Import Competition and Workplace Safety of the U.S. Manufacturing Sector

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Abstract

The American workplace has been much safer. The manufacturing sector did a more remarkable job improving its safety than the non-manufacturing sector. What caused the remarkable safety improvement? Examining cross-industry and cross-region variations of workplace injury and illness rates over time, we estimate that around 12% of the safety improvement of the U.S. manufacturing sector could be attributed to import competition. Such non-wage benefit is worth billions of dollars per year. The sector offers much fewer dangerous jobs to its workers partly because import competition does not displace jobs uniformly but selectively: dangerous jobs get displaced faster than safe ones.

Keywords: Import competition, Workplace safety, Injuries and illnesses, OSHA, Globalization, Job displacement.
JEL Classifications: F10, F61, J28.

1. Introduction

Studies have shown that import competition depresses wage and ships jobs away from the U.S. (for example, Autor, Dorn, and Hanson, 2013; Revenga, 1992; Bertrand, 2004). Workers facing increasing pressure of losing their jobs while stuck with slow wage growth must be very stressed out. One would not be surprised to see their productivity falls as a result.[1]

Yet, instead of falling productivity and reduced output, the U.S. manufacturing sector has been producing more without any sign of productivity drop (Fort, Pierce, and Schott, 2018). Stressed out workers and strong productivity, however, do not seem to add up.

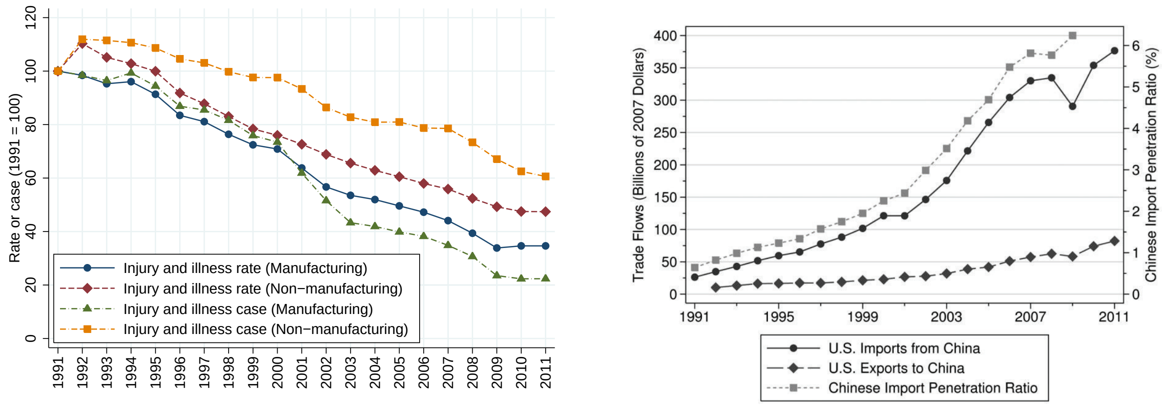
We explore whether import competition brings U.S. manufacturing sector non-wage benefits. If it does, it can partly explain why workers' productivity does not fall. The specific non-wage benefit we focus on is workplace safety. We focus on workplace safety for three reasons. First, everyone cares about how likely they will get killed or lose a finger at work. It is not just working or not at a certain wage, but whether the wage is high enough to compensate the worker for the risk she bears at work (Rosen, 1986). Second, workplace safety indeed carries a high stake. At a scale of millions of workplace accidents per year, Leigh (2011) estimates that each case costs $23,000 of damage in 2007 dollars. Third, there has been a remarkable workplace safety improvement (Krueger, 2000; Bhushan and Leigh, 2011) lacking a satisfactory explanation.

1.1. The remarkable workplace safety improvement and why import competition is a plausible cause

Figure 1(a) plots the (normalized) cases and rates of workplace injuries and illnesses of the private sector (excluding public). The data comes from the U.S. Bureau of Labor Statistics (BLS). The trends show that the American workplace has become much safer over the past decades. The private sector witnessed around 6.3 million cases of workplace injury and illnesses in 1991 but only around 3 million cases in 2011, a

[1] A universal theme in Krueger and Mas (2004), Mas (2006) and Mas (2008) is that the worsening of non-wage working condition adversely affects workers' productivity. The authors carefully study the detailed data surrounding three specific events to identify causality. Mas (2008) is about the dispute between Catepillar and its workers in some but not all plants that produced the same machines. Krueger and Mas (2004) is about the dispute between Bridgestone and its workers in one plant and during the strikes; Bridgestone escalated the dispute by hiring some replacement workers. Mas (2006) is the dispute between U.S. police force and some of its policemen on allegedly unsatisfactory pay raise. All three events not only just concern wage, but also worsened labor relations, an important aspect of non-wage working condition. Worker productivity, measured by output quality, was compromised as a result. In Mas (2008), it is the quality of machines measured by significantly lower resale market prices. In Krueger and Mas (2004), it is the defect frequencies of tires. In Mas (2006), it is the arrest rates. These studies support the view that unhappy workers produce less.

Figure 1: The remarkable improvement of workplace safety and the U.S. import trends



(a) Workplace injuries and illnesses in manufacturing and non-manufacturing sectors (normalized to 100 in 1991)

(b) U.S. imports

Source: (a) - Various issues of *Annual Reports of Workplace Injuries and Illnesses*; (b) - Acemoglu et al. (2016, Figure 2).

more than 50% fall in spite of the employment swell of the private sector during the period. If we extrapolate Krueger (2000)'s conversion of the safety improvement into dollar signs, the safety improvement amounts to at least $250 billion (in 2000 dollars) of an annual lift of the private sector.[2]

The manufacturing sector improves its workplace safety faster than the non-manufacturing sector does. Of the cases in 1991, 1/3 or 2.2 million happened in the manufacturing sector and the other 2/3 or 4.1 million cases happened in the non-manufacturing sector. In 2011, the manufacturing sector cut the number by 80% to half a million, which is about 1/6 of the total. The non-manufacturing sector cut the number by 40% to 2.5 million cases, which is the remaining 5/6 of the total.

Can employment changes explain the remarkable improvement? The answer is no. First, over the period, the manufacturing sector only lost 30% to 40% of jobs, inadequate to explain the 80% drop in cases.[3] Rather than employment shrinkage, the non-manufacturing sector increased its employment over the period, making the 40% reduction appears all the more remarkable.

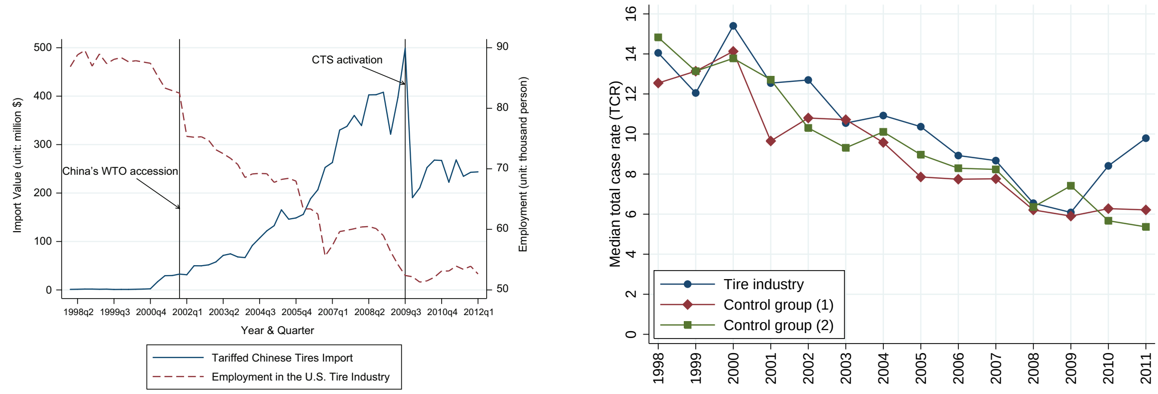
[2]Krueger (2000)'s conversion was that from 1992 to 2000, the cases of workplace injuries and illnesses fell by 25%, which he stated "translates to at least $125 billion annual lift for the economy." An around 50% fall doubles the number to around $250 billion annual lift in 2000 dollars. If one is willing to ignore inflation, then such extrapolation coincides with Leigh (2011)'s estimate of $250 billion in total costs of occupational injuries and illnesses in 2007 in the U.S. (thus, in 2007 dollars). While both our extrapolation from Krueger (2000) and the estimate of Leigh (2011) require a lot of qualifiers, it is safe to say that the stake of workplace safety is large and amounts to billions of dollars.

[3]The BLS's manufacturing sector employment index declined from 143.824 in the 1st quarter of 1991 to 98.744 by the last quarter of 2011, a drop of around 31.3%. The NBER-CES Manufacturing Database records a slightly larger drop but the database does not count the sector's administrative workers (see Bartelsman and Gray 1996).

Second, we also look at the change in the accident rates, allowing us to remove the effects of employment changes. In 1991, on average among 100 full-time manufacturing workers there were about 12.7 injuries and illnesses in a year. In 2011, they cut down the number by 2/3 to only 4.4 injuries and illnesses in a year. In contrast, the non-manufacturing sector witnessed 7.1 injuries and illnesses per 100 full-time workers in 1991 but only 3.4 in 2011, a cut of slightly more than half.[4]

Despite increased likelihood of losing their jobs due to foreign competition that simultaneously depresses wage growth, the manufacturing workers do work at a much safer workplace. This non-wage benefit makes their strong productivity appear less surprising.

Figure 2: The nosedive of tires import due to trade disputes appears to come at a cost of deteriorated domestic workplace safety



(a) Value of imports of Chinese tires (solid blue line)

(b) Workplace injuries and illnesses in the tire industry and industries in control groups

Source: (a) - Chung, Lee, and Osang (2016, Figure 1); (b) - Occupational Safety and Health Administration (OSHA) Data Initiative.

What caused the remarkable safety improvement? Krueger (2000) wrote in 2000 that to explain the safety improvement between 1992 and 2000 "has been easier to rule out potential explanations than to find a smoking gun that is responsible." Since his writing, the growing literature we will survey in section 2 has ruled out foreign competition by generally showing that foreign competition worsens rather than improves health using various health measures including workplace injury and illness rates. We revisit this important research question and ask if foreign competition actually causes the remarkable safety improvement.

Figure 1(b), taken from Acemoglu et al. (2016, Figure 2), shows that our research question does not seem unreasonable. The period of the remarkable safety improvement is when the imports of manufacturing goods from China surged dramatically. If the notion that foreign competition causes workplace safety improvement is true, it

[4]These numbers come from various *Annual Reports of Workplace Injuries and Illnesses* from BLS.

explains why the improvement is faster in the manufacturing sector than in the non-manufacturing sector.

China's accession to the WTO in 2001 appears to accelerate the safety improvement a little. Looking at the rates, figure 1(a) shows that the manufacturing sector speeds up its improvement slightly beginning in 2001; the non-manufacturing sector does not seem to have an obvious speed up during that period. At least from the macro trends, foreign competition does qualify as one plausible cause.

A trade dispute between the U.S. and China offers corroborating evidence. The dispute concerns certain tire imports in the second half of 2009 (Grimmett, 2011). The tariff hike resulted in a nosedive of Chinese tire imports as shown in Figure 2(a), which is taken from Chung, Lee, and Osang (2016, Figure 1)). To be consistent with the notion that foreign competition causes workplace safety improvement, more dangerous tire manufacturing workplaces should follow the trade dispute. Figure 2(b) plots the workplace injury and illness rates of the corresponding industries from the Occupational Safety and Health Administration (OSHA) Data Initiative. Control groups (1) and (2) include the industries in the left and right panels, respectively, of Chung, Lee, and Osang (2016, Table 2). Specifically, the injury and illness rate for each group in a given year is the *median* injury and illness rate for the firms within the corresponding group in that year.[5] Relative to the control groups, the tire industry did experience significantly higher injury and illness rates in 2010 and 2011.

The tire dispute suggests a plausible mechanism through which import competition causes the manufacturing sector safer for its workers. According to Krueger and Mas (2004), the manufacturing of tires is "highly complex, labor-intensive task." They quoted another industry study that describes tire manufacturing as "dark, brooding, and smoky in places, a noisy monument to the almost unchanging way most tires are still made: with much reaching and lifting and cutting, a lot of human muscle power,and an endless demand for unflinching robot-like concentration." Importing tires from abroad means that some or all of these dangerous tasks and processes are being shipped out from the U.S. If politics suddenly stops these imports, the dangerous tasks and processes get shipped back to the U.S., compromising the safety of the American workplace.

In other words, import competition might have displaced U.S. jobs of different levels of dangerousness non-uniformly. In particular, jobs that are dangerous may be more readily displaced by import competition than those that are safe.[6]

[5] More details on these data are in Section 3.

