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Less Pain, More Gain?

The Effect of Exports on Workplace Safety

DECEMBER 7, 2020

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WORKING PAPER NO. 20201202

Less Pain, More Gain? The Effect of Exports on Workplace Safety

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Oct 2020

Abstract

This study examines the effect of exports on worker safety and health in the US during the last two decades. We use foreign countries' unilateral liberalization as an instrument to capture demand shocks on US exports to the world. Our two-stage estimates with establishment fixed effects suggest that a $1,000 increase in exports per worker decreased the workplace injury rate by a significant 0.5%, which implies an annual reduction of about 4,000 injuries among manufacturing workers. The reduction in injuries is more salient among establishments with higher injury rates, indicating an improvement in the inequality of working conditions. The improvement in working conditions might come from more investment in advanced equipment and better compliance of safety and health regulations.

Keywords: Export expansion; workplace safety; health and health behaviors

JEL Codes: F16, J28

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We thank Mark Anderson, Marianne Bitler, Nicolas Ziebarth, seminar participants at San Diego State University and the annual meetings of MEA and SEA, for helpful comments and discussions. Liang acknowledges support from the Center for Health Economics and Policy Studies (CHEPS) and San Diego State University. All errors are our own.

1 Introduction

The expansion of international trade has profoundly influenced the US economy during the last two decades. Many studies have evaluated the effect of trade expansion on the US labor market. Import competition from China and other developing countries was found to reduce employment and decrease wages (Autor et al., 2013; Acemoglu et al., 2016; Hakobyan and McLaren, 2010) and export expansion created new jobs in the manufacturing sector (Feenstra et al., 2019; Liang, 2018). Trade expansion also shifted jobs to non-manufacturing, both within and between firms (Bloom et al., 2019). However, it is less clear how the trade expansion affects the well-being of the workers.

This study focuses on worker safety and health. Worker injuries are prevalent and expansive. The US workers experience about 2.8 million workplace injuries annually (Bureau of Labor Statistics, 2018), costing 206 billion dollars annually on wage and productivity losses, medical expenditures, and administrative expenses (TNS, 2015). Particularly, the manufacturing workers have long been suffering from higher than national average workplace injury rates. This study evaluates the effect of exports on the workplace injuries of US manufacturing workers.

Theoretically, the effect of exports on workplace safety is ambiguous. Workplace injuries and illnesses are affected by a complex combination of firms' production technology, compliance of safety regulations, and workers' training and effort. Safety investment can be conceptualized as one of the input in the production process, similar to labor and capital (Kniesner and Leeth, 2014). On one hand, export expansion generates a positive demand shock, which may allow firms to provide more resources facilitating workplace safety. On the other hand, the increase in demand might lead to higher work intensity and longer working hours, which might worsen workplace safety.

To identify the causal impact of exports on workplace injuries, we construct an instrumental variable using the liberalization of emerging markets. The liberalization of the emerging economies created positive demand shocks to US exports. Since foreign economies' idiosyncratic increase in imports is unlikely driven by unobservables in a US establishment, these shocks are arguably exogenous to any determinants of working conditions in US manufacturing establishments. To construct measures on the regional export exposures, we follow Autor et al. (2013) and use the initial industrial compositions across commuting zones.

We create a unique unbalanced panel of establishments by matching an establishment-level panel dataset on workplace injury rates to commuting-zone level US export exposures. The data on injury rates are from the OSHA Data Initiative (ODI), collected by the Occupational Safety and Health Administration (OSHA). The data include about 80,000 establishments per year in manufacturing and other industries with average injury rates higher than the national average from 1996 to 2011. We link the observations across years based on establishment names and street addresses. The analysis sample covers about 521,000 establishment-year observations among about 115,000 unique manufacturing establishments over 16 years. The panel of establishments allows us to include establishment fixed effects in our analysis, which rules out potential biases generated by unobserved characteristics across establishments. Additionally, we supplement the establishment-level data on workplace injuries with individual-level data on health and health behavior from the Behavioral Risk Factor Surveillance System (BRFSS).

We find that export expansion reduced workplace injuries significantly. Our IV estimate shows that a $1,000 increase in US exports per worker decreased the total injury case rates by a significant 0.05%. The effect persisted five years after the export expansion and is robust to controlling the import penetration. The effect is more salient among establishments with high injury rates, suggesting that export expansion also reduced the inequality of working conditions in the manufacturing sector.

We directly test a few mechanisms through which export expansion might contribute to a safer workplace for manufacturing workers. First, export expansion created a positive demand shock on firms, which might release the financial constraint on investment (Cohn and Wardlaw, 2016). An increase in the investment of equipment and technology might facilitate both the production and workplace safety and lead to fewer workplace injuries. We find that export expansion was associated with higher capital stock and equipment investment, which might contribute to the decrease in injuries. Second, export expansion might affects workplace safety through changes in the compliance of safety and health regulations. We find that export expansion were associated with fewer employee complaints on working conditions and fewer violations on workplace safety and health standards. The results suggest that the improvement in working conditions might be achieved through better compliance of regulations. Last, export expansion increases the labor demand, which might increase working hours and work intensity and cause more workplace injuries. We find that export expansion had a small and insignificant impact on working hours, suggesting that the results are unlikely to be affected by a change of work intensity.

To our knowledge, this study provides the first evidence on the impact of exports on worker safety in the US. During the analysis period from 1996 to 2011, the US exports increased more than 100 percent, from 625 billion dollars to 1,482 billion dollars. Our estimates suggest that the export expansion is associated with an annual reduction of about 4,000 injuries among manufacturing workers. With the median estimate on value of a statistical injury is $69,393 (Viscusi and Aldy, 2003), the reduction in injuries would imply a decrease in related costs of about 274 million dollars.

Two close studies of this paper are Tanaka (2020) and Hummels et al. (2018). Tanaka (2020) find that export expansion in the garment industry in Myanmar was associated with better working conditions, consistent with the findings of this study. This study is different from Tanaka (2020) in several ways. First, we provide evidence in the context of the US, where the workplace safety standards are much higher than many developing countries. Second, we use the injury rate as a direct measure of workplace safety. Tanaka (2020) approximates workplace safety using safety practices self-reported by managers, which might be subject to reporting errors. Lastly, we find that the injury reduction was likely due to firms' higher investments in equipment and better compliance of safety regulations while Tanaka (2020) suggests the improvement is likely through the pressure of foreign suppliers.

