Online Appendix

Trade Adjustment: Worker Level Evidence

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I. A Simple Model of Earnings Adjustment to Sectoral Trade Shocks

In this appendix, we present a simple model of labor market adjustment to trade shocks, which demonstrates how imperfect labor mobility between sectors creates differences in cumulative earnings over time for similarly skilled workers. Following the empirical analysis in the main text, our interest is in comparing cumulative earnings for two groups of workers: those initially employed in a sector directly affected by trade shocks, which we term exposed manufacturing (e), and those initially employed in a sector insulated from the direct effects of trade shocks, which we term unexposed manufacturing (u). We derive the theoretical determinants of this difference so as to characterize the mechanisms behind the effects of trade on cumulative earnings that we estimate econometrically. The model focuses on differences in outcomes for relative earnings across workers and is silent on welfare impacts. This is consistent with our empirical analysis which, absent information on how trade shocks affect consumer prices, cannot address their effect on real earnings.

Motivated by the outcomes examined in the estimation, the main object of interest is the sum of earnings over T periods for a worker initially employed in an exposed sector relative to the sum of earnings for an identically skilled worker initially employed in an unexposed sector. We obtain an expression for this earnings difference in the simplest setting required to generate results, which has one type of labor, two sectors, and three time periods. We treat period 1 as capturing initial conditions in the pre-shock environment, period 2 as when the shock occurs, and period 3 as summarizing the post-shock environment by which time labor market adjustment is complete. Wages are equilibrated across sectors in periods 1 and 3 but not necessarily in period 2. Incomplete sectoral adjustment to labor demand shocks is necessary for us to detect any impact of trade on cumulative earnings according to workers' initial sector of employment.

Turning to the model, output in period t in each sector $i \in \{e, u\}$ is given by

$$Q_{i,t} = \frac{1}{1-\beta} L_{i,t}^{1-\beta}, \tag{1}$$

where $L_{i,t}$ is employment in sector i and $\beta \in (0, 1)$ is assumed to be constant across sectors. We treat the unexposed sector as producing the numeraire good. Under perfect competition and profit maximization, the real product wage in period 1 is

$$w_1 = L_{e,1}^{-\beta} = L_{u,1}^{-\beta}, \tag{2}$$

where we set the initial relative product price to equal one. With total employment set to unity and labor supplied inelastically ($1 = L_e + L_u$), sectoral employment levels in period 1 are given by

$$L_{e,1} = L_{u,1} = \frac{1}{2}, \tag{3}$$

which implies that period 1 economy wide real product wage is

$$w_1 = \left(\frac{1}{2}\right)^{-\beta}. \tag{4}$$

Because the relative price is normalized to one, the value in (4) also characterizes the real consumption wage in the first period. It is straightforward to extend the setup to allow for elastic labor supply, additional production sectors, or variation in labor demand elasticities across sectors. Doing so does not change the fundamental insights from the analysis.

During period 2, changes in import competition cause the relative price of exposed manufactured goods to fall from 1 to $p < 1$, which induces labor to move from the exposed to the unexposed sector. We assume that mobility costs slow the movement of labor between sectors such that the exodus from exposed manufacturing is only partially completed during period 2. Wages, in both nominal and real terms, in the exposed sector will therefore fall below those in the unexposed sector during the adjustment phase. By period 3, wages in the two sectors are again equalized. The period 3 economy wide nominal wage is given by $w_3 = pL_{e,3}^{-\beta} = L_{u,3}^{-\beta}$, which implies that period 3 relative employment in the exposed sector is $L_{e,3}/L_{u,3} = p^{1/\beta} < 1$. Defining $\rho \equiv p^{1/\beta}$, long run sectoral equilibrium employment levels are

$$L_{e,3} = \frac{\rho}{1+\rho}, \qquad L_{u,3} = \frac{1}{1+\rho}, \tag{5}$$

and the final period real consumption wage relative to the initial period real consumption wage is

$$\frac{w_3/p^{\alpha}}{w_1} = \left(\frac{2}{1+\rho}\right)^{-\beta} p^{-\alpha}, \tag{6}$$

where α is the expenditure share on manufactured goods such that $p^{-\alpha}$ is the final period consumer price index. Because $[2/(1+\rho)]^{-\beta}<1$ and $p^{-\alpha} > 1$, the change in the real consumption wage in (6) is ambiguous. It is more likely to be negative the smaller is the expenditure share on manufacturers (α). Combining (3) and (5), sectoral changes in employment between periods 1 and 3 are

$$\Delta L_e = -\Delta L_u = \frac{\rho - 1}{2(1+\rho)} < 0. \tag{7}$$

Define $\hat{L}_i \equiv \Delta L_i / L_{i,1}$ to be the long run percentage change in employment in sector i. This quantity is equal and of opposite sign for sectors e and u: $\hat{L}_u = -\hat{L}_e = (1-\rho)/(1+\rho) > 0$.