[6] One can easily overlook these changes as the NBER-CES Manufacturing Database shows that the ratio of production to total workers shown in (Bartelsman and Gray, 1996) hovered at around 70% from the early 1990s to 2011. However, one needs to be careful drawing conclusions from these numbers because the database excludes the sector's administrative workers when counting employment (Bartelsman and Gray, 1996).

1.2. Empirics

Our data, described in detail in section 3 comes from the surveys of the Occupational Safety and Health Administration (OSHA) called the OSHA Data Initiative (ODI). We use the publicly-available version. To identify the causal impact of import competition on workplace safety, we stick with the specifications and the empirical strategies that are conventional in the literature. Our approach rules out the suspicion that our results are due to either a special or proprietary dataset or a clever identification strategy unconventional in the literature.

We decompose the aggregate trends of the safety of the American workplace (more details in Appendix A) to identify the sources of variations. A large part of the safety improvement happens "within" rather than "between" sectors, with especially pronounced variations across industries. If import competition does make the American workplace safer, it should be able to explain such cross-industry variations. Section 5, therefore, tests whether a manufacturing workplace is significantly less likely to witness its workers getting injured or sick at work if it belongs to an industry more exposed to import competition. But we cannot restrict our examination only at the industry level because workers might join a different industry without relocating. Section 6, therefore, tests whether a manufacturing workplace is significantly less likely to witness their workers getting injured or sick at work if it is located in a region more exposed to import competition.

Examining how import competition relates to the variations of workplace injury and illness rates at both industry and region levels gives other advantages. First, the enforcement of OSHA differs substantially across regions.[7] Looking both at the region and industry levels alleviates our concerns that changes in enforcement across regions over time correlates with our regressor of interest and thus biases our estimates. Second, industry safety regulations change over-time. Not being able to measure (and therefore control) them in our estimation potentially biases the estimates. The regional analysis alleviates such a concern.

We measure import competition using import penetration ratio. To address potential endogeneity, we use an instrumental variable (IV) estimation strategy as in Lu and Ng (2013).[8] Since one can never be absolutely certain if an IV is valid,

[7]For instance, focusing on the construction industry, Morantz (2007) finds that safety regulation enforcement differs between places enforced by the states and those by the federal agencies; such differences result in the differences of the reporting accuracy of workplace injuries. Her results are inline with the links between regional differences of enforcement and reporting shown in Ruser and Smith (1988).

[8]Lu and Ng (2013) use the U.K. import penetration ratio to instrument the U.S. import penetration ratio. Instead, we use Chinese import penetration ratio of other high-income countries as our IV, which is also used by Autor, Dorn, and Hanson (2013) and Acemoglu et al. (2016). This IV more likely satisfy the exclusion restriction than the UK IV because U.S. and U.K. both use English and share more common culture than U.S. with the other 8 countries that not only sue English but also a handful of

we also use a difference-in-differences (DD) strategy that exploits the granting of Permanent Normal Trade Relations (PNTR) to China when it entered the World Trade Organization (WTO), as in Pierce and Schott (2016), Lu and Yu 2015, and Lu, Shao, and Tao (2018). We discuss these Section 4 discusses these two empirical approaches.

Unless we get consistent results using *both* conventional estimation approaches at *both* aggregation levels (i.e., at the industry and region levels), we would be reluctant to draw any causality. Fortunately, sections 5 and 6 show all four sets of results point to the same conclusion: a manufacturing workplace is significantly less likely to witness their workers getting injured or sick at work if it belongs to an industry or is located in a region more exposed to import competition.

Does import competition exert an economically meaningful impact? A back-of-the-envelope calculation suggests that import competition accounts for around 12.1% of the actual reduction in the workplace injury and illness rates. Putting this estimate in the context of Krueger (2000), assume arbitrarily a quarter of the annual lift of $250 billion belongs to the manufacturing sector, the annual contribution attributed to import competition translates to around $7.56 billion (in 2000 dollars). Using the more conservative estimate by Leigh (2011), our estimate corresponds to an annual saving of around $1.58 billion (in 2007 dollars) in injury costs for the American manufacturing sector.[9]

Does import competition make the American workplace safer by displacing dangerous jobs faster than safe jobs? In other words, importing from abroad means that those jobs shipped abroad largely consist of tasks and processes that are dangerous. In section 7, we first show that in those industries with a larger fraction of production workers, import competition reduces the workplace injury and illness rates more. Looking closely at the employment share changes across jobs, we find that industries more exposed to import competition shifts their employment away from jobs that are more dangerous and those that encompasses more manual tasks. A larger fraction of the labor in these industries end up working at safer jobs that encompass more abstract tasks.

2. Relation to the literature

Our paper relates to two strands of literature: (A) Studies on the effects of import competition on the traditional labor market variables, and (B) Studies on the effects of import competition on health. Table 1 organizes the main takeaways of a subset of the

other languages.

[9]The $7.56 billion comes from the extrapolated annual lift of $250 billion times the one-fourth (arbitrarily set) belonging to the manufacturing sector times 12.1%. The $1.58 billion extrapolation is a bit more involved and is detailed in appendix F.

literature.

Table 1: Some related studies

Study	Country	Aggregation	Findings
		Panel A: Labor market outcomes	
Acemoglu et al. (2016)	U.S.	Industry and region levels	Negative impact on **employment**
Adda and Fawaz (2017)	U.S.	Industry and region levels	Negative impact on **employment** and **wage**, among areas with more industries using routine tasks
Autor, Dorn, and Hanson (2013)	U.S.	Region level	Negative impact on **employment** and **wage**
Bloom et al. (2019)	U.S.	Region and firm levels	Negative impact on **mfg. jobs** but positive impact on **service jobs**, among high-human capital areas and large firms.
Lu and Ng (2013)	U.S.	Industry level	Positive impact on **non-routine skills** and negative impact on **routine skills**
Pierce and Schott (2016)	U.S.	Industry level	Negative impact on **employment**
Utar (2014)	Denmark	Firm level	Negative impact on **employment** and positive impact on **wages of skilled workers**
Utar (2017)	Denmark	Individual level	Negative impact on **employment** and the impact on wages depends on occupation specificity to manufacturing
Utar and Ruiz (2013)	Mexico	Plant level	Negative impact on **employment**, positive impact on **wage** (probably due to increased skills), and positive impact on **skills**
		Panel B: Health outcomes	
Adda and Fawaz (2017)	U.S.	Industry, region and individual levels	Negative impact on **mortality rate** and **hospitalization**, among areas with more industries using routine tasks
Colantone, Crinò, and Ogliari (2019)	UK	Individual level	Negative impact on **mental health**
Lang, McManus, and Schaur (2019)	U.S.	Region and individual levels	Negative impact on **mental health** and **obesity**
Pierce and Schott (2019)	U.S.	Region level	Negative impact on **deaths of despair** (drug overdose, suicide, alcohol-related liver diseases)
McManus and Schaur (2016)	U.S.	Establishment level	Negative impact on **workplace safety**
Our paper	U.S.	Industry and region levels	Positive impact on **workplace safety**

2.1. *Studies on the effects of import competition on traditional labor market variables*

Our paper relates to the studies in Panel A. Workers are well aware of their workplace safety. They do not take up a job given a wage without thinking of their own safety. Employers cannot hire anyone unless they offer enough to compensate workers for the risk they bear at work.[10] The effects of import competition on workplace safety, therefore, goes hand-in-hand with the effects of import competition on employment and wages. When import competition depresses wages but improves workplace safety, the net effect on workers is ambiguous.

Important studies such as Acemoglu et al. (2016), Adda and Fawaz (2017), Autor, Dorn, and Hanson (2013) and Pierce and Schott (2016) find that import competition from China displaces U.S. jobs. Utar (2014, 2017) and Utar and Ruiz (2013) find similar displacement in Denmark and Mexico. Import competition depresses wage but does not appear to depress those of skilled and highly educated workers. Lu and Ng (2013) show that import competition increases the U.S. manufacturing industry's use of non-routine skills including interpersonal, cognitive, and manual skills and reduces its use of routine skills.

Bloom et al. (2019) show that while import competition from China displaces manufacturing jobs, it stimulates job growth in the service sector in high-human capital areas and among the large firms. Import competition reallocates jobs geographically from heartland to coasts. Our results complement Bloom et al. (2019) by showing non-uniform trade-induced job displacement within the manufacturing sector. Dangerous jobs are being displaced faster, in turn improving workplace safety. While our results say nothing about those who permanently lose their jobs and those who join the non-manufacturing sectors, those who remain employed in the manufacturing sector work at a safer workplace. To the extent that import competition improves workplace safety, even if it depresses wages, on the net it does not necessarily hurt those who remain at work.

Ultimately, whether import competition makes labor on the net better or worse off depends on careful studies on aspects beyond just employment and wages. Its effect on health is likely one of the most important non-wage effects the studies in Panel B examine.

2.2. *Studies on the effects of import competition on health*

This literature has been growing.[11] Pierce and Schott (2019) find that the U.S. counties more exposed to import competition experience relatively more deaths due to drug overdose, especially among whites. Using survey data from the U.S. Center of Disease Control's Behavioral Risk Factor Surveillance System, Lang, McManus, and Schaur

[10] See also a recent study by Maestas et al. (2018) who evaluate the impact of working conditions on job choice decisions and wage structure.

[11] Beyond economics, the occupational health literature also examines the relationship between globalization and occupational safety. Many studies focus on such issues as the safety of workers in a factory set up by a multinational in a developing country. See, for example, Loewenson (2001) and Baram (2009). There is also a growing literature on the effects of import competition on U.S. politics (e.g., Lu, Shao, and Tao 2018 on the media, Che, Lu, Pierce, Schott, and Tao 2017 and Autor, Dorn, Hanson, and Majlesi 2017 on Americans' voting behaviors).

(2019) find that respondents in Census commuting zones with a large increase in import competition report significantly worse average mental, physical, and general health conditions. Adda and Fawaz (2017) find that in regions with a large share of jobs involving routine tasks, import competition significantly decreases the labor market participation rate and household income. Using detailed U.S. hospitalization data, they find that these regions also experience increases in admissions for heart problems, infectious diseases, suicides, mental health issues, stress and alcohol abuse. Tracking manufacturing workers over time, they find that import competition significantly increase their likelihood of dying.

Outside the U.S., Colantone, Crinò, and Ogliari (2019) use data from the British Household Panel Survey and various measures of import competition in more than 100 industries. They find that import competition has a large negative impact on individuals' mental health.

Examining workplace injuries and illnesses at the establishment-level, McManus and Schaur (2016) find that import competition increases workplace injury rates for small establishments but not for large establishments.

2.3. *Why seemingly opposite result?*

One would notice that the positive effect found in our paper appears to be at odd with the findings in the literature. Why so?

2.3.1. *Health is inherently multi-dimensional.*

Panel B of Table 1 shows that health is inherently multi-dimensional. The measures used in the papers include (but are not limited to) workplace injuries and illnesses, mental health, death of despair, hospitalization, drug abuse and alcoholism, obesity, mental problems, etc. Import competition can directly affect each of these measures. It can also indirectly affect these measures through other channels, such as job displacement. For instance, being displaced may induce some workers to indulge in alcohol. Such a behavioral response is much broader than economics; addressing it is beyond just preventing workers from losing their jobs but also other psychological support under hardship. Workplace injuries directly relates to workers and their jobs, while the other health measures, although can possibly relate to jobs, are not necessarily only driven by their experience at work. In this sense, our results do not contradict with any studies looking at health measures other than workplace safety.

2.3.2. *Aggregation encompasses compositional changes we are unsure of.*

McManus and Schaur (2016) find that import competition increases workplace injury rates in small establishments but not in large establishments.[12] If large establishments are likely owned by large firms, their results are consistent with Bloom et al. (2019) in that large firms add back service jobs facing import competition. However, it is hard to use their negative results to reconcile the remarkable workplace safety improvement shown in Figure 1(a). The divergence suggests that somewhere between the firm-level and the sector-level, there involves some substantial compositional changes. The mechanism in McManus and Schaur (2016) implicitly involves compositional changes at the firm-level too. To the extent that exerting more effort induces more workplace injuries, firms would optimally trade-off the short-term gain of increased productivity versus the long-term liability of deteriorated workplace safety. In case import competition weeds out firms faster, the long-term liability becomes less important, incentivizing firms to cut corners and push for more effort and the expense of higher injury rates. In light of this mechanism, McManus and Schaur (2016) findings suggest that import competition likely weeds out small establishments faster than large establishments. In other words, workplace safety may have been compromised among the small establishments but they are becoming less important in determining workplace safety at the aggregate.

It remains an open question whether import competition improves or compromises aggregate workplace safety because we are still unsure of the compositional changes of import competition. Our paper addresses this question at both the industry and region levels that encompass compositional changes beyond firm.