Hummels et al. (2018) use Danish matched firm-worker data and find that export expansion led to more injuries. Hummels et al. (2018) focus on stress and work-related hospitalization as indicators of workplace injuries, which occurred to 0.026% of the observations and only represented a small share of all workplace injuries. Our study considers both any workplace injuries and more severe injuries involving losses of workdays. To provide a direct comparison to Hummels et al. (2018), we supplement the establishment-level evidence on workplace injuries with individual-level data on worker health from BRFSS. We find that export expansion was associated with worse self-reported physical and mental health, which is consistent with Hummels et al. (2018). The results highlight the difference between subjective self-reported health outcome and the workplace injury rate as a measure of workplace safety and health.

This study also adds to a broader literature studying the effect of demand shocks on worker safety and health. A few studies examined the effect of increasing import competition on worker safety and health and found mixed results. McManus and Schaur (2016) find that import competition, which created a negative labor demand shock, increased injury rates in small establishments. In contrast, Lai et al. (2019) find that import competition decreased injury rates. Studies on the effect of import competition on worker health mostly find that import competition worsened the mental health outcomes, increased hospitalization, and increased suicide rates (Adda and Fawaz, 2017; Colantone et al., 2019; Lang et al., 2019; Pierce and Schott, 2020). Some previous studies use other sources of demand shock to study its impact on workplace safety. Boone and Van Ours (2006) and Boone et al. (2011) use the economic cycle as a source of demand shock and find that recessions were associated with a decrease in workplace accidents, mostly driven by workers under-reporting moderate injuries. Charles et al. (2019) employ the variation in global commodity prices and find that positive price shocks were associated with higher workplace injury rates.

2 Methodology

2.1 Local Labor Market Measures

The empirical objective of this paper is to estimate the impact of exports on workplace injury rates at the establishment level. The main specification is as follows,

$$\ln \text{Injury}_{ict} = \alpha + \beta \text{XPW}_{ct} + \delta_i + \delta_t + \epsilon_{ict}, \tag{1}$$

where the dependent variable ($\ln \text{Injury}_{ict}$) is the log of the injury rate of establishment i in commuting zone (CZ) c in year t. XPW_{ct} indicates the total exports per manufacturing worker in commuting zone c in year t. We include establishment fixed effects (δ_i) to control for any time-invariant establishment-specific unobservables. We also include year fixed effects (δ_t) to adjust for macroeconomic shocks that affect all establishments in the same year.

Following the broad literature on the impact of trade on local labor markets, we construct the export performance measure at the commuting zone level as follows,

$$\text{XPW}_{ct} = \sum_{j=1}^{J} \frac{X_{jt}}{\text{Emp}_{jt_0}} \frac{\text{Emp}_{cjt_0}}{\text{Emp}_{ct_0}} \tag{2}$$

where X_{jt} represents the total exports in industry j in year t; Emp_{jt_0} measures the employment in industry j from the initial year t_0; and the ratio $\frac{\text{Emp}_{cjt_0}}{\text{Emp}_{ct_0}}$ is the share of workers in industry j in each commuting zone c in year t_0.

2.2 Instrumental Variable Approach

There might be unobserved determinants of supply or demand affecting both exports and working conditions. For example, a labor-saving technology might decrease injury rates and improve exports simultaneously. Whereas a labor-augmenting technology might lead to an increase in injury rates and exports at the same time. Thus, to overcome these endogeneity concerns, we create an instrumental variable that purges out variation coming from the US domestic productivity shocks. Inspired by the work of Hummels et al. (2014) and Aghion et al. (2017), we construct an instrumental variable that captures foreign demand shocks on US exported products. Our demand-shock instrument for US exports (X_{jt}) in each industry j in year t is defined as,

$$\text{XIV}_{jt} = \sum_{s \in j} \sum_{n=1}^{N} \frac{X_{st_0}^{US \to n}}{X_{st_0}^{US \to World}} \cdot M_{st}^{n \leftarrow World}, \tag{3}$$

where $\frac{X_{st_0}^{US \to n}}{X_{st_0}^{US \to World}}$ represents the share of US exports to country n in total US exports of product s in the initial period t_0, and this part captures the importance of foreign destination market n to the US for selling product s. The time-varying $M_{st}^{n \leftarrow World}$ is the imports of country n from the world for its product s in year t.

To construct the instrument, we use countries experienced trade liberalizations during our analysis period (Wacziarg and Welch, 2008).[1] Many of the recent liberalizations are unilateral and plausibly exogenous to economic conditions of advanced economies (Goldberg and Pavcnik, 2016). For instance, India's trade liberalization occurred as a results of IMF interventions that dictated the pace and scope of the reforms. Similar stories can be found for many candidate countries in our sample. Hence, the variation generated by import changes in the newly liberalized countries is valid for the purpose of our instrument. First, it is correlated with the actual demand changes on US exports; second, it is uncorrelated with any omitted variables in the error term varying by industry and time.

[1]The selected countries that have unilaterally implemented liberalizations are Bangladesh, Brazil, China, Columbia, Ecuador, Haiti, India, Mexico, New Zealand, Paraguay, Romania, Sri Lanka, Tunisia, and Turkey.

For each product, we first sum across countries to get the product-level demand shocks on US exports at the six-digit Harmonized Commodity Description and Coding System (HS) level. Then we map each manufacturing product s into a specific manufacturing industry j at the four-digit Standard Industrial Classification (SIC) level. To assign these product-level trade flows to four-digit SIC industries, we use the crosswalk files created by Autor et al. (2013) and Pierce and Schott (2012).We create a comparable export-weighted concordance table, and then match each six-digit HS-level exports to a four-digit SIC four-digit industry. Lastly, we project the industry-level demand shocks to CZ level to create the instrument, which is,

$$\text{XPWIV}_{ct} = \sum_{j=1}^{J} \frac{\text{XIV}_{jt}}{\text{Emp}_{jt_0}} \frac{\text{Emp}_{cjt_0}}{\text{Emp}_{ct_0}}. \tag{4}$$

The first-stage result is shown in Figure 1. Each dot in the figure represents a commuting zone by year in our sample, and the line is fitted by the OLS regression. The instrument is strongly correlated with the export exposure at the commuting zone level.

3 Data and Sample

The main analysis sample is constructed by linking establishment-level injury rate data to commuting-zone level trade exposures. The data on workplace injury rates are from the OSHA Data Initiative (ODI). From 1996 to 2011, OSHA surveyed around 80,000 establishments on their injury rates annually. The survey covered establishments in manufacturing and other industries with average injury rates higher than the national average. The establishments were sampled each year from those with 40 or more employees in 46 states.[2]

Three measures of injury rates were calculated, including the total case rate (TCR), the case rate on injuries involving days away from work, days with restricted work activities or

[2]In 1996 and 1997, only establishments with 60 or more employees were included. States did not participate in ODI 2011 include Alaska, Oregon, South Carolina, Washington, Wyoming, and District of Columbia.

transferred to another job (DART), and the case rate on injuries involving days away from work only (DAFWII).[3] The case rates are calculated as the number of injuries per 100 full-time equivalent employees. We exclude establishments reporting total case rates higher than 100 cases per 100 full-time equivalent employees (0.05% of the analysis sample). We also exclude establishments from Alaska, Hawaii, and the District of Columbia. The establishments were typically surveyed a few times during the analysis period, but not every year. Establishments with multiple surveys during the analysis period are linked based on the establishment names and street addresses.