To capture adjustment costs in moving labor between sectors, we assume that only a fraction δ of the long run sectoral employment change occurs during period 2. Because sectoral employment levels are initially equal, this fraction is the same in each sector. In sector i period 2 employment is $L_{i,2} = L_{i,1} + \delta \Delta L_i$ and the ratio of period 2 to period 1 employment is $L_{i,2}/L_{i,1} = 1 + \delta \hat{L}_i$. Thus, $\delta \hat{L}_u$ is the probability that a worker employed in sector e in period 1 is employed in sector u in period 2 (where we use the fact that that $\hat{L}_u = -\hat{L}_e$). Under complete labor market adjustment ($\delta = 1$), period 2 employment equals long run employment in each sector ($L_{i,2} = L_{i,3}$), whereas under no adjustment ($\delta = 0$), period 2 employment equals initial employment ($L_{i,2} = L_{i,1}$). Using equation (2) and the fact that the period 2 nominal wage for sector e is $w_{e,2} = p\left[L_{e,1} + \delta \Delta L_e\right]^{-\beta}$ and likewise for sector u, period 2 real consumption wages relative to period 1 real consumption wages in each sector are

$$\frac{w_{e,2}/p^{\alpha}}{w_1} = p^{1-\alpha}\left[1 + \delta \hat{L_e}\right]^{-\beta}, \qquad \frac{w_{u,2}/p^{\alpha}}{w_1} = p^{-\alpha}\left[1 + \delta \hat{L_u}\right]^{-\beta}. \tag{8}$$

These results permit us to examine cumulative earnings over time by initial sector of employment.

Define cumulative real earnings for a worker who is initially employed in sector i as the undiscounted sum of earnings across time, normalized by real earnings in the initial period, $\sum_t \tilde{w}(i)_t / w_1$, where $\tilde{w}(i)_t$ is the period t real consumption wage of a worker who was employed in sector i in period 1 (recall that the period 1 wage is the same for all workers). As a result of the trade shock, some workers employed in the exposed sector in period 1 will move to the unexposed sector in period 2, but not as many as would like, creating intersectoral wage differences. Because wages are equilibrated across sectors in periods 1 and 3, the difference in earnings between a worker initially employed in the exposed sector and one initially employed in the unexposed sector is determined entirely by earnings in the second period, which is summarized as

$$\sum_t \frac{\tilde{w}(e)_t}{w_1} - \sum_t \frac{\tilde{w}(u)_t}{w_1} = \frac{\tilde{w}(e)_2 - \tilde{w}(u)_2}{w_1}. \tag{9}$$

In period 2, workers initially employed in the unexposed sector will remain in that sector, with real earnings relative to the first period given by $w_{u,2}/w_{u,1}p^{\alpha}$ as in (8). Workers initially employed in the exposed sector have two possible outcomes. They may either continue to work in sector e at a relatively low wage, which occurs with probability $1 - \delta \hat{L}_u$, or they may relocate to sector u at a relatively high wage, which occurs with probability $\delta \hat{L}_u$. The expected period 2 real wage (normalized by the period 1 wage) for a worker initially employed in the exposed sector is then

$$\frac{\tilde{w}(e)_2}{w_1} = \left[\left(1 - \delta \hat{L_u}\right) p \left[1 - \delta \hat{L_u}\right]^{-\beta} + \delta \hat{L_u}\left[1 + \delta \hat{L_u}\right]^{-\beta}\right] p^{-\alpha}, \tag{10}$$

where we again use the fact that $\hat{L}_u = -\hat{L}_e$. Putting (8) and (10) together, we obtain an expression for (9), the expected difference in period 2 real earnings (normalized by period 1 earnings) for a worker initially employed in sector e and a worker initially employed in sector u:

$$\frac{\tilde{w}(e)_2 - \tilde{w}(u)_2}{w_1} = \left(1 - \delta\hat{L_u}\right)\left(p\left[1 - \delta\hat{L_u}\right]^{-\beta} - \left[1 + \delta\hat{L_u}\right]^{-\beta}\right)p^{-\alpha} \leq 0. \tag{11}$$