2.3.3. *Our positive effect is not due to specific estimation methods or special data.*

Our data is officially assembled by the U.S. Department of Labor and freely accessible to anyone. The two identification strategies (our instruments and the accession of China in WTO to be explained later) have been well-received in the trade literature. Our panel estimation specifications are also standard. We can therefore rule out the suspicion that our finding is driven by either the special data we use or the specific estimation strategy non-standard in the literature. These lend us more confidence that the compositional effect is what we are capturing.

[12] In an unreported analysis, we perform establishment-level estimations with our ODI data. Consistent with McManus and Schaur (2016), we find a positive impact of imports on establishment-level injury rates.

3. Data

Our empirical analysis uses the public version of the OSHA Data Initiative (ODI), recorded by the OSHA of the U.S. Department of Labor, the agency that enforces the Occupational Safety and Health Act of 1970 (29 U.S.C. 651). The act requires nonexempt employers to prepare and maintain records of their workplace injuries and illnesses.[13] According to the Code of Federal Regulations (Title 29, Subtitle B, Chapter XVII, Part 1904), "an injury or illness is an abnormal condition or disorder. Injuries include cases such as, but not limited to, a cut, fracture, sprain, or amputation. Illnesses include both acute and chronic illnesses, such as, but not limited to, a skin disease, respiratory disorder, or poisoning."[14] Employers must display a summary of their records in their workplaces' common areas where employees can see them. The ODI contains the records of those employers from whom the OSHA collects records. To ensure accuracy, the OSHA audits workplaces using both surprised and scheduled inspections (U.S. Government Accounting Office, 2009).

BLS also records workplace injuries and illnesses through its Survey of Occupational Injuries and Illnesses (SOII). Some employers submit their records to both ODI and SOII. In principle, ODI and SOII report the same underlying population of workplaces. Our empirical analysis uses ODI but not SOII for three reasons. First, the BLS does not inspect workplaces but OSHA does. Second, some disclosure rules render many four-digit industry-level figures unavailable in the public version of SOII.[15] Third, we cannot use SOII data to conduct a regional analysis because it lacks detailed geographical information of the establishments. Appendix B compares ODI and SOII in detail. The takeaway is that ODI and SOII are consistent with each other.

ODI records workplace injuries and illnesses at the establishment level. Their records contain the names, addresses, industries, and injury and illness rates of the establishments. An establishment differs from a firm. Fort, Pierce, and Schott (2018) highlights that manufacturing firms are increasingly engage in non-manufacturing activities as shown by their increasing number of non-manufacturing establishments in the past dacades. ODI allows us to largely by-pass this concern by looking at manufacturing establishments but not manufacturing firms. The records standardize

[13] Employers with 10 or fewer employees are exempted. Work-sites in specific low hazard industries such as retail, service, finance, insurance, and real estate are also exempted.

[14] However, the distinction between injuries and illnesses was eliminated in 2002.

[15] Using SOII, the BLS generates an annual set of industry-level estimates called "Survey of Occupational Injuries and Illnesses — Annual Summary" (SOII-AS). According to *Chapter 9: Occupational Safety and Health Statistics, BLS Handbook of Methods* (p. 14), industry estimates may not be published if: (i) publication might disclose confidential information, (ii) the relative standard error of the estimate for days away from work, job transfer, or restriction cases for the industry exceeds a specified limit, (iii) the benchmark factor for the industry falls outside an acceptable range.

the annual rate as follows:

$$\text{Injury and illness rate} = \frac{\text{Number of injury and illness cases} \times 100}{\text{Number of full-time workers}}, \\ = \frac{\text{Number of injury and illness cases} \times 200{,}000}{\text{Employee hours worked}}, \quad (1)$$

where 200,000 corresponds to 100 workers working 40 hours per week for 50 weeks a year.

ODI gives us two measures of the annual workplace injury and illness rates spanning 1996-2011: TCR (total case rate that covers all recordable cases) and DART (days away, restricted, and transfer case rate).[16] The definition of DART cases are "those which involve days away from work (beyond the day of injury or onset of illness), or days of job transfer or restricted work activity, or both."[17] As DART covers more serious injury and illness cases that are less prone to misreporting, using it alleviates the concern of imperfect reporting (Ruser, 2008).

Our analysis does not include fatal injuries; they are very rare. The BLS records only around 4,500-6,600 cases of fatal work injuries per year between 1992 and 2014. The rate of fatal work injuries was 0.0033-0.0042 per 100 full-time workers between 2006 and 2014.[18] In contrast, the average non-fatal injury and illness rate per 100 full-time workers was about 4-12 between 1991 and 2012.

The public version of ODI we use does not give the employment of the establishments. We therefore cannot compute the industry-level employment-weighted injury and illness rate. Instead, in the industry-level analysis, we compute the outcome variable R_{jt} as the median injury and illness rate of establishments in industry j and year t.[19] Similarly, for the regional-level analysis, we compute the outcome variable R_{rt} as the median of the injury and illness rate among manufactduring establishments in region r and year t.[20] To minimize the impact of outliers, we discard establishment-level observations in which the injury and illness rates are above the 99% percentile. Including them yields similar results. Using unweighted means

[16] Another ODI injury and illness rate measure is DAFWII (days away from work case rate), but it is only available from 2002 to 2011.

[17] For example, consider 2 employees who are injured at work. Employee A can continue to work at the same position on the day of the injury. Employee B must be away from work for 5 days and when she returns to work, she is unable to perform normal duties for another 3 days. TCR records 2 cases, but both DART and DAFWII only record employee B's case as 1 case. Specifically, DART records employee B's case for 8 days of abnormal work, while DAFWII records 5 days of absence from work. DAFWII cases are thus a subset of DART cases.

[18] These numbers come from BLS's presentations: http://www.bls.gov/iif/oshwc/cfoi/cfch0013.pdf.

[19] We have cross-validated the median injury and illness rate derived from ODI and the published injury and illness rate from SOII-AS in Appendix B. The two variables are highly correlated.

[20] In the raw data, we observe the ZIP codes of the establishments, and convert to 1990 CZ (as in Acemoglu et al. 2016).

instead of the medians also yields similar results.

4. Econometric Specification

4.1. Industry-level analysis

We run the following estimation, à la Lu and Ng (2013), to identify the link between import competition and workplace injury and illness rates across industries and over time:

$$R_{jt} = \alpha_j + \beta \log(impr_{jt-1}) + \gamma X_{jt-2} + \theta_t + \varepsilon_{jt}, \tag{2}$$

where R_{jt} measures the annual workplace injury and illness rate of 4-digit industry j in year t; $\log(impr_{jt-1})$ is log Chinese import penetration ratio (lagged by a year) and, following Acemoglu et al. (2016), $impr_{jt-1}$ is defined as:[21]

$$impr_{jt} = \frac{\text{Chinese imports to the U.S.}_{jt}}{\text{Industry shipment}_{j,1991} + \text{Industry import}_{j,1991} - \text{Industry export}_{j,1991}}; \tag{3}$$

X_{jt-2} is a vector of covariates (lagged by two years); α_j and θ_t are industry and year fixed-effects, respectively; and ε_{jt} is the error term. If correctly estimated, a negative β implies that industries exposed to higher import competition see fewer of their workers getting injured and sick at work.

Estimating (2) using OLS biases the estimates. Beyond sector-wide safety policies, there are industry-specific safety policies and regulations. Safety policies encompass many different dimensions and matter differently for different industries. For instance, the safety guidelines of using chemicals matter more for toy industries than for apparel industries. We are not aware of any consistent measure that encompasses all different safety dimensions across industries and over time. Industrial safety policies we fail to control for likely affect imports as well, biasing our β estimate. Industry-specific changes in organizations such as unions and worker advocacy group also likely affect both workplace safety and imports. However, we also do not have a consistent measure over time and across industries.

We address such endogeneity issues by instrumenting Chinese import penetration ratio in the U.S. with the corresponding Chinese import penetration ratio in 8 other countries (including Germany, Switzerland, Spain, Denmark, Finland, Japan,

[21] Their data come from the UN Comtrade Database, which contains bilateral import data for 6-digit Harmonized Commodity Description and Coding System (HS) products. Their import amounts are converted to constant year 2007 USD using the personal consumption expenditure deflator.

Australia, and New Zealand). Specifically, the instrument is defined as:

$$impr_{jt}^{IV} = \frac{\text{Chinese imports to other high income countries}_{jt}}{\text{Industry shipment}_{j,1991} + \text{Industry import}_{j,1991} - \text{Industry export}_{j,1991}}. \tag{4}$$

Autor, Dorn, and Hanson (2013) and Acemoglu et al. (2016) also use this instrument. Its validity hinges on two identification assumptions. First, the industry-specific changes (such as changes in safety policies, unions, or worker advocacy groups) in the U.S. do not synchronize with the corresponding changes in the other countries. Second, Chinese manufacturing industries do not exhibit strong increasing returns to scale. If they do, exporting more to the U.S. would make it more efficient for an industry to export to the other eight countries.

One cannot completely rule out the possibility that Chinese import penetration ratio of the other 8 high-income countries correlates with our error term, violating the exclusion restriction. For instance, the Internet facilitates the coordination of political actions for activists around the world. If enough groups of workers from these countries coordinate with their American counterparts to compel the World Health Organization (WHO) to make certain industry-specific safety changes, our IV would fail the exclusion restriction. Also, if enough industries are dominated by a few multinationals having operations both in the U.S. and in these other countries, company-wide safety instructions could be synchronized across all 9 countries; our IV fails the exclusion restriction.

If import competition is indeed negatively associated with workplace injuries and illness rates, the empirical pattern should emerge when using another credible estimation strategy. Following Pierce and Schott (2016), Lu and Yu (2015), and Lu, Shao, and Tao (2018), we use a difference-in-differences (DD) strategy. The U.S. granted a permanent normal trade relations (PNTR) status to China in 2000, effective when the nation joined the World Trade Organization (WTO) in 2001. Pierce and Schott (2016) define the "NTR gap" as the difference between the non-NTR and the NTR tariff rate. We use the NTR gaps measured in 2000, 1998, and 1996 in the following estimation model:

$$R_{jt} = \alpha_j + \beta \, NTRGap_j \times PostPNTR_t + \gamma X_{jt} + \theta_t + \varepsilon_{jt}, \tag{5}$$

where $PostPNTR_t$ is a dummy equal to 1 for 2001 onward and $NTRGap_j$ is the NTR gap for industry j. If correctly estimated, a negative β implies that industries with a larger NTR gap (their import competition increases more dramatically because the uncertainty falls more dramatically after the granting of PNTR) have significantly lower injury rates.[22]

4.2. Region-level analysis

Industry is not the only aggregation level that reflects compositional changes in the labor force across firms. Foreign competition may displace a worker in industry A, making her switch to industry B within the same region. If import competition is associated with lower workplace injury and illness rates, a similar pattern should emerge when we use region as an aggregation unit.

We run the following estimation to identify the link between import competition and workplace injury and illness rates across regions and over time:

$$R_{rt} = \alpha_r + \beta \log(impr_{rt-1}) + \gamma X_{rt-2} + \theta_t + \varepsilon_{rt}, \tag{6}$$

where R_{rt} is the annual workplace injury and illness rate among the manufacturing establishments in community zone r in year t; $impr_{rt-1}$ is the employment-weighted average of the region's Chinese import competition ratio constructed as follows:

$$impr_{rt-1} = \sum_j \frac{\text{Employment}_{rjt-1}}{\text{Employment}_{rt-1}} impr_{jt-1}; \tag{7}$$

α_r and θ_t are region and year fixed-effects, respectively, and ϵ_{rt} is the error term. We instrument the employment-weighted average of the region's Chinese import penetration ratio with the average of the corresponding ones of the 8 other countries. We verify if a similar pattern emerges using DD strategy:

$$R_{rt} = \alpha_r + \beta\, NTRGap_r \times PostPNTR_t + \gamma X_{rt-2} + \theta_t + \varepsilon_{jt}, \tag{8}$$

where $NTRGap_r$ is the regional exposure to the PNTR shock as measured by the employment-weighted average NTR gap across the industries.

5. Industry-level empirical results

Our sample includes 5,888 industry by year observations covering 390 distinct 4-digit industries.[23] Table 2 reports the summary statistics.[24] In a typical year for 100 full-time workers, a manufacturing industry witnesses around 7 cases of workplace injuries and illnesses (i.e., TCR); among them 3.4 cases are more serious (i.e., DART). The average

[22]The identification assumption for DD is the common trend assumption that, for brevity, we do not discuss here. Lu and Yu (2015) and Lu, Shao, and Tao (2018) have extensive discussion on its validity.