To examine the effect of export competition on workers' health and health behaviors, we supplement our main analysis with individual-level data from the Behavioral Risk Factor Surveillance System (BRFSS). BRFSS is an annual telephone survey on health-related risky behaviors, chronic health conditions, and usage of preventive services of US residents. We use data from 1996 to 2011, consistent with the sample period of the establishment-level data. The analysis sample includes individuals from 18 to 65 years old. We use the county of residence to assign individuals to commuting zones. The outcomes include self-reported general health, physical health, and mental health, diagnosis of chronic health conditions (hypertension and diabetes), and health-related risky behaviors (smoking and drinking).

The establishment-level panel data on injury rates and individual-level data on health outcomes are matched to measures of trade flows at the commuting zone level. The country-product level trade data are from the UN Comtrade Database, which provides bilateral import and export volumes at the six-digit product level; and the United States International Trade Commission (USITC), which provides the US imports and exports at the six-digit HS product level.[4] We use the CZ employment composition data from County Business Patterns (CBP) to transform our industry-level measures to the CZ level. All trade data

[3]DAFWII was collected from 2002 to 2011.

[4]The UN Comtrade database can be accessed at http://comtrade.un.org. The USITC data can be accessed at https://dataweb.usitc.gov/.

are converted to 2011 US dollar value using the Personal Consumption Expenditure (PCE) deflator.

To examine the potential channels through which exports might affect working conditions, we construct measures on investment, employment, and compliance of safety regulations. The NBER-Center for Economic Studies Manufacturing Industry Database (NBER-CES) provides annual industry-level data on output, employment, payroll, working hours, and various investment accounts (total capital, equipment, and plant structures) for all manufacturing industries at the four-digit SIC level. Date on compliance of safety and health regulations are retrieved from OSHA's Integrated Management Information System (IMIS). The IMIS includes the history of all closed OSHA inspections since 1984. We focus on three types of inspections: inspections on fatalities and severe accidents, inspections on employee complaints, and programmed inspections conducted based on industries, locations, or specific hazards. We construct two measures of compliance: the number of violations of safety and health regulations, and the total financial penalties on these violations.

Table 1 presents the summary statistics of the main analysis sample. The analysis sample includes about 521,000 observations among about 115,000 unique establishments. Figure 2 presents geographical variation of the exports per worker at the commuting zone level in 1996 and 2011, the first and the last year of the analysis period. The total US exports increased by 108% during the analysis period, totaled $1.5 trillion in 2011. States in the south and west accounted for a larger share of the US exports growth than other regions, and experienced an average 200% increase during our sample period.

4 Result

4.1 Baseline Results

Table 2 presents the baseline estimates on the effect of export expansion on the workplace injury rates. Panel A shows the estimates on log of the total case rate (TCR), which measures the number workplace injuries per 100 full-time equivalent workers. Columns (1) and (2) present the OLS estimates of our baseline model (equation 1), with Column (1) controlling for industry and commuting-zone fixed effects, and Column (2) controlling for establishment fixed effects. Both estimates include year fixed effects to control time-variant macroeconomic shocks. The standard errors, presented in the parentheses, are robust and clustered at the establishment level and commuting zone by five year-period level. Larger exports per worker were associated with lower total case rates (TCR) on average, but the difference was small and statistically insignificant.

To identify the causal effect of export expansion on workplace injuries, we construct an instrument for US exports using the demand shocks from the foreign countries' unilateral liberalizations. Table 2, Columns (3) and (4) present the 2SLS estimates with Column (3) controlling for industry and commuting zone fixed effects, and Column (4) controlling for establishment fixed effects. [5] Export expansion was associated with lower total case rates. Our preferred model with 2SLS and establishment-fixed effects shows that a $1,000 increase in exports per worker decreased the total case rate (TCR) by 0.5% (Table 2, Column (4)). The 2SLS estimates are much larger and more significant than the OLS estimates. The difference suggests omitted unobservables that affect both exports and workplace injuries in the OSL estimates. The 2SLS estimate with commuting zone fixed effect (Column (3)) is also smaller and less significant than the estimate with establishment fixed effect, which might be driven by differential survival rate within each industry.

A common concern for measures of workplace injuries is under-reporting. To alleviate

[5] The first-stage estimates are presented in Table 3.

this concern, we estimate the effect of export expansion on relatively severe injuries, DART and DAFWII, which are less likely to be under-reported compared to mild cases with no losses of workdays. DART includes injuries involving days away from work, days with restricted work activities or transferred to another job. DAFWII includes only cases involving losses of workdays. A $1,000 increase in exports per worker was associated with a 0.8% decrease in DART case rate and a 0.5% decrease in DAFWII case rate (Table 2, Panel B and C). The estimates in Panel C include fewer observations as data on DAFWII were only collected from 2002 to 2011. Overall, the effect of export expansion on DART and DAFWII is similar to that on TCR, suggesting that the reduction in injury rates is unlikely to be driven by underreporting.

During the analysis period from 1996 to 2011, US exports increased dramatically by 108 percent. At the same time, import increased by 136 percent, mostly from China joining the World Trade Organization (WTO) in 2001. One concern on the results from the baseline model is that exports and imporst within each commuting zone might be correlated. Import competition, which created negative demand shocks, could affect workplace safety as well. Omitting the import penetration may biased the estimates on the effect of exports on workplace injuries.

We address this concern by estimating the baseline model and controlling for the magnitude of import competition from China. Table 4, Column (1) presents the baseline estimates on TCR, DART, and DAFWII using the preferred model with 2SLS estimates and establishment fixed effects, same as the Column (4) in Table 2. Table 4, Column (2) shows the estimates adding the import penetration from China as a control variable. Controlling the import competition does not change the magnitude or the significance level of the baseline results. Establishments in commuting zones with higher imports per worker on average had higher workplace injury rates, although the estimates are insignificant.

