initial Wage in Top Tercile of Cohort							
Cum Earnings	-0.22		-9.15	~	2.24		6.69	
	(2.07)		(4.69)		(2.36)		(5.38)	
Cum Yrs Emp	-0.41		-7.79	~	1.10		6.28	
	(0.55)		(4.29)		(1.59)		(4.29)	
Cum Earn/Yr	0.03		-0.04		0.07		0.03	
	(0.14)		(0.12)		(0.29)		(0.22)	

Notes: N=169,386/169,357/169,386 for panels A/B/C, except smaller samples for cumulative earnings per year. Earnings and employment outcomes are reported cumulatively over all firms that employ a worker during the outcome period (columns 1), and separately for the initial firm (column 2), other firms of the same sector (column 3), and firms that are either outside the initial sector or have missing industry information (column 4). All regressions include a constant and the full vector of control variables from column 9 of Table 2. Robust standard errors in parentheses are clustered on start-of-period 3-digit industry. ~ $p \leq 0.10$, * $p \leq 0.05$, ** $p \leq 0.01$.

Table X

Effect of Exposure to Chinese Imports at the Industry and Commuting Zone Level on Earnings and Employment: 2SLS Estimates

Dep Var: 100 x Cumulative Earnings, Years of Employment, or Earnings/Year, 1994-2007

	Outcomes Measured at					
	I. All CZ			II. Initial	III. Other	IV. N/A
	(1)	(2)	(3)	(4)	(5)	(6)
			A. Outcome: Cumulative Earnings			
(Δ Imports from China to US)/ US Consumption$_{91}$	-6.65 **		-6.07 **	-3.31 **	-2.09 ~	-0.66
	(2.42)		(2.16)	(1.24)	(1.25)	(0.59)
CZ Avg of [Δ Imports from China to US)/ US Consumption$_{91}$]		-20.30 **	-19.68 **	-16.88 **	-0.56	-2.24
		(6.72)	(6.79)	(4.59)	(4.88)	(1.38)
			B. Outcome: Cumulative Years of Employment			
(Δ Imports from China to US)/ US Consumption$_{91}$	-0.65		-0.65	-0.14	-0.38	-0.14
	(0.51)		(0.50)	(0.65)	(0.58)	(0.31)
CZ Avg of [Δ Imports from China to US)/ US Consumption$_{91}$]		2.26 ~	2.33 ~	0.42	1.15	0.76
		(1.23)	(1.22)	(3.13)	(2.74)	(0.71)
			C. Outcome: Earnings per Year of Employment			
(Δ Imports from China to US)/ US Consumption$_{91}$	-0.42 **		-0.37 **	-0.30 **	-0.71 *	-0.97 **
	(0.15)		(0.14)	(0.12)	(0.36)	(0.36)
CZ Avg of [Δ Imports from China to US)/ US Consumption$_{91}$]		-1.66 **	-1.62 **	-1.59 **	-1.02 ~	-1.33 ~
		(0.58)	(0.59)	(0.52)	(0.58)	(0.81)

Notes: N=508,129, except smaller samples in Panel C. The commuting zone (CZ) average of import exposure for worker i in CZ j is defined as the average trade exposure of all other workers -i located in CZ j, according to the industry employment structure obtained from the 1990 County Business Patterns. Workers' 1991 CZ of residence is not observed in the data and thus imputed based on available location and employment information. For most workers, it corresponds to the observed 1993 CZ of residence. All regressions include the full control vector from column 9 of Table 2 and regressions in columns 2-6 include a dummy for observations with missing 1993 CZ and dummies for 1991 Census divisions. Robust standard errors in parentheses are two-way clustered on start-of-period 3-digit industry and on imputed 1991 CZ of residence. ~ $p \leq 0.10$, * $p \leq 0.05$, ** $p \leq 0.01$.

Table XI

Alternative Measures of Import Exposure: 2SLS Estimates

Dep Vars: 100 x Cumulative Earnings; 100 x Years with Earnings; 100 x Earnings per Year of Employment (in Multiples of Initial Annual Wage), 1992-2007

Alternative Measure of Trade Exposure	Cum Earnings (1)		Years w/ Earn>0 (2)	Earn/ Year (3)		*Alternative Measure of Trade Exposure*	Cum Earnings (4)		Years w/ Earn>0 (5)		Earn/ Year (6)	
	A. 2SLS Main Results						E. 2SLS (Instr: Chn-OTH Trade)					
Δ Import Penetration, using Imports from China	-6.864	**	-0.535	-0.393	**	Δ Import Penetration, using China Imports to U.S. and other Markets	-5.616	**	-0.493		-0.321	**
	(2.477)		(0.505)	(0.140)			(2.029)		(0.442)		(0.113)	
	B. Reduced Form OLS						F. 2SLS (Instr: Chn-OTH Trade)					
Δ China-US Productivity Differential (Gravity Residual)	-4.684	**	-0.383	-0.270	**	Δ *Net* Import Penetration, using China Imports	-4.170	**	-0.761	*	-0.204	*
	(1.494)		(0.378)	(0.090)			(1.410)		(0.360)		(0.081)	
	C. 2SLS (Instr: Low-OTH Trade)						G. 2SLS (Instr: Chn-OTH Trade)					
Δ Import Penetration, using all Low-Income Country Imports	-6.836	**	-0.489	-0.396	**	Δ *Net* Imports from China in Worker-Equivalent Units	-5.658	**	-0.790		-0.301	**
	(2.409)		(0.486)	(0.138)			(1.965)		(0.497)		(0.112)	
	D. 2SLS (Instr: Mex-OTH Trade)						H. 2SLS (Instr: Chn-OTH Trade)					
Δ Import Penetration, using Imports from Mexico/CAFTA	-0.118		1.583	0.029		Δ Import Penetration, using China Imp adj for Imported Inputs	-6.499	**	-0.568		-0.368	**
	(6.688)		(2.160)	(0.411)			(2.386)		(0.514)		(0.134)	

Notes: N=508,129 in columns 1-2 and 4-5, N=506,339 in columns 3 and 6. Panel A repeats results from Tables 2 and 3. The mean (and standard deviation) of trade exposure among manufacturing workers is 1.02 (3.11) in Panel B, 8.56 (14.94) in Panel C, 3.20 (5.54) in Panel D, 8.62 (15.22) in Panel E, 6.14 (13.96) in Panel F, 5.91 (13.87) in Panel G, 5.77 (12.69) in Panel H. All models include the full vector of control variables from column 9 of Table 2, except that start-of-period import exposure levels are adjusted to reflect the alternative definitions of import exposure measures where feasible. Robust standard errors in parentheses are clustered on start-of-period 3-digit industry. ~ $p \leq 0.10$, * $p \leq 0.05$, ** $p \leq 0.01$.