[23]The industry classification is *sic87dd* as in Acemoglu et al. (2016).

[24]These control variables are constructed using data from the NBER-CES database.

Table 2: Industry-level summary statistics

	Observations	Mean	S.D.
Injury and illness rates per 100 full-time workers, R_{jt}			
- Total case rate (TCR)	5,888	7.028	4.070
- Days away, restricted, and transfer case rate (DART)	5,888	3.350	2.259
Lagged import penetration			
- from China to the U.S., $impr_{jt-1}$	5,888	0.077	0.178
- from China to other high-income countries, $impr^{IV}_{jt-1}$	5,888	0.069	0.178
Employment (1,000 workers)	5,888	31.243	38.960
4-factor TFP	5,888	1.140	2.047
Capital-labor ratio	5,888	104.879	122.271

Note: Each observation is a 4-digit industry by year. The sample period is 1996-2011.

import penetration ratio from China of the U.S. for a typical industry is about 7.7% and that of the other 8 high-income countries is about 6.9%.[25] The relatively large standard deviations of these variables reassure us that there is enough variation for making inferences.

5.1. IV results

Table 3 reports the estimation results of model (2) by OLS and 2SLS. In all specifications, we report robust standard errors, adjusted for arbitrary heteroskedasticity and autocorrelation. Appendix C reports the first-stage results of the IV estimations.

Columns (1)-(3) use all workplace injuries and illnesses (i.e., TCR) as the outcome variable. Column (1) shows the OLS results when we regress TCR on log Chinese import penetration ratio with industry and year fixed-effects. Column (2) estimates the model with 2SLS, in which log Chinese import penetration ratio is instrumented by the log Chinese import penetration ratio of the other high-income countries. Column (3) further saturates the model by controlling for total employment, productivity, and capital-labor ratio (all in log). These results suggest that import competition is associated with significantly fewer injuries and illnesses among the manufacturing industries.

We are aware that industries facing tougher foreign competition may under-report their injury and illness cases more often than do other industries. To alleviate this concern, in Columns (4)-(6), we use DART as the outcome variable. Since DART measures more serious injuries and illnesses, it is less prone to under-reporting than TCR. The estimated coefficients of the regressor of interest remain negative and significant.

[25] As can be seen in Figure 1(a), the import penetration ratio for the entire manufacturing sector never exceeded 7% during the period 1991-2011. At the industry-level, the import penetration ratio is defined by (3). It is possible that some industries have a larger numerator and a smaller denominator while the opposite holds for some other industries. Therefore, the industry-level mean of 7.7% is not inconsistent with the overall trend for the entre manufacturing sector.

Table 3: Industry-level IV results

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Total case rate (TCR)			Days away, restricted & transfer case rate (DART)		
$\log(impr_{jt-1})$	-0.401^{***}	-0.559^{***}	-0.429^{***}	-0.209^{***}	-0.322^{***}	-0.245^{***}
	(0.025)	(0.109)	(0.110)	(0.013)	(0.069)	(0.071)
log Employment			-0.659^{**}			-0.439^{**}
			(0.302)			(0.198)
log 4-factor TFP			0.416			−0.009
			(0.279)			(0.175)
log Capital-labor ratio			0.666^{**}			0.242
			(0.288)			(0.180)
Estimation method	OLS	2SLS	2SLS	OLS	2SLS	2SLS
Industry fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.083			0.073		
F-stat for weak id		237.328	190.988		237.328	190.988

Note: $N = 5,888$. The first-stage estimation results are reported in Appendix C. Robust standard errors, adjusted for arbitrary heteroskedasticity and autocorrelation, are reported in parentheses. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

These results support the view that import competition is associated with significantly fewer injuries and illnesses among the U.S. manufacturing industries. The finding is unlikely driven entirely by the possibility of under-reporting of workplace injuries and illnesses under tougher foreign competition.

In both sets of estimations, the sizes of the 2SLS estimates are larger than the corresponding OLS estimates. This pattern suggests the possibility of the omitted variable bias in the OLS estimation. As discussed earlier, a possible omitted variable is industry-specific changes in organizations, such as unions and worker advocacy groups. If industries facing weaker foreign competition have stronger unions and worker advocacy groups, and if these industries also happen to improve their workplace safety faster, then ignoring this factor in the OLS estimation could bias the estimate of $\log(impr_{jt-1})$ upwards.

5.2. DD results

Table 4 reports the estimation results of model (5).[26] Columns (1)-(3) use all workplace injuries and illnesses (i.e., TCR) as the outcome variable while Columns (4)-(6) consider the more serious cases (i.e., DART). In each set of estimations, we use the NTR gaps measured in 2000, 1998, and 1996. Consistent with the IV results, in all columns the coefficients of the interaction between $NTRGap_j$ and $PostPNTR_t$ are negative and statistically significant. They suggest that import competition is significantly negatively associated with workplace injury and illness rates at the industry level.

[26]The number of observations in Table 4 is different from that in Table 3 because the industry classifications in Acemoglu et al. (2016) and Pierce and Schott (2016) are slightly different.

Table 4: Industry-level DD results

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Total case rate (TCR)			Days away, restricted & transfer case rate (DART)		
$NTRGap_j \times PostPNTR_t$	-1.036^{*}	-1.071^{**}	-1.894^{***}	-0.768^{**}	-0.792^{**}	-1.046^{***}
	(0.542)	(0.540)	(0.552)	(0.326)	(0.326)	(0.336)
log Employment	-0.859^{***}	-0.863^{***}	-0.920^{***}	-0.530^{***}	-0.533^{***}	-0.561^{***}
	(0.324)	(0.324)	(0.323)	(0.203)	(0.203)	(0.202)
log 4-factor TFP	0.783^{***}	0.782^{***}	0.791^{***}	0.414^{**}	0.413^{**}	0.419^{**}
	(0.294)	(0.294)	(0.293)	(0.180)	(0.180)	(0.180)
log Capital-labor ratio	0.113	0.113	0.117	−0.015	−0.016	−0.031
	(0.330)	(0.330)	(0.327)	(0.193)	(0.193)	(0.191)
Industry fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
$NTRGap_j$ measured in	2000	1998	1996	2000	1998	1996
R^2	0.688	0.688	0.689	0.587	0.587	0.587

Note: $N = 5,895$. Robust standard errors, adjusted for arbitrary heteroskedasticity and autocorrelation, are reported in parentheses. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

6. Region-level empirical results

Table 5: Region-level summary statistics

	Observations	Mean	S.D.
Injury and illness rates per 100 full-time workers, R_{rt}			
- Total case rate (TCR)	9,819	8.948	5.207
- Days away, restricted, and transfer case rate (DART)	9,819	4.112	2.771
Lagged import penetration			
- from China to the U.S., $impr_{rt-1}$	9,819	0.007	0.008
- from China to other high-income countries, $impr^{IV}_{rt-1}$	9,819	0.006	0.006
Total population (in million)	9,819	0.442	1.142

Note: Each observation is a commuting zone by year. The sample period is 1996-2011.

Our sample for regional-level analysis contains 9,819 community zone by year observations, representing more than 700 distinct community zones covering the entire U.S. territory except Alaska and Hawaii.[27] Table 5 reports the summary statistics for the key variables. In a typical year for 100 full-time manufacturing workers, a community zone witnesses about 8.95 workplace injuries and illnesses (i.e., TCR), among them 4.11 are more serious (i.e., DART). The average employment-weighted Chinese import penetration ratio in a commuting zone is around 0.7%.[28] Considerable variation is present in these outcome and explanatory variables.

[27] A community zone roughly corresponds to a labor market and is often bigger than a county.

[28] The fact that the manufacturing employment is small relative to non-manufacturing employment throughout the U.S. shrinks the employment-weighted Chinese import penetration ratio by roughly one-tenth of what we observe at the industry level, which is around 7.7%.

6.1. IV results

Table 6: Region-level IV results

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Total case rate (TCR)			Days away, restricted & transfer case rate (DART)		
$\log(impr_{rt-1})$	-0.247^{*} (0.142)	-0.527^{***} (0.177)	-0.525^{***} (0.179)	-0.079 (0.075)	-0.221^{**} (0.094)	-0.229^{**} (0.094)
log Total population			0.141 (0.948)			-0.522 (0.522)
Estimation method	OLS	2SLS	2SLS	OLS	2SLS	2SLS
Region fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.592			0.522		
F-stat for weak id		2560.519	2472.831		2560.519	2472.831

Note: $N = 9,819$. The first-stage estimation results are reported in Appendix C. Robust standard errors, adjusted for arbitrary heteroskedasticity and autocorrelation, are reported in parentheses. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

Table 6 reports the estimation results of (6) by OLS and 2SLS. In these specifications, we also report robust standard errors, adjusted for arbitrary heteroskedasticity and autocorrelation, in parentheses. We use the two measures of injury and illness rates, TCR and DART, as the outcome variables. In Columns (1) and (4), we estimate the model using OLS with region and year fixed-effects. In Columns (2) and (5), we estimate the model using 2SLS. In Columns (3) and (6), we further control for the population of the commuting zones. Focusing on the 2SLS results in Columns (2) and (3), we also find that the coefficients of log Chinese import penetration ratio are negative and statistically significant.

A region facing tougher foreign competition may also under-report workplace injuries and illnesses. One possible reason is that worker advocacy groups and unions can be weaker in these regions, the resulting weaker monitoring leaves employers there more leeway to under-report without being scrutinized. When we use DART as our outcome variable to capture the more serious injuries and illnesses in Columns (4) to (6), the negative and statistically significant estimates remain. These results suggest that the negative association between import competition and workplace injuries and illnesses at the region level is unlikely driven entirely by under-reporting.

6.2. DD results

Table 7 reports the results of model (8). We use the NTR gaps measured in 2000, 1998, and 1996 in these estimations. Consistent with the IV results, in all columns the coefficients of the interaction term between $NTRGap_r$ and $PostPNTR_t$ are negative and statistically significant. These results suggest that in the regions facing tougher import competition, the workplace injury and illness rates are significantly lower.

Table 7: Region-level DD results

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Total case rate (TCR)			Days away, restricted & transfer case rate (DART)		
$NTRGap_r \times PostPNTR_t$	-6.097^{**}	-6.124^{**}	-6.678^{***}	-2.981^{**}	-2.932^{**}	-3.145^{**}
	(2.435)	(2.453)	(2.554)	(1.302)	(1.312)	(1.364)
log Total population	1.157	1.159	1.162	−0.101	−0.100	−0.100
	(0.903)	(0.903)	(0.903)	(0.500)	(0.500)	(0.500)
Region fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
$NTRGap_r$ measured in	2000	1998	1996	2000	1998	1996
R^2	0.557	0.557	0.557	0.487	0.487	0.487

Note: $N = 10,193$. Robust standard errors, adjusted for arbitrary heteroskedasticity and autocorrelation, are reported in parentheses. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

7. Channels

While many have shown that foreign competition displaces U.S. domestic jobs, we examine if different jobs are displaced at different rates. Foreign competition can increase the safety of the manufacturing workplace by displacing dangerous jobs faster than safe ones.

7.1. The composition of jobs in the manufacturing sector

Understanding the channels through which foreign competition affects workplace safety requires us to know how the composition of jobs in the manufacturing sector links to workplace safety and how such a composition changes over time.

7.1.1. How does the composition of jobs link to workplace safety?

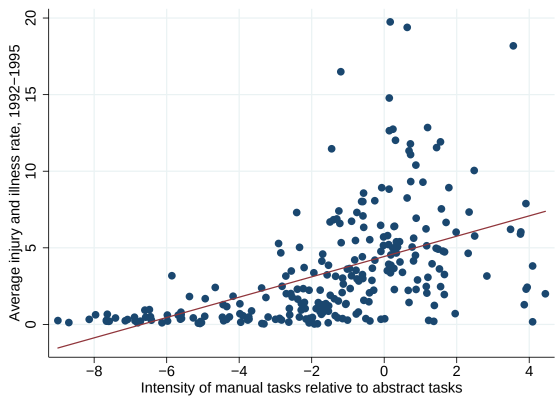
First, we correlate the share of production workers of an industry to the workplace injuries and illnesses. The share of workers comes from the NBER-CES Manufacturing Database. Figure 3(a) shows that industries with a higher share of production workers tend to have higher rate of workplace injuries and illnesses.[29] The jobs production workers perform appear to be more dangerous than those non-production workers perform.

Second, we look closely at the tasks of the jobs. Figure 3(b) sorts occupations

[29]To calculate the average share of production employment of an industry over 1992-1995, we use data from the NBER-CES Manufacturing Database. Besides, we compute the average industry-level injury and illness rates over 1992-1995 using data from Survey of Occupational Injuries and Illnesses — Annual Summary (SOII-AS). Note that the ODI data used in our main analysis are not available before 1996.