The inequality in (12) follows from comparing two extremes. When labor is completely immobile between sectors in period 2 ($\delta = 0$), the earnings difference collapses to $(p-1)/p^{\alpha} < 0$; when labor is completely mobile between sectors ($\delta = 1$), the earnings difference equals 0. With incomplete adjustment ($0 < \delta < 1$), the quantity in (12) lies between these two values.

To evaluate the earnings difference with incomplete adjustment, we apply the approximation that for small x, $(1+x)^{\alpha} \approx 1 + \alpha x$. The earnings difference in (9) is then approximated as

$$\begin{aligned}\frac{\tilde{w}(e)_2 - \tilde{w}(u)_2}{w_1} &\approx \left(1 - \delta\hat{L_u}\right)\left(p\left[1 + \beta\delta\hat{L_u}\right] - \left[1 - \beta\delta\hat{L_u}\right]\right)p^{-\alpha} \\ &= \left(1 - \delta\hat{L_u}\right)\left([p-1] + \beta\delta\hat{L_u}\,[p+1]\right)p^{-\alpha}. \end{aligned} \tag{12}$$

Consider the terms on the second line of (12) separately. The term $\left(1 - \delta\hat{L_u}\right)$ captures the probability that a worker initially employed in the exposed sector remains employed in that sector in period 2. Naturally, the larger is this probability, the larger is the earnings difference. The term $[p-1] < 0$ captures the difference in period 2 earnings in the exposed versus unexposed sector caused by the change in relative prices resulting from greater import competition. The larger is the trade-induced price decline the larger is the sectoral difference in cumulative earnings. The next term in (12), $\beta\delta\hat{L_u}\,[p+1] \geq 0$, captures partial wage adjustment resulting from the flow of labor out of the exposed and into the unexposed sector. This quantity is in turn the product of the labor flow ($\delta\hat{L_u}$), multiplied by the wage elasticity (β), and scaled by the relative price change $(p+1)$ as a consequence of linearization. The larger are adjustment costs (the smaller is δ) and the smaller is the wage elasticity elasticity, the larger is the sectoral difference in cumulative earnings.

How do we relate these theoretical results back to our empirical findings? In the estimation, we compare cumulative earnings across workers based on the magnitude of trade exposure in their initial industry of employment. Following the logic of the above analysis, this empirical exercise implicitly captures earnings differences that result from barriers to the mobility of labor between sectors. Absent such barriers, workers with common skill levels would earn identical wages in all periods and we would detect no differences in cumulative earnings based on the sector in which they were employed prior to the trade shock. Our estimation approach is thus predicated on the existence of slow adjustment to changes in labor market conditions. In the regressions, we include explicit measures of the increase in import competition in the initial industry. To the extent the theoretical model applies to our empirical context, the reduced form regression coefficients that we estimate are proportional to the magnitudes of barriers to sectoral labor mobility and of the elasticity of labor demand. The larger is the former and the smaller is the latter, the larger are the implied coefficients.

Because mobility costs and demand elasticities are likely to vary by worker type, in the estimation we allow for heterogeneity in the impact of import competition on cumulative earnings according to observable worker characteristics. Our empirical results suggest that the negative relative earnings impacts of import competition are larger for lower wage workers, workers with weaker attachment to the labor force, and workers in firms that hire lower wage workers. Interpreting these results in light of the theoretical model, it would appear that these workers face relatively high costs of moving between employer or industries.

Additional outcomes that we examine in the estimation relate to the specific quantities that appear in equations (10) and (12). In Table 3, we estimate the impact of trade exposure on earnings per year of employment at the initial employer (and in the initial industry). During the period of labor market adjustment, this value (normalized by initial year earnings) appears in (10) as $\left(p\left[1-\delta\hat{L_u}\right]^{-\beta}-\left[1+\delta\hat{L_u}\right]^{-\beta}\right)$ (or in linearized form in (12) as $\left(p\left[1+\beta\delta\hat{L_u}\right]-\left[1-\beta\delta\hat{L_u}\right]\right)$). Further, we report estimates for the differential number of years that a worker exposed to a trade shock spends at the initial employer. Figure 3 reports an equivalent version of these estimates in which we vary the horizon over which we allow the shock to cumulate. The values in Figure 3 are proportional to the probability of leaving the initial employer or industry in (10) and (12), given by $\left(1-\delta\hat{L_u}\right)$, in which we vary mobility from none ($\delta=0$) to complete ($\delta=1$).