The estimates on the import variable cannot be interpreted as the causal effect of import on workplace injuries as unobserved factors, such as quality of workers, could affect both import volume and workplace safety. We use the growth in other high-income countries' import from China to instrument the growth in US imports from China, following Autor et al. (2013).[6] The 2SLS estimates (Table 4, Column (3)) suggest that the import from China were associated with a small decrease in workplace injuries. A $1,000 increase in import per worker from China was associated with a 0.1% decrease in TCR, a 0.1% decrease in DART, and a 0.1% increase in DAFWII, all statistically insignificant.

Two close studies on the effect of import competition on workplace injuries are Lai et al. (2019) and McManus and Schaur (2016). Lai et al. (2019) find that import competition were associated with lower injury rates. The main difference is that that our model controls establishment fixed effect, which estimates changes within establishments over time. Lai et al. (2019) only includes industry fixed effect, which might include bias generated by cross-sectional difference in survival rate caused by import expansion. McManus and Schaur (2016) find that over a five-year period, import competition decreased the injury rates among smaller establishments. The main difference between McManus and Schaur (2016) and this study is that McManus and Schaur (2016) focuses on differential changes by establishment size while we estimate on the average treatment effect among all manufacturing establishments.

To examine how exports might affect injury rates dynamically over time, we include lags of the exports per worker in the baseline model. Table 2 presents the estimates of the baseline model, with one to five years of lags in exports. Overall, the effect became larger as the estimates included longer periods of lags. In five years, a $1,000 increase in exports per worker was associated with a 1.5% decrease in TCR, a 2% decrease in DART, and a 1.1% decrease in DAFWII.

[6]Specifically, the instrument for import penetration from China is calculated as, $IPWIV_{ct} = \sum_{j=1}^{J} \frac{M_{jt}^{Other}}{Emp_{jt_0}} \frac{Emp_{cjt_0}}{Emp_{ct_0}}$. And M_{jt}^{Other} represents the realized imports from China to other high-income markets including Australia, Denmark, Finland, Germany, Japan, New Zealand, Spain, and Switzerland. Emp_{jt_0} measures the employment in industry j in initial year t_0; and the ratio $\frac{\mathrm{Emp}_{cjt_0}}{\mathrm{Emp}_{ct_0}}$ is the share of workers in industry j in each commuting zone c in year t_0.

Overall, our results show that export expansion reduced workplace injuries significantly. During the analysis period, the US manufacturing exports increased from $613 billion in 1996 to $1,277 billion in 2011, which is an average of $5.88 thousand per worker per year. Our estimates suggest that a $1,000 increase in exports per worker is associated with a 0.5% decrease in workplace injuries. With the average case rate of 9.8 injuries per 100 full-time equivalent worker and an average of 13.7 million manufacturing workers, the implied total reduction in injuries was 4,807 per year. The studies on the value of a statistical injury shows a median estimate of $69,393 per injury in 2016 dollar value (Viscusi and Aldy, 2003). Thus, the injury reduction from export expansion was associated with a cost saving of $273.9 million per year.

4.2 Distributional Effect

The baseline results suggest that export expansion decreased the workplace injury rates in the manufacturing sector. To explore the heterogeneous effect by the distribution of injury rates, Figure 3 and 4 present estimates on the distributional effect of exports on TCR and DART. Both TCR and DART showed consistent and significant decreases across the whole distribution. The largest decrease appeared among establishments with injury rates above the 90th percentile, corresponding to a TCR of 22 cases and a DART of 14 cases per 100 workers or higher. Overall, establishments with higher injury rates showed the largest decrease facing export expansion. The results imply that export expansion might contribute to an improvement in the equality of working conditions in the manufacturing sector.

4.3 Mechanisms

We explore three potential channels on how export expansion could impact the workplace safety. First, the positive demand shock might release the financial constraints of firms and lead to more investment in capital and equipment. We find that industries experiencing larger export expansion were associated with more capital stock and plant structures per establishment. With a 10% increase in total exports, the capital stock increased by 4.3% and the equipment increased by 6.1% (Table 6, Column (2) and (3)).

Second, the demand shock might directly affect the working hours of employees in manufacturing. Increasing working intensity is found to affect the workers' safety and health negatively (Spurgeon et al. (1997)). Column (1) of Table 6 shows that export expansion was associated with a significant increase in the number of establishments. While export expansion increased the number of establishments, the effect on number of employees, working hours, and wage bill per establishment was small and statistically insignificant (Table 6, Columns (4)-(6)). The results suggest that workers did not work longer hours facing export expansion.

Lastly, export expansion might change firms' incentives and resources to comply with workplace safety and health standards. We find that export expansion was associated with fewer inspections and violations, as well as lower financial penalties (Table 7, Column (1)). We further examine the effect separately by three common types of inspections and the associated violations and penalties. First, we find that export expansion significantly decreased the number of fatalities and severe accidents.[7] With a $1,000 increase in exports per worker, the number of fatalities and accidents decreased by 0.9%. Second, we find that the number of inspections triggered by employee complaints decreased by 1.9% with a $1,000 increase in exports per worker. Third, we find that the number of programmed inspections showed a 0.5% insignificant decrease while the associated violations decreased by 1.8% and penalties decreased by 2.8%. The programmed inspections are planned programs targeting based on specific industry, geographical areas, and locations. While the change in the frequency of these inspections were small, the number of violations and total penalties decreased at a much larger magnitude, suggesting an improvement in the compliance of safety and health standards.

[7]OSHA requires investigation on work-related fatalities or severe accidents involving hospitalization of three or more employees

4.4 Worker Health and Health Behavior

The effect of export expansion on workers' health might not be constrained to the activities at the workplace. To explore how export expansion affect workers' general health, we examine the effect on worker' self-reported health outcomes and health behaviors using individual-level data from BRFSS. Table 8 presents the estimates. Export expansion was associated with worse self-reported physical and mental health. A $1,000 increase in exports per worker decreased the self-reported general health index by 0.003 and increased the number of days per month with fair or poor physical health and mental health by 0.02% and 0.03%.[8]

We also find that export expansion was associated with a less healthy lifestyle. A $1,000 increase in exports per worker increased the probability of being a frequent smoker or drinker by 0.1 percentage point. The Body Mass Index (BMI) increased by 0.025, or eight percent (Table 8 Column (5)-(7)).

The results on worker health and health behavior are individual-level evidence including all working age adults, regardless of employment status or sector of employment. This is different from the estimates on workplace injury rate, which use establishment-level data in manufacturing firms. To understand whether the results on worker health and health behaviors were driven by workers in the manufacturing sector, we estimate the model including an interaction term between the export volume and the share of manufacturing workers in each commuting zone. Panel B of Table 8 shows the estimates. Overall, the negative effect of export expansion on self-reported health and health behaviors were more salient among commuting zones with higher share of manufacturing workers.