Figure 3: Relationship between injury and illness rate, task intensity, and production employment

(a) Relationship between injury and illness rate and production employment at the industry level (Slope = 15.91, robust standard error = 1.67)



(b) Relationship between injury and illness rate and task intensity at the occupational level (Slope = 0.66, robust standard error = 0.06)

(c) Relationship between production employment and task intensity at the industry level (Slope = 6.73, robust standard error = 0.73)

along the horizontal axis by the intensity of manual tasks relative to abstract tasks.[30] Occupations involving relatively more manual tasks tend to be more dangerous as shown by their higher injury and illness rates.[31] Figure 3(c), on the other hand, does

[30] Precisely, the measure is:

$$\text{Intensity of manual task relative to abstract task}_o = T^M_{o,1980} - T^A_{o,1980}, \tag{9}$$

where o is an occupation, $T^M_{o,1980}$ and $T^A_{o,1980}$ are the indexes of manual task input and abstract task input constructed by Autor and Dorn (2013). Their measures are derived from the U.S. Department of Labor's *Dictionary of Occupational Titles* (DOT) 1977. We have also followed Keller and Utar (2019) to construct measures of manual task and cognitive task intensities derived from Department of Labor's Occupational Information Network database (O*NET). Our results are similar.

[31] To measure occupational injury and illness rate, we use data from the Survey of Occupational Injuries and Illnesses – Case and Demographics (SOII-C&D) and the March Supplement of the Current Population Survey (CPS). The former records the number of injury and illness cases by occupation for all industries (up to 2010) and the latter provides data on occupational employment.

show that the share of production workers and the intensity of manual tasks are highly correlated at the industry level.[32]

Third, we gauge the composition of jobs by the actual injury rates of the different occupations. Table C in the appendix shows the most dangerous and safest jobs in the manufacturing sector. The table allows us to identify the occupations that are dangerous and safe. It shows that the most dangerous occupations are exclusively occupations of the production workers; the safest ones are exclusively of non-production workers. The table echoes well with figure 3.

7.1.2. *How does the composition of jobs change over time?*

Table 8 traces the employment share changes among the different kinds of jobs in the manufacturing sector. We sort occupations into quintile bins by their average injury and illness rates between 1992 and 1995 in panel A, and by the intensity of manual tasks relative to abstract tasks in panel B.

Table 8: Trends in occupational injury and illness rates and employment shares

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Median injury and illness rate				Employment share			
Quintile bins / Year	1996	2001	2006	2010	1996	2001	2006	2011
	Panel A: Occupations sorted by average injury and illness rate, 1992-1995							
Bin 1(Safe)	0.15	0.10	0.13	0.08	0.13	0.15	0.16	0.17
Bin 2	0.60	0.39	0.26	0.22	0.20	0.20	0.22	0.23
Bin 3	1.47	1.03	0.73	0.59	0.16	0.16	0.14	0.13
Bin 4	2.58	2.28	1.43	1.27	0.24	0.23	0.22	0.23
Bin 5(Dangerous)	5.27	3.97	2.78	1.91	0.26	0.25	0.25	0.25
	Panel B: Occupations sorted by intensity of manual tasks relative to abstract tasks							
Bin 1(Abstract)	0.23	0.12	0.13	0.11	0.27	0.29	0.30	0.31
Bin 2	0.67	0.51	0.34	0.20	0.16	0.16	0.16	0.17
Bin 3	1.49	1.16	0.68	0.73	0.13	0.13	0.12	0.13
Bin 4	2.94	2.69	1.42	1.37	0.32	0.31	0.31	0.28
Bin 5(Manual)	2.66	2.30	1.66	1.39	0.13	0.11	0.12	0.11

Note: All occupations are sorted by either average injury and illness rate, 1992-1995 (Panel A) or intensity of manual tasks relative to abstract tasks (Panel B). In Panel A, Bin 1 contains the safest occupations while Bin 5 contains the most dangerous ones. Table C in the Appendix lists the most dangerous occupations and the safest occupations. In Panel B, Bin 1 contains occupations that use relative more abstract task inputs while Bin 5 contains occupations that use relative more manual task inputs. Each number in Columns (1)-(4) is the median injury and illnes rate of occupations in the corresponding bin. Each number in Columns (5)-(8) is the share of workers in occupations in the corresponding bin.

Columns (1)-(4) show that that the occupations in different bins become safer over time. They are so irrespective of whether we sort the occupations according to

In particular, the injury and illness rate (per 100 workers) for occupation o in year t is R_{ot} = Number of injury and illness cases$_{ot}$/Employment$_{ot}$ $\times$ 100.

[32]The intensity of manual task relative to abstract task for an industry is calculated as the weighted sum of (9) where the weight is the employment shares of different occupations in the industry (estimated by data from CPS).

their average injury and illness rate or their intensity of manual tasks. Columns (5)-(8) show that, over time, the employment shares of occupations in Bins 1 and 2 increase while those in Bins 4 and 5 decrease, irrespective of the way we sort the occupations.

The takeaway is that the manufacturing sector has been having fewer dangerous jobs and more safe jobs.

7.2. *Evidence of import competition driving the compositional changes*

7.2.1. *Does import competition affect workplace safety more strongly in industries employing a higher share of production workers?*

Table 9: Industry-level results: Interaction with production employment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	Total case rate (TCR)				Days away, restricted & transfer case rate (DART)			
$\overline{E}_j^P \times \log(impr_{jt-1})$	-2.300^{***}				-1.172^{***}			
	(0.276)				(0.177)			
$\overline{E}_j^P \times NTRGap_j \times PostPNTR_t$		-2.392	-6.326	-0.033		-6.371^{**}	-7.879^{***}	-5.312^{*}
		(4.964)	(5.018)	(5.048)		(2.869)	(2.952)	(2.993)
F-stat for weak id	110.180				110.180			
$NTRGap_r$ measured in		2000	1998	1996		2000	1998	1996
R^2		0.692	0.692	0.692		0.591	0.591	0.591

Note: $N = 5,888$ for Columns (1) and (5) and $N = 5,895$ for Columns (2)-(4) and (6)-(8). Robust standard errors, adjusted for arbitrary heteroskedasticity and autocorrelation, are reported in parentheses. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

To check if import competition improves workplace safety through displacing dangerous jobs faster, we check whether it affects workplace injury and illness rates more strongly in industries employing a higher share of production workers. These industries are shown in section 7.1 to involve more dangerous jobs.

Table 9 shows that this is indeed the case. Specifically, we add the interaction of the average share of production employment between 1992 and 1995 (denoted as $\overline{E}_j^P$) with $\log(impr_{jt-1})$ in (2) and with $NTRGap_j \times PostPNTR_t$ in (5). Table 9 show the coefficients of these interaction terms. The coefficients are all negative; they are statistically significant for the specifications in (1) and (5)-(8). These results suggest that import competition likely displace dangerous jobs faster, resulting in a safer manufacturing workplace. A caveat, however, is that the NBER-CES Manufacturing Database does not include auxillary employment (Bartelsman and Gray, 1996) which has also grown among the industries in the manufacturing sector.

7.2.2. *Does import competition make jobs safer?*

Columns (1)-(4) of table 8 show that that the jobs in the manufacturing sector are becoming safer over time. We estimate the following equation to check whether import competition directly affects the workplace injury and illness rates of different occupations:

$$R_{ot} = \alpha_o + \beta \log(impr_{ot-1}) + \gamma X_{ot-2} + \theta_t + \varepsilon_{ot}, \tag{10}$$

where R_{ot} is the injury and illness rate per 100 workers, and , as in (7), $impr_{ot-1}$ is the (lagged) employment-weighted average of the occupation's exposure to Chinese import competition:

$$impr_{ot-1} = \sum_j \frac{\text{Employment}_{ojt-1}}{\text{Employment}_{ot-1}} \times impr_{jt-1}; \tag{11}$$

α_o and θ_t are occupation and year fixed-effects, and ε_{ot} is the error term.[33]

Table 10: Occupational-level results: Import competition and occupational injury and illness rates

	(1)	(2)	(3)
Dependent variable:	100 × Injury and illness rate per 100 full-time workers		
log ($impr_{ot-1}$)	−1.880*	−0.058	0.888
	(1.058)	(1.095)	(1.034)
log occupational employment	No	No	Yes
Estimation method	OLS	2SLS	2SLS
Occupation fixed-effects	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes
R^2	0.758		
F-stat for weak id		5438.767	5439.668

Note: $N = 4,063$. Robust standard errors, adjusted for arbitrary heteroskedasticity and autocorrelation, are reported in parentheses. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

Table 10 reports the results. In Column (1), we run an OLS estimation with only occupation and year fixed-effects. The OLS estimate is negative and statistically significant, suggesting that occupations facing more intense import competition are associated with lower injury and illness rates. Column (2) shows the results of a 2SLS estimation using the Chinese import penetration ratios to other 8 high-income countries. Column (3) further controls for log Occupational employment. Focusing on the results in Column (3), we find that the coefficient of $\log(impr_{ot-1})$ is statistically insignificant. In unreported tables, we use the injury and illness rates by different

[33] Note that the CPS only contains (roughly) 3-digit industry codes (*ind1990*); to estimate the above model, we use *ind1990* as the industry classification. In addition, we use the occupational codes constructed by Dorn (2009) (*occ1990dd*).

categories as the outcome variables; we find that, in most cases, the coefficients of $\log(impr_{ot-1})$ are statistically insignificant.[34] We conclude that the safety of jobs are unlikely driven by import competition.[35] Something else seems to be driving the changes.

7.2.3. Does import competition shift labor away from dangerous occupations?

Columns (5)-(8) of table 8 show that the manufacturing sector have fewer dangerous jobs and more safe jobs. Is import competition driving the changes? We estimate the following equation:

$$S^d_{jt} = \alpha_j + \beta \log(impr_{jt-1}) + \gamma X_{jt-2} + \theta_t + \varepsilon_{jt}, \tag{12}$$

where S^d_{jt} is the share of workers in industry j and year t who work in occupations in quintile bin d:

$$S^d_{jt} = \frac{\sum_{o \in d} \text{Employment}_{ojt}}{\text{Employment}_{jt}}. \tag{13}$$

The industry classification is *ind1990*; the observations are weighted by the industry's 1996 employment.

Table 11 reports the results. Columns (1)-(5), respectively, use S^1_{jt} to S^5_{jt} as the dependent variable. In Panel A, the bins are defined by the average injury and illness rates. In Panel B, the bins are defined by the intensity of manual tasks relative to abstract tasks.

In Panel A, the positive and significant coefficient of $\log(impr_{jt-1})$ in column (1) suggests that in industries facing tougher import competition, the share of workers in the safest occupations goes up. On the other hand, the negative and significant coefficient of $\log(impr_{jt-1})$ in column (5) suggests that in industries facing tougher import competition, the share of workers in the most dangerous occupations goes down.

In Panel B, we also find in column (1) that the share of workers in occupations with relatively more abstract task inputs are higher in industries facing tougher import competition. Besides, columns (2) and (3) show that the shares of workers in occupations in Bins 2 and 3 go down; these occupations are those with medium abstract task inputs. These results also suggest a shift of employment towards occupations using more abstract tasks, for which figure 3(b) shows are the safer jobs.

[34] These unreported results are available upon request.

[35] One may argue that, due to import competition, workers may work fewer hours so that they get injured less likely. To address this concern, we use number of working hours (obtained from the variable "hours worked last week" from CPS) to construct the occupational injury and illness rates; we also obtain similar results.

Table 11: Industry-level results: Import competition and employment shares of occupations with different degrees of dangerousness/task inputs

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	S^1_{jt}	S^2_{jt}	S^3_{jt}	S^4_{jt}	S^5_{jt}
	Panel A: Occupations sorted by degrees of dangerousness				
$\log(impr_{jt-1})$	1.264***	−0.091	−0.065	−0.136	−0.972**
	(0.360)	(0.379)	(0.316)	(0.484)	(0.439)
Estimation method	2SLS	2SLS	2SLS	2SLS	2SLS
F-stat for weak id	40.655	40.655	40.655	40.655	40.655
	Panel B: Occupations sorted by intensities of manual tasks relative to abstract tasks				
$\log(impr_{jt-1})$	1.095**	−0.862**	−0.861**	0.279	0.349
	(0.453)	(0.426)	(0.404)	(0.554)	(0.346)
Estimation method	2SLS	2SLS	2SLS	2SLS	2SLS
F-stat for weak id	40.655	40.655	40.655	40.655	40.655

Note: $N = 915$. S^d_{jt} is the share of workers in industry j and year t who work in the occupations in quintile bin d according to the average injury and illness rates, 1992-1995. Each regression includes log 4-factor TFP, log Capital-labor ratio, industry, and year fixed-effects. Robust standard errors, adjusted for arbitrary heteroskedasticity and autocorrelation, are reported in parentheses. The observations are weighted by the 1996 employment of the respective industries. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

Overall, our findings are consistent with the notion that import competition displaces dangerous jobs in the manufacturing sector faster than safe jobs. The corresponding shifts of employment correlate significantly with the intensity of import competition at the industry level. Such shifts appear from occupations with higher pre-sample injury and illness rate to those with lower pre-sample injury and illness rate, and from occupations with relatively more manual tasks to those with relatively more abstract tasks. Consistently, import competition affects workplace injury and illness rates more strongly in industries employing a higher share of production workers.