II. Trade Shocks Seen Through the Lens of Mass Layoffs

Our results make evident that workers with low earnings are differentially impacted by trade shocks. No such distinctions between low and high-wage workers appear in the literature on mass layoffs, where low and high-skill workers are found to fare equally poorly subsequent to large contractions in their initial firms. How do we reconcile our results on adverse trade impacts for low-wage workers with the absence of differential outcomes following mass layoffs?

In Table A.3, we examine when and how workers separate from their initial employer in response to changes in trade exposure, and also consider the wage changes associated with these separations. The dependent variable in columns 1 to 4 is an indicator for exit from the initial firm. In column 1, exit is defined as separation from the initial employer at any time during the 1992 to 2007 period. The positive and significant coefficient, consistent with results in Table IV, shows that more trade exposed workers are more likely to separate from their initial place of work. Reading down the rows for column 1, the effects are about one-and-a-half-times larger for low-wage workers (panel B) as for middle or high-wage workers (panels C and D). Columns 2 to 4 divide exits into three additive and mutually exclusive categories: exits that occur within two years after the start of the first mass layoff at the initial firm (column 2), exits within two years *before* a mass layoff at the initial firm (column 3), and exits that did not occur just before or during a mass layoff (column 3).[1]

For the full sample in panel A, separations during the two years of the first recorded mass layoff episode at the firm (column 2) account for about three-fourths of the total trade-induced separation effect (column 1). The contribution of mass layoff separations to total separations is highest among low-wage and middle-wage workers (panels B and C), at 85% (.430/.508) and 92% (.325/.352), and lowest among high-wage workers, at 60% (.216/.355). Separations from the initial employer immediately *before* a mass layoff have the opposite pattern, accounting for over a quarter of trade-induced separations for high-wage workers but less than one-fifth of separations among low-wage workers. While trade exposure significantly increases the likelihood that a low-wage or middle-wage worker leaves the initial firm during a mass layoff, the only significant effect among high-wage workers is for separations *before* mass layoffs.[2]

The difference in pre-mass layoff separations between low and high-wage workers is, naturally, absent in the mass layoff literature. While that literature finds that mass layoffs can have scarring effects for workers of all skill levels (Jacobson, LaLonde and Sullivan, 1993; Chan and Stevens, 2001; von Wachter, Manchester and Song, 2009; Couch and Placzek, 2010), our results suggest that high-wage workers are less exposed to such mass layoffs, and relatively more likely to leave their initial firm in a pre-layoff period when presumably a larger fraction of separations is voluntary.[3]

III. Appendix Figures and Tables

[1] A mass layoff is defined as in von Wachter, Song and Manchester (2009): an event in which employment at a firm with at least 50 initial employees contracts by at least 30% over the course of two years, with less than half of the displaced workers moving to a common new employer. Column 4 in Table A.3 includes separations from initial firms that had no mass layoffs during the sample period.

[2] A Wald test for equality of the coefficients in columns 2 and 3 of Panel D cannot reject the null hypothesis that high-wage workers' likelihood to leave the initial firm is equally large in the two years prior and in the two years during a mass layoff (p-value of 0.39). The corresponding test is clearly rejected for middle-income workers, who are significantly more likely to leave during rather than prior to a mass layoff (p-value 0.04), and only marginally fails rejection (p-value of 0.12) for the low-income workers in Panel B where estimates are less precise.

[3] In a separate analysis available from the authors, we contrast worker adjustment according to employer size. Across the board, the adverse consequences of trade shocks, measured in cumulative earnings, cumulative years worked, and earnings per year worked, are larger for workers who start out in larger enterprises. While these findings are at odds with the implications of the original Melitz (2003) model, they are consistent with more recent literature on the relationship between firm size and trade exposure (von Wachter and Bender, 2006; Biscourp and Kramarz, 2007; Holmes and Stevens, 2010).

