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Trade with China and Rising Mortality in the United States

August 2017

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Abstract:

I analyze the effect of a large exogenous trade shock on mortality in the United States between 2002 and 2012. Following the example of Autor, Dorn, and Hanson (2013), I construct a variable that captures the difference in exposure to import competition stemming from differences in initial manufacturing employment structures. I avoid endogeneity issues by instrumenting US commuting zones' exposure to Chinese import penetration with an equivalent measure of import penetration to eight comparable developed countries. My findings complement existing literature: a large trade shock, in the form of increased trade with China, had a significant positive effect on mortality in the United States. I found that a $1000 increase in Chinese import penetration is associated with an increase in mortality by 1.076 per 100,000 persons over the long run and by 0.545 per 100,000 persons over the 10-year short-run. The effect is statistically significant for White non-Hispanic Americans and is insignificant for individuals of other races and of Hispanic origin. Contrary to the findings of other papers, the effect is greater for women of all races and also greater for White non-Hispanic women than for White non-Hispanic men.

Keywords: Globalization; Free trade; China; the United States; Mortality

Acknowledgements: I would like to thank my supervisor, Alessandro Martinello, for his advice and guidance throughout the thesis writing process.

Table of Contents

Abbreviations

U.S. Census County Business Patterns	CBP
Difference-in-differences	DID
Eight other developed countries	OTH
Federal Information Processing Standard	FIPS
Harmonized System	HS
Heckscher-Ohlin	H-O
Instrumental Variables	IV
Instrumental Variables Two-Stage Least Squares	IV 2SLS
Normal Trade Relations	NTR
Permanent Normal Trade Relations	PNTR
Standard Industrial Classification	SIC
U.S. Centers for Disease Control and Prevention	CDC
United Nations	UN
United States of America	US, USA

1. Introduction

In 1776, Adam Smith published *The Wealth of Nations* advocating for free trade as a means of improving overall economic welfare. Since then, generations of economists have studied the effect of free trade and had determined that costs and benefits associated with free trade are asymmetrically distributed over the population. Furthermore, recent analysis has disproven one of the main assumptions in classical trade models: that labor can costlessly reallocate to the next best opportunity following a trade-induced disruption to the labor market. For example, this assumption failed in the United States (US) following greater trade integration with China since it produced an unusually large trade shock to manufacturing which resulted in widespread job losses in the US (see Acemoglu *et al.*, 2015).

In a series of papers, Autor, Dorn, Hanson, and their co-authors revealed that the segment of the population hardest hit by integration were the least able to successfully deal with the consequences of trade-induced unemployment. Typically, these individuals had less than a college education and predominantly worked in manufacturing. As such, they lacked the skills and attributes necessary to quickly or easily find other jobs on an increasingly well-educated and competitive labor market. The assumption that labor would costlessly reallocate to the next best opportunity turned out to be false. (Autor, Dorn and Hanson, 2013, 2017, Autor *et al.*, 2014, 2016; Acemoglu *et al.*, 2015).

Concurrently as US-China trade increased, mortality for middle-aged White non-Hispanic Americans began to rise, starting in the late 1990s (Case and Deaton, 2015). Of the possible contributing factors, I hypothesize that trade shocks to the labor market might be highly correlated with many of them. There exists a large body of work in economic literature that links unemployment to mortality (Roelfs *et al.*, 2011; Case and Deaton, 2017). Case and Deaton (2017) argue that one major factor contributing to increased mortality is the accumulation of disadvantages over one's lifetime. The longer one lives in an insecure position, the more one will turn to risky health behaviors as a coping mechanism, such as smoking, drinking more, and taking drugs. Since US-China trade was so disruptive to the manufacturing labor force, I argue that the trade shock to labor induced individuals who lost their job to trade to engage in risky health behaviors which led to the rise in mortality.