7.3. Other potential channels

A few other potential channels do not seem to be much relevant.

First, appendix E tests if the degree of safety compliance is an underlying channel. Since workplace injuries and illnesses are costly to firms, firms facing tougher foreign competition have incentives to reduce them. Being more compliant to the safety regulations can help. Foreign competition affects the overall safety compliance level in two ways. First, individual firms improve their own safety compliance. Second, competition weeds out faster those firms that are less compliant; they therefore have more workplace injuries and illnesses and therefore run at higher costs relative to their rivals. However, our empirical results support neither, suggesting that safety compliance is unlikely the underlying channel.

Second, what we have found may simply be due to the possibility that those industries and regions facing tougher foreign competition are also more likely to under-report workplace accidents. Foreign competition affects under-reporting in two ways. First, while enforcement of safety regulations are the same across regions and industries, firms facing tougher foreign competition may under-report workplace accidents. They may privately settle minor accidents with workers in order not to raise the attention of the regulator and to raise the expectation of an accident to current and potential employees. Second, enforcers of safety regulations may inspect firms having a tough time fighting with foreign competition more leniently. Morantz (2007) show more under-reporting in areas less strictly enforced by the regulators in the construction industry. The extent to which her result carries over to the manufacturing sector is unknown. Ruser and Smith (1988) has also reported under-reporting is not uncommon. Both suggest regional variations in the agencies responsible for enforcing OSHA and their inspection style difference can lead to predictable patterns of under-reporting. Our region-level analysis may suffer biases because the commuting zone dummies may not be able to capture changes in regional differences over time. To the extent that these changes correlate with the exposure of foreign competition at the community zone level, our results can be biases. The industry-level analysis alleviates this concern by aggregating at the industry level, largely by-passing the concerns of regional variations in enforcement. Our use of more severe injury and illness rates also alleviates the under-reporting channel. However, we have to be frank in acknowledging that we cannot completely rule out this channel.

Third, Morantz and Mas (2008) show that introducing post-accident drug tests in a major retailer leads to the under-reporting of minor accidents. The retailer was one of the Fortune 100 firms at the time of their study. The extent to which their result carries over to the manufacturing sector is unknown. It is a potential channel because firms facing tougher foreign competition have incentives to avoid costly accidents. If post-accident drug tests have the effects of reducing drug abuse at work as well as inducing injured workers who did take drugs at work to under-report, firms may see greater benefits of introducing post-accident drug tests under tougher foreign competition. The prevalence of substance abuse among manufacturing workers was reported by Bush and Lipari (2015), which also studies other sectors. Comparing to the retail sector, and even the services sector, manufacturing sector workers do seem to be less indulged in substance abuse, indirectly weakening this channel. Second, the beginning of the post-accident drug tests in the U.S. was largely due to President Reagan's executive order in 1986. Since then, the tests slowly became more common across the U.S. But the spread appeared a little too early to explain our trends. We view that this channel is at best marginally relevant.

8. Concluding remarks

We examine whether import competition brings non-wage benefits to the U.S. manufacturing sector. Data shows that the sector have been offering a more pleasant workplace to its workers; they face a much lower chance of getting injured or sick at work. Using workplace injury and illness data from the Occupational Safety and Health Data Initiative, we find that a manufacturing workplace is significantly less likely to witness its workers getting injured and sick at work if it belongs to an industry or is located in a region more exposed to import competition. Two different estimation estimation strategies conventional in the literature yield similar results, lending confidence to the view that import competition is one significant driver of the safety improvement of the American manufacturing workplace. Import competition is significantly associated with fewer dangerous jobs and more safe jobs, consistent with the view that import competition displaces dangerous jobs faster than safe jobs.

8.1. Economic significance

Do our estimates suggest a meaningful impact? A back-of-the-envelope calculation using results in Table 3 suggests the following:[36]

1. Import competition accounts for roughly 12.1% of the actual reduction in the injury and illness rates in the U.S. manufacturing sector.

2. In absolute terms, import competition accounts for an annual reduction of roughly 68,640 injury cases in the entire sector, or 176 cases per industry.

3. The sector saves at least $1.58 billion (in 2007 dollars) of injury costs in a year and the annual contribution to the private sector may go up to $7.56 billion (in 2000 dollars).

8.2. Implications on the effects of import competition on the well-being of U.S. manufacturing workers

Studies have shown that import competition reduces manufacturing employment and slows down the sector's wage growth, especially among unskilled workers. These negative effects do not fully address the question of whether import competition worsens the overall well-being of U.S. manufacturing workers. If their odds of getting sick and injured at work *increases* due to import competition, the negative effects are stronger than what the literature has found.

Our results do not support such a conclusion. If anything, their odds of getting sick and injured at work *decreases* due to import competition. We do not know if such

[36] Further details are in Appendix F.

a gain makes workers overall better off. But at least for those who remain employed, the negative effects of import competition do not seem to be as strong as previously suggested. These results leave open the question of whether those who are displaced out of the work force are *less* negatively affected by import competition than the literature suggests. While economically important, addressing the issue requires us to look into how workers behave after they are displaced and remain unemployed. We do not attempt to make any statement on this issue.

8.3. Future directions

As of 2019, WHO groups "burnout" as an occupational phenomenon but stresses that it is not a medical condition. One can be burnt out at work without obvious medical symptoms. On the other hand, some jobs, such as mining, have overlooked diseases and sicknesses that can haunt a worker long after they leave the jobs.

Measuring health is a tricky business; health is inherently multi-dimensional and crippled with time lags. While we focus on workplace safety, our two measures cannot paint the whole picture. Our paper does not make any statement to address how import competition relates to the following important issues:

1. Which types and severity of injuries and illnesses change?
2. Are certain types of workers (e.g., part-time, older, ethnic group, education level, etc.) becoming more prone to them?
3. How about illnesses and hidden injuries from work that only become known after a period of time, such as certain kinds of cancers?
4. Are workers getting more mental issues that they may or may not be aware of?

We leave these important questions to future research.

References

Acemoglu, Daron, David Autor, David Dorn, Gordon Hanson, and Brendan Price. 2016. "Import Competition and the Great US Employment Sag of the 2000s." *Journal of Labor Economics* 34 (1):S141–S198.

Adda, Jérôme and Yarine Fawaz. 2017. "The Health Toll of Import Competition." Working Paper.

Autor, David, David Dorn, Gordon H. Hanson, and Kaveh Majlesi. 2017. "Importing Political Polarization? The Electoral Consequences of Rising Trade Exposure." NBER Working Paper #22637.

Autor, David H. and David Dorn. 2013. "The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market." *American Economic Review* 103 (5):1553–1597.

Autor, David H., David Dorn, and Gordon H. Hanson. 2013. “The China Syndrome: Local Labor Market Effects of Import Competition in the United States.” *American Economic Review* 103 (6):2121–2168.

Baram, Michael. 2009. “Globalization and Workplace Hazards in Developing Nations.” *Safety Science* 47 (6):756–766.

Bartelsman, Eric J. and Wayne Gray. 1996. “The NBER Manufacturing Productivity Database.” NBER Technical Working Paper No. 205.

Bertrand, Marianne. 2004. “From the Invisible Handshake to theInvisible Hand? How Import Competition Changes the Employment Relationship.” *Journal of Labor Economics* 22 (4):723–765.

Bhushan, Abhinav and J Paul Leigh. 2011. “National trends in occupational injuries before and after 1992 and predictors of workers’ compensation costs.” *Public Health Reports* 126 (5):625–634.

Bloom, Nicholas, Kyle Handley, Andre Kurmann, and Phillip Luck. 2019. “The Impact of Chinese Trade on U.S. Employment: The Good, The Bad, and The Debatable.” Working Paper.

Bush, Donna M and Rachel N Lipari. 2015. “Substance use and substance use disorder by industry.” In *The CBHSQ Report*. Substance Abuse and Mental Health Services Administration (US).

Che, Yi, Yi Lu, Justin R. Pierce, Peter Schott, and Zhigang Tao. 2017. “Did Trade Liberalization with China Influence U.S. Elections?” NBER Working Paper #22178.

Chung, Sunghoon, JoonHyung Lee, and Thomas Osang. 2016. “Did China Tire Safeguard Save U.S. Workers?” *European Economic Review* 85:22–38.

Colantone, Italo, Rosario Crinò, and Laura Ogliari. 2019. “Globalization and Mental Distress.” *Journal of International Economics* 119:181–207.

Dorn, David. 2009. *Essays on Inequality, Spatial Interaction, and the Demand for Skills*. Dissertation University of St. Gallen no. 3613.

Fort, Teresa C., Justin R. Pierce, and Peter K. Schott. 2018. “New Perspectives on the Decline of US Manufacturing Employment.” *Journal of Economic Perspectives* 32 (2):42–72.

Grimmett, Jeanne J. 2011. “Chinese Tire Imports: Section 421 Safeguards and the World Trade Organization (WTO).” *Congressional Research Service Report for Congress* 7-5700.

Keller, Wolfgang and Hâle Utar. 2019. “International Trade and Job Polarization: Evidence at the Worker Level.” Working Paper.

Krueger, Alan B. 2000. “Fewer workplace injuries and illnesses are adding to economic strength.” *New York Times* .

Krueger, Alan B. and Alexandre Mas. 2004. "Strikes, Scabs, and Tread Separations: Labor Strife and the Production of Defective Bridgestone/Firestone Tires." *Journal of Political Economy* 112 (2):253–289.

Lang, Matthew, T. Clay McManus, and Georg Schaur. 2019. "The Effects of Import Competition on Health in the Local Economy." *Health Economics* 28 (1):44–56.

Leigh, J. Paul. 2011. "Economic Burden of Occupational Injury and Illness in the United States." *Milbank Quarterly* 89 (4):728–772.

Loewenson, Rene. 2001. "Globalization and Occupational Health: A Perspective from Southern Africa." *Bulletin of the World Health Organization* 79 (9):863–868.

Lu, Yi and Travis Ng. 2013. "Import Competition and Skill Content in U.S. Manufacturing Industries." *Review of Economics and Statistics* 95 (4):1404–1417.

Lu, Yi, Xiang Shao, and Zhigang Tao. 2018. "Exposure to Chinese imports and media slant: Evidence from 147 U.S. local newspapers over 1998–2012." *Journal of International Economics* 114 (5):316–330.

Lu, Yi and Linhui Yu. 2015. "Trade Liberalization and Markup Dispersion: Evidence from China's WTO Accession." *American Economic Journal: Applied Economics* 7 (4):221–253.

Maestas, Nicole, Kathleen J. Mullen, David Powell, Till von Wachter, and Jeffrey Wenger. 2018. "The Value of Working Conditions in the United States and Implications for the Structure of Wages." Working Paper.

Mas, Alexandre. 2006. "Pay, Reference Points, and Police Performance." *Quarterly Journal of Economics* 121 (3):783–821.

———. 2008. "Labour unrest and the quality of production: Evidence from the construction equipment resale market." *Review of economic studies* 75 (1):229–258.

McCaffrey, David P. 1983. "An Assessment of OSHA's Recent Effects on Injury Rates." *Journal of Human Resources* 18 (1):131–146.

McManus, T. Clay and Georg Schaur. 2016. "The Effects of Import Competition on Worker Health." *Journal of International Economics* 102:160–172.

Morantz, Alison D. 2007. "Has devolution injured American workers? State and federal enforcement of construction safety." *Journal of Law, Economics, & Organization* 25 (1):183–210.

Morantz, Alison D and Alexandre Mas. 2008. "Does post-accident drug testing reduce injuries? Evidence from a large retail chain." *American Law and Economics Review* 10 (2):246–302.

Pierce, Justin R. and Peter K. Schott. 2016. "The Surprisingly Swift Decline of U.S. Manufacturing Employment." *American Economic Review* 106 (7):1632–1662.

———. 2019. "Trade Liberalization and Mortality: Evidence from U.S. Counties." *American Economic Review: Insights* Forthcoming.

Revenga, Ana L. 1992. "Exporting Jobs? The Impact of Import Competition on Employment and Wages in U.S. Manufacturing." *Quarterly Journal of Economics* 107:255–284.