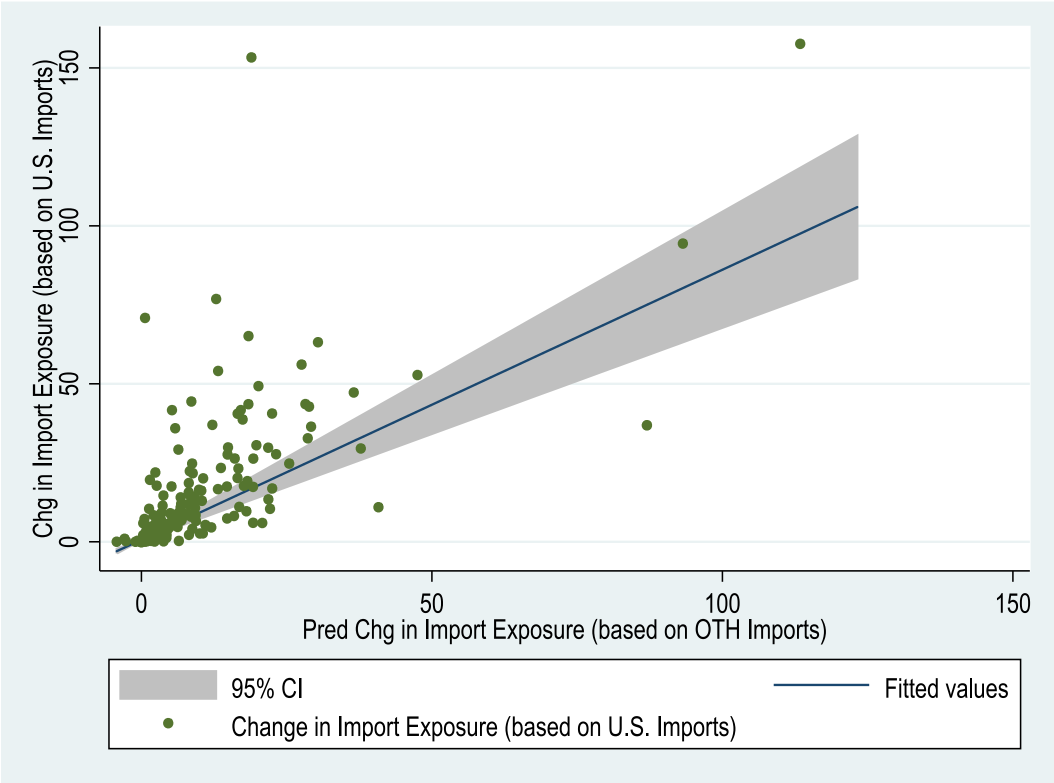

Figure A.1
2SLS First Stage Regression.

Notes: The graph corresponds to the first stage regression for the model in column 2 of Table 1 (coefficient 0.855, standard error 0.093, t-statistic 9.20), and partials out a dummy variable for workers employed in manufacturing industries. The shaded area indicates a 95% confidence interval around the fitted regression line. The scatterplot is displayed only for workers who did not change their industry of employment between 1988 and 1991.