Building on the work of Autor, Dorn, and Hanson (2013), I employ an "instrumental variables" approach to estimate the effect of a trade shock on mortality mediated through the labor market. Assuming that trade between other developed economies and China is exogenous to labor market conditions and mortality in the United States, I instrument Chinese import penetration[1] to the US with an equivalent measure of import penetration to eight comparable developed economies. This allows me to avoid the issue of possible confounding factors and to identify the effect that Chinese import penetration had on labor market conditions and mortality.

My findings complement existing literature on the effect of a large trade shock to manufacturing employment and on the link between unemployment and mortality: a large trade shock, in the form of increased trade with China, had a significant positive effect on mortality in the United States. Using the framework introduced by Autor, Dorn, and Hanson (2013), I confirm that labor market disruption is a possible channel through which import penetration could affect mortality. I found that a $1000 increase in Chinese import penetration is associated with an increase in mortality by 1.076 per 100,000 persons over the long run and by 0.545 per 100,000 persons over the 10-year short-run. As other papers have found (Pierce and Schott, 2016), the effect is statistically significant for White non-Hispanic Americans and is insignificant for individuals of other races and of Hispanic origin. Contrary to the findings of other papers (e.g., Pierce and Schott, 2016; Autor, Dorn and Hanson, 2017; Case and Deaton, 2017), the effect is greater for women of all races and also greater for White non-Hispanic women than for White non-Hispanic men. I discuss possible explanations for the unexpected result in Section 5. Nonetheless, this differential result would be an interesting area for future research.

Previous papers revealed that the "costless reallocation of labor" assumption does not hold in all settings. The lesson policymakers should take from this strand of literature is that more assistance is necessary to prevent individuals from suffering as a result of trade integration. Indeed, other countries experienced labor market disruptions due to trade but managed to avoid the worst possible outcome: rising mortality.[2] Policymakers in the United States should research and identify the institutions and policies that helped to mediate the effect of trade-induced labor market disruptions and seek to implement them in the US.

This paper proceeds as follows: Section 2 discusses literature related to the effect of a trade shock on labor and the link between unemployment and mortality; Section 3 describes the data, its sources, and its limitations; Section 4 details the methodology used to investigate the

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[1] Import penetration is defined as an increase in imports to a particular sector relative to the pre-analysis period.

[2] Countries in Europe experienced similar labor market disruptions (see Dippel *et al.*, 2017; Colantone and Stanig, 2017; Kallen, 2017), but did not see similar mortality outcomes (see Case and Deaton, 2017).

research question; Section 5 describes the results and robustness checks; Section 6 concludes with a summary and discussion of potential policy implications and areas for future research.

2. Background information

This paper relates to emergent themes in trade, labor, and health economics. The first theme describes the effect that a large exogenous shock to trade, e.g., China's integration into global trade markets, had on labor market conditions in the United States (Autor, Dorn and Hanson, 2013; Colantone and Stanig, 2017; Dippel *et al.*, 2017). The second theme describes the rising mortality trends in the United States (Case and Deaton, 2015, 2017). The third theme explores the relationship between unemployment and mortality; (Roelfs *et al.*, 2011; Krueger, 2016). This paper seeks to identify the connection between the various themes, of which few papers have thus far been written (see Pierce and Schott, 2016; Autor, Dorn and Hanson, 2017).

2.1. The China shock

Classical theoretical models of trade had long identified that integration would lead to widespread benefits and concentrated costs. Furthermore, they relied on the assumption that labor could costlessly reallocate to the next best opportunity. This assumption held as long as the goods exchanged between two countries were produced with approximately similar mixes of factors of production, resulting in taste-based trade patterns (Dubner, 2017). For example, prior to increased trade with China and other developing countries, the US's main trading partners were other countries with developed economies and approximately similar distributions of labor and capital (ibid.). Thus, the US traded skill-intensive goods produced with high-skilled and high-cost labor in exchange for similar goods using similar inputs from other countries. As Mr. Autor said in an interview, "It's not trying to see who can make the cheapest version of X, Y, or Z. We're often focusing on a set of expensive goods in which we all are differently good at different subsets" (Dubner, 2017). The costless reallocation of labor assumption held because neither country had a comparative advantage in a particular sector. Traded goods were approximately equivalent in either country. If one country captured a greater share of production than the other, laid off workers in the latter country could relatively easily find new jobs working in a different industry.