Rosen, Sherwin. 1986. "The Theory of Equalizing Differences." Handbook of Labor Economics, Vol. 1. Elsevier.

Ruser, John W. 2008. "Examining Evidence on Whether BLS Undercounts Workplace Injuries and Illnesses." *Monthly Labor Review* :20–32.

Ruser, John W and Robert S Smith. 1988. "The effect of OSHA records-check inspections on reported occupational injuries in manufacturing establishments." *Journal of Risk and Uncertainty* 1 (4):415–435.

Ruser, John W. and Robert S. Smith. 1991. "Reestimating OSHA's Effects: Have the Data Changed?" *Journal of Human Resources* 26 (2):212–235.

Smith, Robert S. 1979. "The Impact of OSHA Inspections on Manufacturing Injury Rates." *Journal of Human Resources* 14 (2):145–170.

U.S. Government Accounting Office. 2009. "Workplace Safety and Health: Enhancing OSHA's Records Audit Process Could Improve the Accuracy of Worker Injury and Illness Data." *Report to Congressional Requesters* GAO-10-10.

Utar, Hâle. 2014. "When the Floodgates Open: "Northern" Firms' Response to Removal of Trade Quotas on Chinese Goods." *American Economic Journal: Applied Economics* 6 (4):226–50.

———. 2017. "Workers beneath the Floodgates: Impact of Low-Wage Import Competition and Workers' Adjustment." *Review of Economics and Statistics* :Forthcoming.

Utar, Hâle and Luis B. Torres Ruiz. 2013. "International Competition and Industrial Evolution: Evidence from the Impact of Chinese Competition on Mexican Maquiladoras." *Journal of Development Economics* 105:267–287.

Appendix

A. A decomposition of the aggregate trends

We decompose the trends of workplace injuries and illnesses to better understand the source of variations. Our decomposition exercise suggests that the variations of workplace safety improvement across industries are especially pronounced. If import competition does affect the safety of the American workplace, it must be able to explain such variations.

Let R_t denote the aggregate injury and illness rate in year t of the economy consisting of the manufacturing sector and other different non-manufacturing sectors (all indexed by k).[37] We may write R_t as a weighted sum of the injury and illness rates

[37] We exclude the public sector in the analysis. We consider the following major non-manufacturing sectors: "Agriculture, forestry, and fishing," "Mining," "Construction," "Manufacturing," "Transportation and public utilities," "Wholesale and retail trade," "Finance, insurance, and real estate," and "Services."

in these sectors:

$$R_t = \sum_k S_{kt} R_{kt}, \tag{A.1}$$

where S_{kt} is the employment share of sector k in year t and R_{kt} is the injury and illness rate of sector k in year t. The change in the aggregate injury and illness rate from $t-1$ to t can be decomposed as follows:

$$\Delta R_t = R_t - R_{t-1} = \underbrace{\sum_k \Delta S_{kt} \overline{R}_{kt}}_{\text{“Between”}} + \underbrace{\sum_k \overline{S}_{kt} \Delta R_{kt}}_{\text{“Within”}}, \tag{A.2}$$

where $\overline{x}_t = (x_t + x_{t-1})/2$. The first term (“between”) measures the changes in the aggregate injury and illness rates due to the reallocation of workers across different sectors. The second term (“within”) measures the changes in the injury and illness rates within each sector. Note that, for a given sector k, the sum of the “between” and the “within” components is $\Delta S_{kt}\overline{R}_{kt} + \overline{S}_{kt}\Delta R_{kt} = \Delta(S_{kt}R_{kt})$; this sum measures the contribution of sector s to the change of the aggregate injury and illness rate.

Panel A of Table A shows the results using the aggregate data from various *Annual Reports of Workplace Injuries and Illnesses* published by the Bureau of Labor Statistics (BLS). The unit of different variables is 100 times the annual change of the corresponding variable. The results reveal the following patterns. First, the bottom row shows that, during 1991-1996, workplace safety in the entire economy witnessed rapid improvement. Such an improvement shifted gears and became even more rapid in 1996-2001 and in 2001-2006 but slowed down somewhat in 2006-2011. Second, most of these changes can be attributed to the “within” part. Third, the manufacturing and other major non-manufacturing sectors differ in a way consistent with the overall trends in Figure 2(a). The manufacturing sector recorded large reductions in the injury rate in both the “between” component and the “within” component. It contributes substantially to the overall reduction of the aggregate injury and illness rate. In contrast, the other non-manufacturing sectors did not experience the same large reductions, except for the Wholesale and retail trade sector during 2001-2006. In some non-manufacturing sectors, the sums of the “between” component and the “within” component were close to 0 (or even positive, for the Services sector during 1991-1996), suggesting that these sectors did not contribute much to the reduction of aggregate injury and illness rate.

Table A: Decomposition of the change in the aggregate injury and illness rate

	1991-1996			1996-2001			2001-2006			2006-2011		
	B	W	$B+W$	B	W	$B+W$	B	W	$B+W$	B	W	$B+W$
	Panel A: Decomposition of the change in the aggregate injury and illness rate											
Manufacturing	−3.09	−9.48	−12.57	−5.61	−10.20	−15.81	−8.77	−6.42	−15.19	−1.99	−4.11	−6.10
Non-manufacturing												
Agriculture, forestry, and fishing	0.38	−0.61	−0.23	0.17	−0.45	−0.28	−0.98	−0.49	−1.47	0.03	−0.07	−0.04
Mining	−0.25	−0.33	−0.58	−0.07	−0.20	−0.27	−0.09	−0.01	−0.10	0.05	−0.16	−0.11
Construction	1.30	−3.43	−2.13	1.60	−2.50	−0.90	0.12	−3.30	−3.18	−1.43	−2.45	−3.88
Transportation and public utilities	−0.50	−0.86	−1.36	0.39	−2.58	−2.19	−3.95	−0.93	−4.88	0.00	−1.22	−1.22
Wholesale and retail trade	−0.86	−4.33	−5.19	−0.83	−6.34	−7.17	−6.67	−7.80	−14.47	−0.10	−3.58	−3.68
Finance, insurance, and real estate	−0.32	0.00	−0.32	0.13	−0.88	−0.75	−0.05	−0.64	−0.69	−0.09	−0.24	−0.33
Services	2.82	−1.12	1.70	2.30	−8.44	−6.14	12.78	−14.22	−1.44	2.02	−4.61	−2.59
Total	−0.52	−20.16	−20.68	−1.92	−31.59	−33.51	−7.61	−33.81	−41.42	−1.51	−16.44	−17.95
	Panel B: Decomposition of the change in the injury and illness rate in the manufacturing sector											
Food and kindred products	0.31	−8.20	−7.89	1.75	−7.78	−6.03	1.03	−7.08	−6.05	2.80	−4.13	−1.33
Tobacco products	−0.06	0.01	−0.05	−0.03	−0.10	−0.13	1.47	0.59	2.06	0.34	−0.36	−0.02
Textile mill products	−0.44	−1.55	−1.99	−0.92	−1.58	−2.50	−0.13	−0.39	−0.52	−0.39	−0.44	−0.83
Apparel and other textile products	−1.31	−1.83	−3.14	−2.14	−1.84	−3.98	−0.98	−0.98	−1.96	−0.17	−0.12	−0.29
Lumber and wood products	1.50	−2.07	−0.57	0.45	−3.10	−2.65	−0.80	−1.76	−2.56	−1.60	−1.38	−2.98
Furniture and fixtures	0.47	−1.96	−1.49	0.32	−0.67	−0.35	2.03	−2.39	−0.36	−1.18	−1.54	−2.72
Paper and allied products	−0.07	−2.45	−2.52	−0.03	−1.40	−1.43	−0.35	−1.19	−1.54	−0.01	−0.60	−0.61
Printing and publishing	−0.06	−1.17	−1.23	−0.45	−2.27	−2.72	−2.98	−0.49	−3.47	−0.27	−1.12	−1.39
Chemicals and allied products	−0.26	−1.82	−2.08	0.22	−0.91	−0.69	0.19	−1.31	−1.12	0.45	−0.65	−0.20
Petroleum and coal products	−0.10	−0.26	−0.36	0.01	−0.26	−0.25	0.01	−0.03	−0.02	0.07	−0.12	−0.05
Rubber and misc. plastics products	1.71	−2.80	−1.09	0.31	−3.87	−3.56	0.29	−2.11	−1.82	−0.24	−2.10	−2.34
Leather and leather products	−0.37	−0.22	−0.59	−0.37	−0.17	−0.54	−0.09	−0.16	−0.25	−0.01	0.01	0.00
Stone, clay, and glass products	0.29	−1.39	−1.10	0.91	−1.45	−0.54	0.44	−2.09	−1.65	−0.56	−1.15	−1.71
Primary metal industries	−0.30	−2.10	−2.40	−0.06	−3.29	−3.35	−1.04	−1.49	−2.53	−0.07	−1.63	−1.70
Fabricated metal products	1.50	−4.56	−3.06	1.32	−5.35	−4.03	4.71	−6.73	−2.02	0.54	−4.43	−3.89
Industrial machinery and equipment	1.14	−2.90	−1.76	−0.11	−6.15	−6.26	−4.11	−1.97	−6.08	0.47	−3.06	−2.59
Electronic and other electric equipment	0.46	−3.17	−2.71	0.35	−3.28	−2.93	−6.27	0.12	−6.15	0.08	−1.24	−1.16
Transportation equipment	−1.90	0.00	−1.90	1.48	−7.35	−5.87	4.71	−10.42	−5.71	−1.28	−6.71	−7.99
Instruments and related products	−0.65	−0.88	−1.53	0.09	−1.03	−0.94	2.71	−2.79	−0.08	0.05	−1.12	−1.07
Miscellaneous manufacturing industries	0.26	−0.74	−0.48	−0.07	−1.30	−1.37	2.66	−1.46	1.20	0.28	−0.86	−0.58
Total	2.12	−40.06	−37.94	3.03	−53.15	−50.12	3.50	−44.13	−40.63	−0.70	−32.75	−33.45

Note: The unit is 100 × the annual change of the relevant variable. B is the "between" component and W is the "within" component.

To understand the changes in the different industries within the manufacturing sector, we use the same method to further decompose the change in injury and illness rate in the manufacturing sector in (A.2), denoted by ΔR_{Mt}:

$$\Delta R_{Mt} = \underbrace{\sum_j \Delta S_{jt} \overline{R}_{jt}}_{\text{"Between"}} + \underbrace{\sum_j \overline{S}_{jt} \Delta R_{jt}}_{\text{"Within"}}. \tag{A.3}$$

where j indexes the individual industries within the manufacturing sector. The first term ("between") measures the changes in injury and illness rates in the manufacturing sector due to the reallocation of workers between different industries within the manufacturing sector. The second term ("within") measures the changes in injury and illness rates for each manufacturing industry. Panel B of Table A shows the results for the 20 2-digit SIC manufacturing industries.[38]

The results suggest that the changes in the manufacturing workplace injury and illness rates are mostly due to the "within" component. In each period, there are substantial variations of the "within" term of the different industries. Some industries have rather small reductions (e.g., petroleum and coal products), while others have large reductions (e.g., fabricated metal products). This table suggests that understanding the driver behind the industrial differences of the safety improvement is the key to understanding the safety of the American workplace.

B. Further details about the data

This appendix briefly describes the available data on non-fatal workplace injuries and illnesses in the U.S. Some other background information can also be found in *Chapter 9: Occupational Safety and Health Statistics, BLS Handbook of Methods*.

B.1. The Occupational Safety and Health Act of 1970

Before the 1970s, data on workplace injuries and illnesses were provided by employers on a voluntary basis; besides, they only included work injuries that resulted in death, permanent impairment, or temporary disability. As such, these data did not include many injury cases, especially those less severe ones which did not result in days away from work. To address these limitations, the U.S. Congress passed the Occupational Safety and Health Act of 1970, under which most of the employers in the private sectors were required to maintain records and submit reports on workplace injuries and illnesses of different types of severeness.[39]

[38] These industries include: Food and kindred products (20), Tobacco products (21), Textile mill products (22), Apparel and other textile products (23), Lumber and wood products (24), Furniture and fixtures (25), Paper and allied products (26), Printing and publishing (27), Chemicals and allied products (28), Petroleum and coal products (29), Rubber and miscellaneous plastics products (30), Leather and leather products (31), Stone, clay, and glass products (32), Primary metal industries (33), Fabricated metal products (34), Industrial machinery and equipment (35), Electronic and other electric equipment (36), Transportation equipment (37), Instruments and related products (38), and Miscellaneous manufacturing industries (39). Note that the industry classification used in 2006 and 2011 is NAICS. We convert it to SIC to match the earlier data.