Our results have similar implications to those in Hummels et al. (2018). Hummels

[8]The self-reported general health is measured with a categorical variable, with 1 representing excellent health and 5 representing poor health. One concern of using the categorical variable as an outcome in a linear model is that the variable does not provide a cardinal health scale (Van Doorslaer and Jones (2003)). Table 9 presents the estimates using ordered logit regressions and show similar results. Export expansion was associated with an increase in the probability of reporting general health being good, fair, or poor and a decrease in the probability of reporting excellent and very good.

et al. (2018) find that export expansion was related with more stress and work-related hospitalization, consistent with our findings on export expansion leading worse mental health and health behaviors. Although export expansion might improve the health and safety at the workplace through more investment in equipment and better compliance of regulations, workers might face more stress and show less healthy lifestyles.

5 Conclusion

This study provides the first empirical evidence on the effect of exports on worker safety and health in the US. We find that export expansion was associated with a significant decrease in workplace injury rates. In five years, the injuries decreased by 1.5% with a $1,000 increase in exports per worker. The reduction in injuries was more salient among establishments with higher injury rates.

We explore three mechanisms: first, we find that export expansion led to more investment in capital and equipment, which might contribute to the improvement of workplace safety. Second, we find that export expansion was associated with fewer severe accidents and employee complaints, and fewer violations and penalties on planned inspections, suggesting an improvement in compliance with workplace safety and health regulations. Lastly, we find that export expansion increased the number of workers but had a small and insignificant impact on working hours per worker.

Overall, our estimates imply that the export expansion during in the late 1990s and early 2000s were associated with an annual reduction of 4,000 injuries among manufacturing workers, accounting for a cost saving of about 274 million dollars per year.

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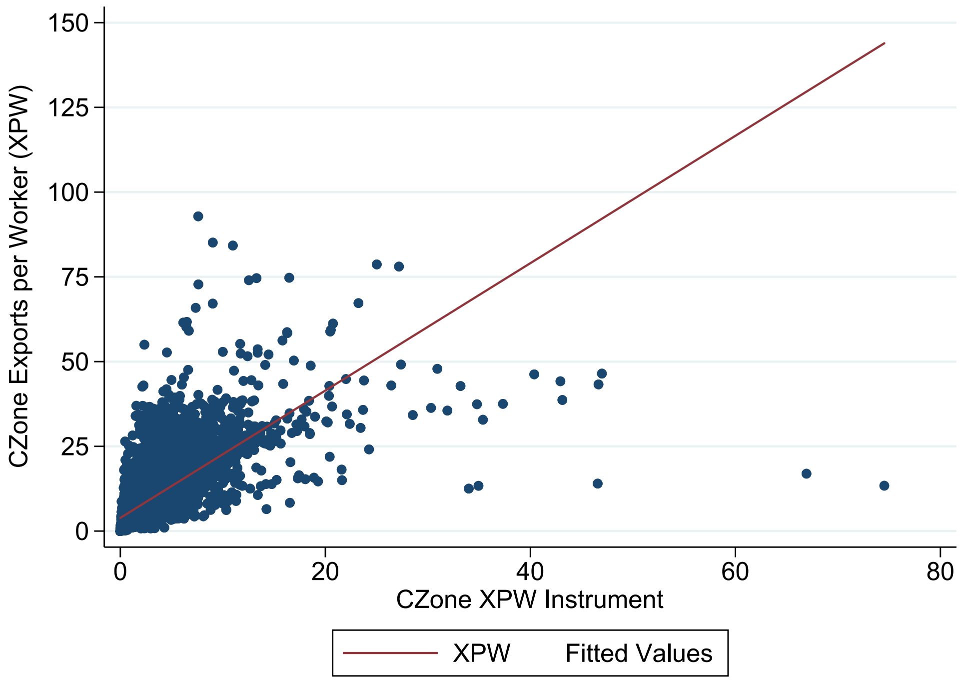
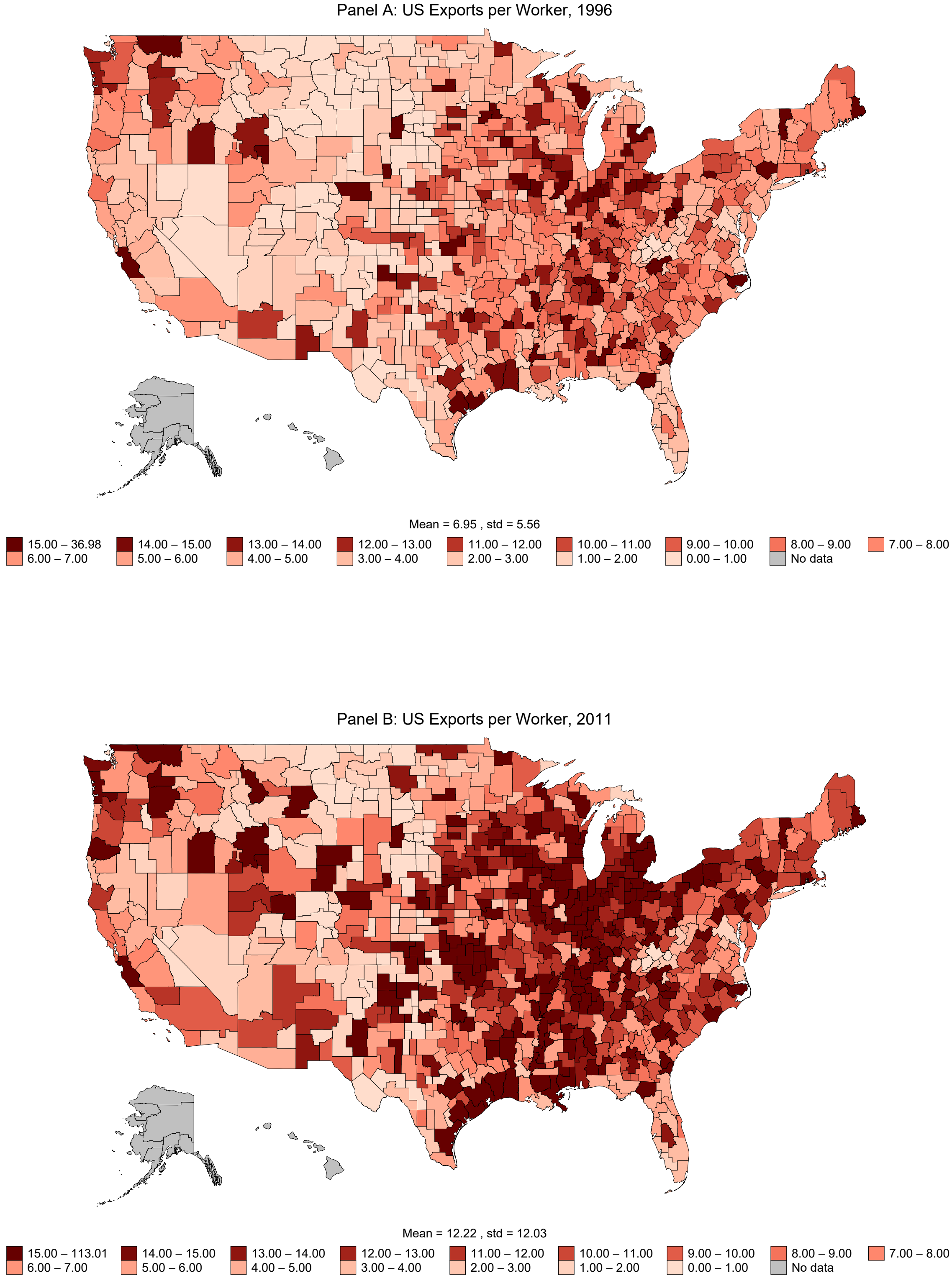
Figures and Tables