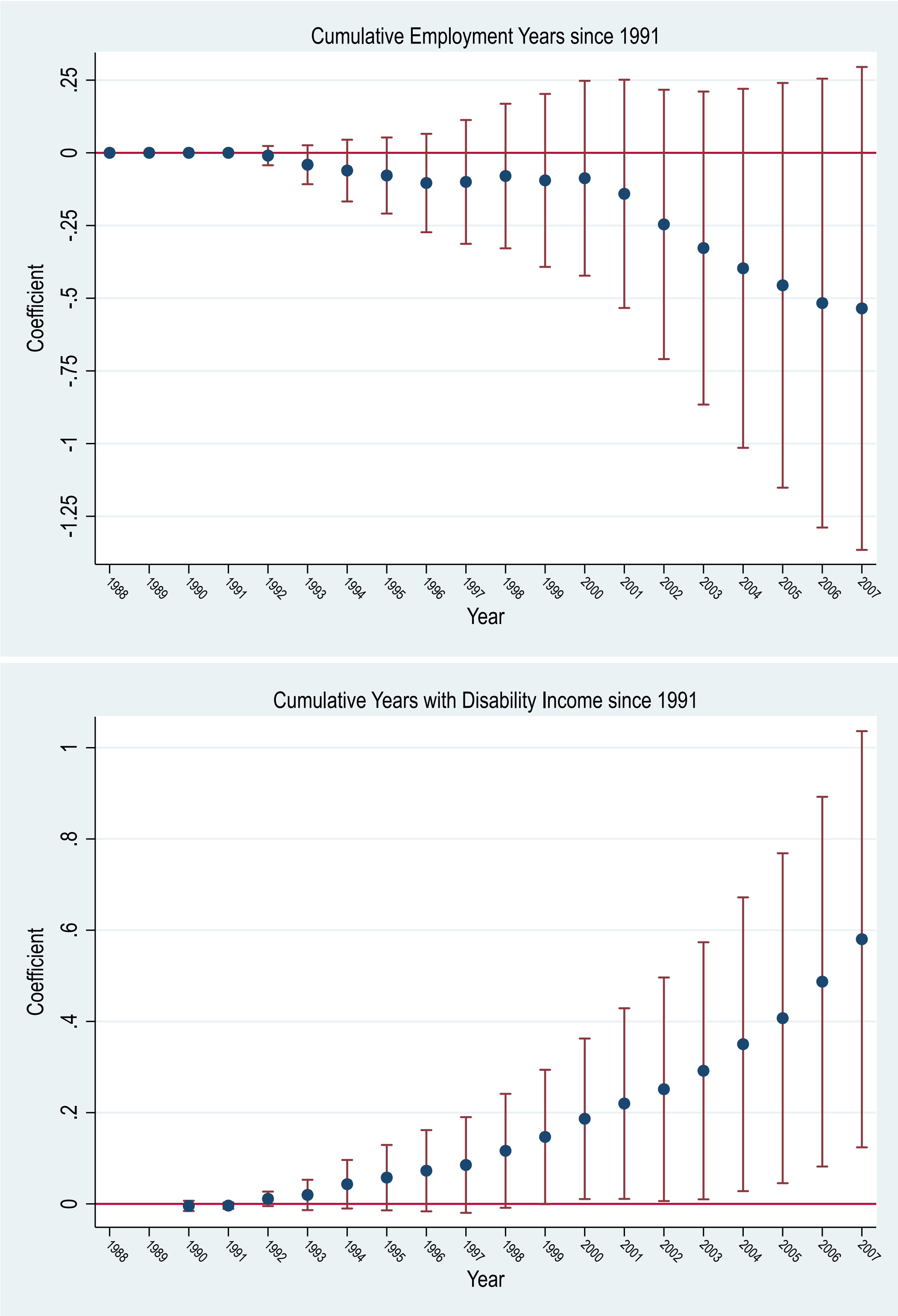

Figure A.2

Cumulative Employment Years and Cumulative SSDI Years 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 variable in the top panel is equal to 100 times the cumulative number of years in which a worker has obtained positive earnings between 1992 and the year indicated on the x-axis (inclusive). The outcome in the bottom panel is 100 times the corresponding count of years in which a worker has received any Social Security Disability Benefits. For years prior to 1992, the outcome variables capture cumulative years of employment or disability between the indicated year and 1991, with disability data being only available since 1990. All regressions include the vector of control variables from column 9 of Table 1.

Table A.1
Import Exposure by Subsample

	Δ Import Exposure 1991-2007	Δ Import Exposure 1991-1999	Δ Import Exposure 1999-2007
	A. Full Sample		
Full Sample	7.72	1.81	5.91
	B. Sample Splits by 1991 Worker Characteristics		
Initial Wage < Cohort Median	8.83	2.28	6.55
Initial Wage ≥ Cohort Median	6.85	1.44	5.41
Firm Tenure < 5 Years	8.50	1.99	6.51
Firm Tenure ≥ 5 Years	6.83	1.60	5.23
Workers Born in 1957-1970	7.85	1.88	5.97
Workers Born in 1943-1956	7.59	1.75	5.84
Male	7.02	1.58	5.45
Female	9.25	2.32	6.92
	C. Sample Splits by 1991 Firm Characteristics		
Avg Firm Wage < Sample Median	9.17	2.52	6.65
Avg Firm Wage ≥ Sample Median	7.05	1.48	5.57
Firm Size 1-999 Employees	8.66	2.18	6.48
Firm Size 1000+ Employees	6.97	1.52	5.45

Notes: This table indicates the average trade exposure for manufacturing workers in the main sample and in subsamples. Trade exposure for subperiods in columns 2 and 3 sums to overall trade exposure in column 1, and indicates the distribution of the trade shock over time.