[39] Despite mandatory reporting, Ruser (2008) points out that the data are not without its own limitations.

B.2. OSHA Data Initiative and Survey of Occupational Injuries and Illnesses

There are currently two establishment-level datasets on workplace injuries and illnesses. The first is OSHA Data Initiative (ODI) provided by the Occupational Safety and Health Administration (OSHA); the second is the Survey of Occupational Injuries and Illnesses (SOII) provided by the Bureau of Labor Statistics (BLS).

B.2.1. OSHA Data Initiative

ODI contains the names, addresses, industries, and the injury and illness rates of the establishments in different manufacturing and non-manufacturing industries over the period 1996-2011. The annual ODI sample is smaller than that of SOII and contains roughly 50,000 to 80,000 observations. These data are publicly-available at https://www.osha.gov/pls/odi/establishment_search.html.

B.2.2. Survey of Occupational Injuries and Illnesses

SOII also contains establishment-level estimates of the number and frequency of non-fatal work-related injuries and illnesses in different industries. The annual sample of SOII consists of about 230,000 establishments. The establishment-level injuries and illnesses data of these establishments are used to tabulate estimates for two industry-level data series, namely Survey of Occupational Injuries and Illnesses — Annual Summary ("SOII-AS") and Survey of Occupational Injuries and Illnesses — Case and Demographics ("SOII-C&D").

- *SOII-AS*: It includes estimates of non-fatal work-related injuries and illnesses for different industries and is available since 1976.

  A limitation of these industry-level data is that the number of industries with available data may vary subject to BLS's publication guidelines. In particular, estimates for a particular industry may not be published if the estimates may disclose confidential information, the relative standard errors of the estimates exceed a specified limit, or the benchmark factor for the industry is outside an acceptable range. The unpublished industries are only included in the total of the upper levels.[40]

- *SOII-C&D*: It includes detailed case circumstance and characteristics (such as age range, occupations of the workers etc.) for cases involving days away from work and is available since 1992.

While the micro-level data from SOII are not publicly available, the aggregated data in SOII-AS and SOII-C&D can be obtained from the BLS website (http://www.bls.gov/data/).

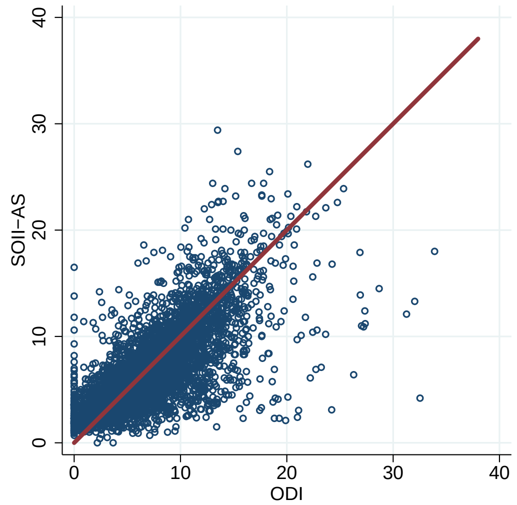
B.3. ODI versus SOII-AS

As we explained in the main text, in the industry-level analysis, we compute the outcome variable R_{jt} as the median injury and illness rate of establishments in industry j and year t taken from the ODI data. In Figure A, we compare the injury

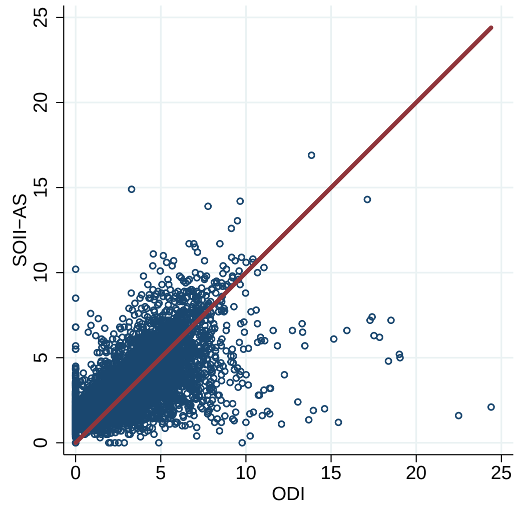
[40] For instance, if the injury rate estimate for an SIC4 industry is not published, the injury rate of this industry will be included in the injury rate of the respective SIC3 industry.

and illness rates from ODI and SOII-AS over 1996-2011. In each figure, each point is an industry-year with available injury data from both ODI (calculated as the median injury and illness rate for each industry-year) and SOII-AS. In Figure A(a), we show the total case rate. The red line indicates the 45-degree line. The correlation coefficient between the two variable is 0.73 (p-value < 0.001). Similarly, in Figure A(b), we show the rate of cases involving days away, restricted, and transfer. The correlation coefficient between the two variable is 0.63 (p-value < 0.001).

Figure A: Injury and illness rates: ODI versus SOII-AS



(a) Total case rate (TCR)



(b) Days away, restricted, and transfer case rate (DART)

Note: The line in each figure is the 45-degree line.

C. First-stage results

Panels A of Table B reports the first stage regression results for the model in (2). Panel B of Table B reports the first stage regression results for the model in (6).

D. The most dangerous and safest occupations in the manufacturing sector

Table C lists some of the most dangerous occupations (in Panel A) and the least dangerous occupations (in Panel B) in the manufacturing sector.

Table B: First-stage results

	(1)	(2)
	Panel A: Industry-level estimations; Dependent variable: log $(impr_{jt-1})$	
log $(impr^{IV}_{jt-1})$	0.610***	0.578***
	(0.038)	(0.040)
log Employment		0.305***
		(0.106)
log 4-factor TFP		0.065
		(0.098)
log Capital-labor ratio		−0.121
		(0.104)
R^2	0.939	0.940
	Panel B: Regional-level estimations; Dependent variable: log $(impr_{rt-1})$	
log $(impr^{IV}_{rt-1})$	0.783***	0.778***
	(0.015)	(0.015)
log Total population		−0.426***
		(0.091)
R^2	0.949	0.950

Note: $N = 5,888$ (Panel A) and $N = 9,819$ (Panel B). Each regression in Panel A includes industry and year fixed-effects. Each regression in Panel B includes region and year fixed-effects. Robust standard errors, adjusted for arbitrary heteroskedasticity and autocorrelation, are reported in parentheses. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

Table C: The most dangerous and safest occupations in the manufacturing sector

Occupations	Average injury and illness rate, 1992-1995
Panel A: Most dangerous occupations	
Production helpers	14.81
Structural metal workers	13.64
Other precision and craft workers	12.37
Washing, cleaning, and pickling machine operators	11.08
Machine feeders and offbearers	9.64
Machinery maintenance occupations	9.56
Helpers, constructions	9.02
Construction laborers	8.94
Helpers, surveyors	8.66
Metal platers	8.60
Insulation workers	8.31
Food preparation workers	7.80
Railroad brake, coupler, and switch operators	7.54
Nail, tacking, shaping and joining mach ops (wood)	7.27
Forge and hammer operators	6.96
Sawing machine operators and sawyers	6.70
Molders and casting machine operators	6.69
Grinding, abrading, buffing, and polishing workers	6.43
Furnance, kiln, and oven operators, apart from food	6.01
Punching and stamping press operatives	5.66
Millwrights	5.50
Garage and service station related occupations	5.48
Railroad conductors and yardmasters	5.48
Repairers of household appliances and power tools	5.31
Glaziers	5.20
Panel B: Safest occupations	
Lawyers and judges	0.03
Writers and authors	0.03
Fire fighting, fire prevention, and fire inspection occs	0.05
Architects	0.06
Mathematicians and statisticians	0.06
Real estate sales occupations	0.08
Physicians	0.08
Medical scientists	0.08
Chemical engineers	0.09
Computer and peripheral equipment operators	0.09
Computer systems analysts and computer scientists	0.11
Barbers	0.11
Computer software developers	0.11
Retail salespersons and sales clerks	0.11
Librarians	0.11
Physicists and astronomists	0.12
Petroleum, mining, and geological engineers	0.13
Managers and administrators, n.e.c.	0.13
Door-to-door sales, street sales, and news vendors	0.13
Purchasing managers, agents, and buyers, n.e.c.	0.13
Dentists	0.13
Economists, market and survey researchers	0.14
Library assistants	0.15
Accountants and auditors	0.15
Managers in education and related fields	0.16
Mechanical engineers	0.16

E. Does import competition raise the level of safety compliance?

Since workplace injuries and illnesses are costly to the firms, reducing them becomes all the more meaningful under more intense competition. Compliance can play a role thereby reducing workplace injuries and illnesses. How may competition affect the overall compliance level? It could be that individual firms improve their compliance of the safety standard. It could also be the case that competition weeds out faster those firms that are less likely to compliant (which themselves have more workplace injuries and illnesses).

The OSHA Enforcement data contain establishment-level data about inspections and violation cases in the workplaces in different industries.[41] Higher compliance means fewer inspections find violations.[42] We use these data to define a dummy variable that equals to 1 if a violation is found in an inspection case. We then create a variable ($Violate_{jt}$) to measure the fraction of inspected cases found violating the OSH standards of industry j in year t.

$$Violate_{jt} = \alpha_j + \beta \log(impr_{jt-1}) + \gamma X_{jt-2} + \theta_t + \varepsilon_{jt}. \tag{E.1}$$

Table D reports the results. In Column (1), we run an OLS estimation with industry and year fixed effects. In Column (2), we run a 2SLS estimation using the corresponding Chinese import penetration ratios of the 8 other high-income countries to instrument $\log(impr_{jt-1})$. Column (3) further includes other industry-level controls. We fail to find any significant association between import competition and the safety compliance measure, suggesting that import competition improving industries' safety compliance is unlikely the underlying channel through which import competition reduces workplace injuries and illnesses.

F. Further details on the economic significance

The numbers in Section 8.1 are calculated as follows. Between 1996 and 2011, the change in the lagged Chinese import penetration ratio of an "average industry" in the sample is about 10.19 percentage points,[43] or about 132.3% as a percentage of the sample mean ($\approx 0.1019/0.077 \times 100\%$). Based on Column (3) of Table 3, this change is associated with a change in TCR by -0.568 ($\approx -0.429 \times 1.323$).[44]

Since the average employment in the industries is roughly 31,000, the reduction in TCR is equivalent to a reduction of 176 ($\approx 0.568/100 \times 31,000$) injury cases for the "average industry" in a given year. Given that there are 390 distinct industries in our

[41] These data are available at http://enforcedata.dol.gov/views/data_summary.php.

[42] Examining the detailed records, Ruser and Smith (1991) do not find strong evidence to support the claim that OSHA inspections effectively reduce injury rate, which is a result consistent with those in Smith (1979) and McCaffrey (1983). However, firms' reporting behaviors may well have been changed due to OSHA inspections.

[43] To calculate this number, we first compute the difference between the Chinese import penetration ratios (in levels) between 2010 and 1995 for each industry j in the sample and then take the average.

[44] Since the baseline model in (2) is a linear-log model, an x% change in $impr_{jt-1}$ from the mean is associated with a change in the outcome variable by $\widehat{\beta} \times x/100$, where $\widehat{\beta}$ is the estimated coefficient of $\log(impr_{jt-1})$.

Table D: Industry-level results: Import competition and OSH violations

	(1)	(2)	(3)
Dependent variable:	100× Average OSH violation of establishments		
log ($impr_{jt-1}$)	0.174	−0.897	−0.691
	(0.297)	(0.668)	(0.702)
log Employment			−1.404
			(1.748)
log 4-factor TFP			−1.821
			(2.105)
log Capital-labor ratio			0.062
			(1.835)
Estimation method	OLS	2SLS	2SLS
R^2	0.184		
F-stat for weak id		227.504	191.152

Note: $N = 5,835$. Each regression includes industry and year fixed-effects. Robust standard errors, adjusted for arbitrary heteroskedasticity and autocorrelation, are reported in parentheses. *: significance at 10% level; **: significance at 5% level; ***: significance at 1% level.

sample, the annual total reduction of injury cases is roughly 68,640 (= 176 × 390).

Using estimate from Leigh (2011), the per-case cost of an injury (as of 2007) is roughly $23,000. Assuming that the per-case cost of injury is constant across different industries over the sample period, the increase in Chinese imports over the sample period would have saved the manufacturing sector roughly $1.58 billion ($\approx \$23,000 \times 68,640$) in injury costs per year.

To get a sense of the size of this impact, we compare the change in TCR predicted by Chinese imports according to the model with the actual change observed in the data. We calculate that the average change in TCR between 1996 and 2011 observed in the data is about −4.687 injury and illness cases per 100 full-time workers. Therefore, about 12.1% ($\approx 0.568/4.687 \times 100\%$) of the actual change in TCR can be explained by Chinese imports according to the model.