Figure 1: First Stage



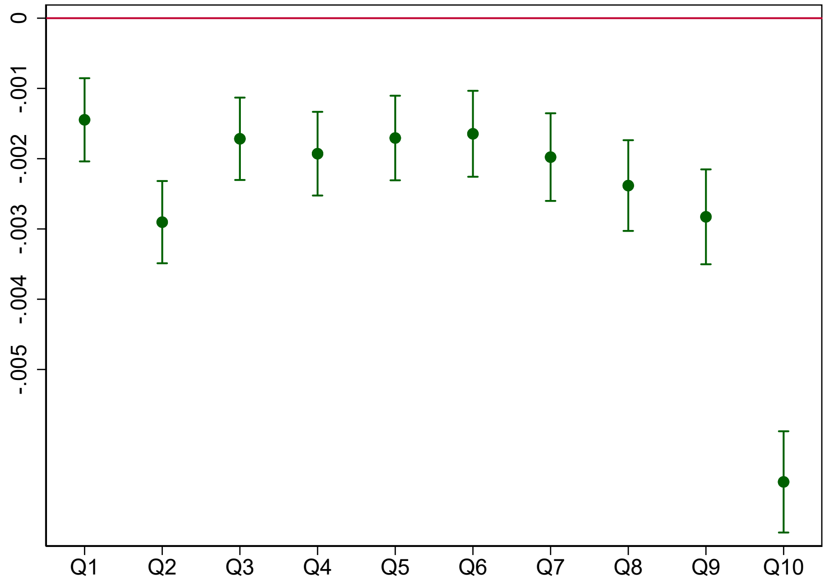
Note: The figure presents the results of the first stage. The x-axis is the instrument on exports and y-axis is the exports per worker (in $1000). Each dot represents a commuting zone by year and the line is fitted by the OLS regression. Coefficient = 1.88, s.d.=0.264, $R^2 = .518$

Figure 2: Regional Variation in U.S. and Export Performance



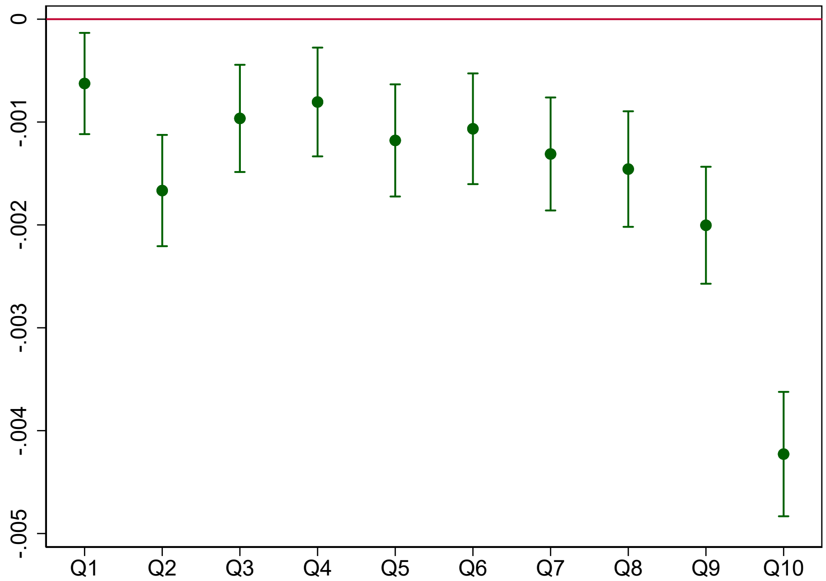
Note: The figures show the exports per worker (in $1000) at the commuting zone level in 1996 and 2011.

Figure 3: Distributional Effects, Depvar.=ln(TCR)



Note: The outcome is log of total case rate (TCR). The dots indicate the point estimates, and lines indicate the 95% confidence interval. Q1 to Q10 indicate establishments with total case rate below 10th percentile to those below 100th percentile.

Figure 4: Distributional Effects, Depvar.=ln(DART)



Note: The outcome is log of injury rate on days away from work, job Restrictions, or job transfers (DART). The dots indicate the point estimates, and lines indicate the 95% confidence interval. Q1 to Q10 indicate establishments with total case rate below 10th percentile to those below 100th percentile.