Table A.2

Imports from China and Employment by Geographic Location for Subsamples of Workers, 1994-2007: 2SLS Estimates

	Cumulative Emp Years by			Cumulative Emp Years by		
	Initial CZ	Other CZ	N/A CZ	Initial CZ	Other CZ	N/A CZ
	(1)	(2)	(3)	(4)	(5)	(6)
	A. Full Sample			C1. Tenure with Initial Firm ≥5 Years		
(Δ China Imports)/ US Consumption$_{91}$	-0.008	-0.491	-0.154	-1.217 *	0.281	-0.221
	(0.599)	(0.539)	(0.253)	(0.489)	(0.265)	(0.219)
	B1. Initial Wage in Bottom Tercile of Cohort			C2. Tenure with Initial Firm<5 Years		
(Δ China Imports)/ US Consumption$_{91}$	1.801	-2.355 ~	-0.195	2.399 ~	-2.112 ~	0.252
	(1.510)	(1.291)	(0.594)	(1.354)	(1.183)	(0.425)
	B2. Initial Wage in Middle Tercile of Cohort			D1. Workers born 1943-1956		
(Δ China Imports)/ US Consumption$_{91}$	0.969	-1.329	-0.101	-0.500	-0.620	-0.262
	(1.247)	(1.039)	(0.376)	(0.694)	(0.514)	(0.278)
	B3. Initial Wage in Top Tercile of Cohort			D2. Workers born 1957-1970		
(Δ China Imports)/ US Consumption$_{91}$	-1.380	1.049	0.010	0.822	-0.391	0.115
	(1.006)	(0.841)	(0.232)	(1.131)	(0.871)	(0.367)

Notes: Sample sizes as in Tables 7 and 8. Columns 1-3/4-6 show results for cumulative employment years while residing in the 1993 Commuting Zone of residence (columns 1 and 4), in all CZs other than the 1993 CZ of residence (columns 2 and 5), and in CZs than cannot be classified because either the 1993 location or subsequent location of the worker is unknown (columns 3 and 6). 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 A.3

Imports from China and Probability of Leaving Initial Firm by Timing of Departure: 2SLS Estimates

Dep Var: Probability of Indicated Event in Percentage Points, 1992-2007

	Probability of Exit Initial Firm							
	At Any Time		w/in 2 yrs during Mass Layoff		w/in 2 yrs before Mass Layoff		*not* w/in 2yrs of Mass Layoff
	(1)		(2)		(3)		(4)
	A. All Workers						
(Δ China Imports)/ US Consumption$_{91}$	0.418	*	0.327	**	0.096	~	-0.006
	(0.169)		(0.127)		(0.057)		(0.099)
	B. Workers with Initial Wage in Bottom Tercile of Cohort						
(Δ China Imports)/ US Consumption$_{91}$	0.508	**	0.430	*	0.098		-0.020
	(0.157)		(0.177)		(0.119)		(0.202)
	C. Workers with Initial Wage in Middle Tercile of Cohort						
(Δ China Imports)/ US Consumption$_{91}$	0.352	**	0.325	**	0.074		-0.048
	(0.134)		(0.106)		(0.055)		(0.101)
	D. Workers with Initial Wage in Top Tercile of Cohort						
(Δ China Imports)/ US Consumption$_{91}$	0.355		0.216		0.093	~	0.045
	(0.217)		(0.132)		(0.052)		(0.124)

Notes: N=508,129/169,386/169,357/169,386 for panels A/B/C/D. The first column measures the probability that a worker leaves the 1991 firm at any time during 1992-2007. The next three columns disaggregate the outcome into departures during the first mass layoff of the firm (column 2), departures right before the first mass layoff (column 3), and departures at any other time (column 4). A mass layoff is defined as an employment decline of >30% over two years at a firm with at least 50 employees, with less than half of the departing workers moving to the same new firm. All regressions include the full control vector from column 9 of Table 2. Robust standard errors in parentheses are clustered on start-of-period 3-digit industry. ~ $p \leq 0.10$, * $p \leq 0.05$, ** $p \leq 0.01$.