Table 1: Summary Statistics

	mean	sd	min	max	*N*
Establishment-Level Injury Rates					
Total Case Rate (TCR)	9.80	9.56	0.00	100.00	521,273
Days away, Job Restrictions, and Transfer (DART)	5.13	5.74	0.00	98.85	521,273
Days away from Work (DAFWII)	2.08	3.13	0.00	97.11	310,588
CZone-Level Trade Variables					
Export Performance (XPW)	8.39	7.48	0.00	113.01	11,552
Import Penetration (IPW) from CHN	2.10	3.33	0.00	60.09	11,552
IV for Export Performance	2.47	2.95	0.00	74.53	11,552
IV for Import Penetration from CHN	1.94	2.38	0.00	33.75	11,552
CZone-Level Enforcement Measures					
Number of Inspections on Accidents	6.57	43.85	0.00	1191.00	11,552
Number of Inspections on Complaints	25.35	78.38	0.00	1712.00	11,552
Number of Programmed Inspections	80.07	216.16	0.00	4172.00	11,552
Total Number of Inspections	136.21	365.13	0.00	5453.00	11,552
Number of Violation in Inspections on Accidents	16.68	107.02	0.00	3484.00	11,552
Number of Violation in Inspections on Complaints	76.50	226.79	0.00	4578.00	11,552
Number of Violations on Programmed Inspections	211.26	607.45	0.00	13202.00	11,552
Total Number of Violations	353.48	958.70	0.00	15859.00	11,552
Amount of Penalties in Inspections on Accidents (kUSD)	51.45	382.26	0.00	13,239.69	11,552
Amount of Penalties in Inspections on Complaints (kUSD)	64.78	218.79	0.00	4,706.23	11,552
Amount of Penalties on Programmed Inspections (kUSD)	124.37	376.55	0.00	9,080.78	11,552
Total Amount of Penalties (kUSD)	307.07	1,062.88	0.00	36,916.85	11,552
Industry-Level Investment and Other Production Measures					
Capital Stock (mUSD)	3,432.91	7,495.56	15.80	105,477.70	7,104
Equipment Investment (mUSD)	2,353.08	5,363.82	7.00	80,439.10	7,104
Plant Structures (mUSD)	1,079.88	2,215.37	6.30	25,167.00	7,104
Production Hours per Worker	2.02	0.13	1.33	3.00	7,104
Production Wage Bill (mUSD)	733.24	1,268.55	3.10	16,566.60	7,104
Production Employment (1,000)	21.83	35.53	0.10	442.30	7,104
Individual-Level Health Outcomes and Health Behaviors					
General health indicator	2.38	1.07	1.00	5.00	2,531,631
Days with bad mental health in the past month	3.82	7.98	0.00	30.00	2,415,006
Days with bad physical health in the past month	3.58	7.93	0.00	30.00	2,417,264
Days with bad health in general in the past month	2.07	6.32	0.00	30.00	2,432,059
Smoke daily	0.09	0.29	0.00	1.00	2,537,951
Drink more than 15 days per month	0.25	0.43	0.00	1.00	2,538,269
BMI greater than 30	0.32	0.47	0.00	1.00	2,538,269

Note: The establishment-level injury rate data are from the OSHA Data Initiative (ODI). Three measures of injury rates were collected at the establishment level for the manufacturing sector, including total case rate (TCR), case rate on injuries involving days away from work, job restrictions, and job transfer (DART), and case rate on injuries involving days away from work only (DAFWII). The Trade variables are from UN Comtrade Database and the US International Trade Commission. The CZone-level enforcement data are from OSHA's Integrated Management Information System (IMIS). The investment measures are from NBER-Center for Economic Studies Manufacturing Industry Database. The health outcomes are from the Behavioral Risk Factor Surveillance System (BRFSS). The general health indicator ranges from 1 to 5, with 1=Excellent, 2=Very good, 3=Good 4=Fair, 5=Poor.

Table 2: The Impact of Exports on Injury Rates, Baseline

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS
	Panel A: Depvar. = ln(TCR)			
XPW	-0.001	-0.001	-0.004	-0.005**
	(0.001)	(0.001)	(0.003)	(0.002)
Kleibergen-Paap Weak IV F-Stats			29.18	49.52
Observations	521,273	521,273	521,273	521,273
	Panel B: Depvar. = ln(DART)			
XPW	-0.001	-0.001	-0.008***	-0.008***
	(0.001)	(0.001)	(0.003)	(0.003)
Kleibergen-Paap Weak IV F-Stats			29.18	49.52
Observations	521,273	521,273	521,273	521,273
	Panel C: Depvar. = ln(DAFWII)			
XPW	-0.000	-0.002**	-0.003	-0.005**
	(0.001)	(0.001)	(0.003)	(0.002)
Kleibergen-Paap Weak IV F-Stats			80.948	120.319
Observations	310,588	310,588	310,588	310,588
CZ FE	Yes	No	Yes	No
Industry FE	Yes	No	Yes	No
Establishment FE	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes

Note: Table reports results of OLS and 2SLS regressions. Dependent variables are log of indicated injury measures in establishment i at commuting zone c in year t. TCR is the total case rate, DART is the case rate on injuries involving days away from work, job restrictions, and job transfer, and DAFWII is the case rate on injuries involving days away from work only, all measured as number of cases per 100 full-time equivalent employees. Independent variable (XPW) is the kUSD exports per worker at commuting zone c in year t; see text for details. Robust standard errors in parentheses are clustered at the establishment level and commuting zone by five year-period level.
* $p < .10$, ** $p < .05$, *** $p < .01$

Table 3: First-Stage Results

	(1) XPW	(2) XPW
XPW IV	0.959***	1.053***
	(0.178)	(0.151)
Kleibergen-Paap Weak IV F-Stats	29.18	49.52
Underidentification Test Stats	34.17	55.91
Observations	521273	521273
CZ FE	Yes	No
Industry FE	Yes	No
Establishment FE	No	Yes
Year FE	Yes	Yes

Note: Table reports first-stage results of columns (3) and (4) in Table 2. Robust standard errors in parentheses are clustered at the establishment level and commuting zone by five year-period level. * $p < .10$, ** $p < .05$, *** $p < .01$

Table 4: The Impact of Exports on Injury Rates, with Import Controls

	(1)	(2)	(3)
	Panel A: Depvar. = ln(TCR)		
XPW	-0.005**	-0.006**	-0.005**
	(0.003)	(0.002)	(0.002)
IPW from CHN		0.001	
		(0.002)	
IPW from CHN with IV			-0.001
			(0.002)
Observations	521,273	521,273	521,273
	Panel B: Depvar. = ln(DART)		
XPW	-0.008***	-0.008***	-0.008***
	(0.003)	(0.003)	(0.003)
IPW from CHN		0.000	
		(0.002)	
IPW from CHN with IV			-0.001
			(0.002)
Observations	521,273	521,273	521,273
	Panel C: Depvar. = ln(DAFWII)		
XPW	-0.005**	-0.006**	-0.006**
	(0.002)	(0.002)	(0.002)
IPW from CHN		0.002	
		(0.002)	
IPW from CHN with IV			0.001
			(0.003)
Observations	310,588	310,588	310,588
Establishment & Year FE	Yes	Yes	Yes

Note: Dependent variables are log of indicated injury measures in establishment i at commuting zone c in year t. TCR is the total case rate, DART is the case rate on injuries involving days away from work, job restrictions, and job transfer, and DAFWII is the case rate on injuries involving days away from work only, all measured as number of cases per 100 full-time equivalent employees. Independent variable XPW is the kUSD exports per worker at commuting zone c in year t and IPW from CHN is the kUSD imports from China per worker at commuting zone c in year t. Robust standard errors in parentheses are clustered at the establishment level and commuting zone by five year-period level. * $p < .10$, ** $p < .05$, *** $p < .01$

Table 5: The Impact of Lagged Exports on Injury Rates

	(1)	(2)	(3)	(4)	(5)
			Panel A: Depvar. = ln(TCR)		
1 Period Lagged XPW	-0.008**				
	(0.003)				
2 Period Lagged XPW		-0.011***			
		(0.003)			
3 Period Lagged XPW			-0.011***		
			(0.003)		
4 Period Lagged XPW				-0.013***	
				(0.004)	
5 Period Lagged XPW					-0.015***
					(0.005)
Observations	521,273	521,273	521,273	521,273	521,273
			Panel B: Depvar. = ln(DART)		
1 Period Lagged XPW	-0.009***				
	(0.003)				
2 Period Lagged XPW		-0.013***			
		(0.003)			
3 Period Lagged XPW			-0.015***		
			(0.004)		
4 Period Lagged XPW				-0.017***	
				(0.005)	
5 Period Lagged XPW					-0.020***
					(0.005)
Kleibergen-Paap Weak IV F-Stats	45.812	56.487	64.662	64.316	71.914
Observations	521,273	521,273	521,273	521,273	521,273
			Panel C: Depvar. = ln(DAFWII)		
1 Year Lagged XPW	-0.002				
	(0.003)				
2 Years Lagged XPW		-0.006**			
		(0.002)			
3 Years Lagged XPW			-0.006**		
			(0.003)		
4 Years Lagged XPW				-0.006*	
				(0.004)	
5 Years Lagged XPW					-0.011*
					(0.006)
Kleibergen-Paap Weak IV F-Stats	98.133	87.614	72.937	44.910	25.899
Observations	310,588	310,588	310,588	310,588	310,588
Establishment & Year FE	Yes	Yes	Yes	Yes	Yes

Note: Dependent variables are log of indicated injury measures in establishment i at commuting zone c in year t. TCR is the total case rate, DART is the case rate on injuries involving days away from work, job restrictions, and job transfer, and DAFWII is the case rate on injuries involving days away from work only, all measured as number of cases per 100 full-time equivalent employees. Independent variable (XPW) is the kUSD exports per worker at commuting zone c, lagged from one year to five years. Robust standard errors in parentheses are clustered at the establishment level and commuting zone by five year-period level. * $p < .10$, ** $p < .05$, *** $p < .01$

Table 6: The Impact of Exports on Investment and Employment per Establishment, Industry-Level Evidence

	(1)	(2)	(3)	(4)	(5)	(6)
	Estab. Count	per Establishment				
		Capital Stock	Equipment	Prod. Emp.	Prod. Hours	Wage bill
ln(Exports)	0.070*	0.043	0.061**	0.006	0.008	0.049
	(0.036)	(0.031)	(0.030)	(0.005)	(0.007)	(0.031)
Industry & Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,232	8,232	8,232	8232	8,232	8,232

Note: Table reports estimates of 2SLS regressions. Dependent variables are log of indicated entities in industry j in year t. Independent variable ($\ln(Exports)$) is the log of exports in industry j. Robust standard errors in parentheses are clustered at the establishment level and commuting zone by five year-period level.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 7: The Impact of Export on Inspections, Violations, and Penalties

	(1)	(2)	(3)	(4)
Type:	ln(Total)	ln(Accident)	ln(Complaint)	ln(Programmed)
		Panel A: ln(Number of Inspection)		
XPW	-0.010	-0.009*	-0.019***	-0.005
	(0.009)	(0.005)	(0.007)	(0.010)
		Panel B: ln(Number of Violation)		
XPW	-0.020**	-0.010	-0.031**	-0.018
	(0.009)	(0.010)	(0.014)	(0.014)
		Panel C: ln(Total Penalties)		
XPW	-0.033	-0.029	-0.070*	-0.028
	(0.031)	(0.036)	(0.034)	(0.035)
CZone FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	14,572	14,572	14,572	14572

Note: Table reports estimates of 2SLS regressions. Dependent variables are log of indicated enforcement measures at commuzing zone c in year t. Independent variable (XPW) is the kUSD exports per worker at commuting zone c in year t. Robust standard errors in parentheses are clustered at the establishment level and commuting zone by five year-period level. * $p < .10$, ** $p < .05$, *** $p < .01$

Table 8: The Impact of Export on Health and Health Behaviors

		Days of Bad or Poor					
	(1) General Health	(2) Mental Health	(3) Physical Health	(4) General Health	(5) Smoke Frequently	(6) Drink Frequently	(7) BMI
Panel A: Average Effect of XPW							
XPW	0.003***	0.021***	0.027***	0.022***	0.001*	0.001	0.025***
	(0.001)	(0.008)	(0.007)	(0.007)	(0.000)	(0.001)	(0.006)
Panel B: Adding Interactions with the Share of Mfg. Employment							
XPW	-0.001	0.003	-0.008	-0.005	-0.006***	0.004	-0.017
	(-0.003)	(0.022)	(0.020)	(0.020)	(0.001)	(0.003)	(0.014)
XPW $\times$ Mfg. Share	0.014	0.069	0.124**	0.100*	0.027***	-0.008	0.150***
	(0.009)	(0.067)	(0.062)	(0.059)	(0.004)	(0.009)	(0.043)
Observations	2,231,302	2,119,899	2,121,279	2,133,963	2,237,296	2,237,296	2,022,964

Note: Table reports estimates of 2SLS regressions. In columuns (1) to (4), dependent variables are log of indicated health measures for each individual at commuting zone c in year t. Independent variable (XPW) is the kUSD exports per worker at commuting zone c in year t; see text for details. Column (1) reports the 2SLS regression coeffiicent, where the general health status is defined as: 1=excellent to 5=poor. Dependent variables in columns (2) to (4) are log of days with fair or poor physical, mental health, and general health in the past month. Smoke Frequently = 1 if the individual smokes everyday. Drink frequently = 1 if the individual drinks more than 15 days per month. Column (7) the dependent variable equals to 1 if the individual's BMI is greater than 30. Robust standard errors in parentheses are clustered at the establishment level and commuting zone by five year-period level.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table 9: Ordered Logit Marginal Effects, Outcome=General Health Status

	(1) Excellent	(2) Very Good	(3) Good	(4) Fair	(5) Poor
XPW	-0.0004***	-0.0001***	0.0002***	0.0002***	0.0001***
Observations	2237296	2237296	2237296	2237296	2237296

Note: This table provides the marginal effect interpretation for the ordered logit results on health status. Every $1,000 increase in US exports per worker leads to 0.04% less likely to be in the excellent health status, 0.01% less likely to be in the very good health status, 0.02% more likely to be in the good and fair health status, respectively, and 0.01% more likely to be in the poor health status.
* $p < .10$, ** $p < .05$, *** $p < .01$