The assumption does not hold when trade occurs between two countries with different distributions of factors of production because each country has a comparative advantage over the other. Each country will cease production in sectors in which they are uncompetitive in favor of expanding production in sectors in which they have an advantage (Kling, 2008).

Following the Communist Revolution in 1949, China's economy was underproductive and suffered several crises (Dubner, 2017). Most resources were under- and inefficiently utilized and most people worked in relatively unproductive rural agriculture (ibid.). Thus, China's labor force was less-educated and less-paid than the US's labor force (Li *et al.*, 2012). China began reforming its economy in the late 1970s and through the 2000s, resulting in phenomenal changes in its labor market, institutions, and private sector (ibid.). During China's transition period, over 150 million workers moved from rural areas to cities and began working in more productive industries such as manufacturing (Chen, Jin and Yue, 2010). Consequently, US-China trade followed the predictions of classical trade theories based on comparative advantage: the US exported skill-intensive goods to China and imported low-cost labor-intensive goods from China. US manufacturers using low-skilled labor or producing labor-intensive goods could no longer compete with the much cheaper goods being imported from China (Autor *et al.*, 2014).

Recently, economists have begun to investigate the validity of the "costless reallocation of labor" assumption. In 2013, Autor, Dorn, and Hanson published "The China Syndrome: Local Labor Market Effects of Import Competition in the United States" which studies the effect trade with China had on local labor market conditions in the United States. Using an "instrumental variables" approach, they estimate the effect of increased exposure to Chinese import competition on changes in various labor market outcomes such as manufacturing and nonmanufacturing employment and earnings.[3] Increased Chinese import competition adversely affects manufacturing employment as well as other outcomes. For example, "import shocks trigger a decline in wages that is primarily observed outside of the manufacturing sector." Furthermore, "reductions in both employment and wage levels lead to a steep drop in the average earnings of households." Autor, Dorn, and Hanson also examine sub-populations by gender and educational attainment. They find that "declining employment and increasing unemployment and nonparticipation are similar for males and females in percentage-point terms" although the declines are larger for females than males, due to different initial shares of manufacturing employment. Although all education levels were adversely affected following increased Chinese import competition, individuals without a college education suffered to a

[3] The authors instrument increased Chinese import penetration to the United States with Chinese import penetration to eight other developed countries: Australia, Denmark, Finland, Germany, Japan, New Zealand, Spain, and Switzerland.

greater extent than individuals with a college education. This is true for both manufacturing and nonmanufacturing employment. (Autor, Dorn and Hanson, 2013).

Since their 2013 paper, Autor, Dorn, Hanson, and other coauthors have published several studies that explore what effect the China shock has had on various outcomes such as political polarization (Autor *et al.*, 2016) and the marriage marketability of men (Autor, Dorn and Hanson, 2017). Autor, et al. (2016) use a similar approach as the one outlined above to identify that greater exposure to import competition resulted in greater political polarization: "congressional districts exposed to larger increases in import penetration disproportionately removed moderate representatives from office in the 2000s." Regarding the marriage marketability of men: "trade shocks to manufacturing industries have particularly negative impacts on the labor market prospects of men and degrade their marriage-market value along multiple dimensions" (Autor, Dorn and Hanson, 2017). The dimensions include reduced relative earnings, reduced participation in the labor force, and increased risky and damaging behavior patterns. This last result was my inspiration for conducting this study.

Several papers published in the past few years provide evidence that this is true in the case of the United States (Autor, Dorn and Hanson, 2013); Germany (Dippel *et al.*, 2017); and Western Europe (Colantone and Stanig, 2017).

2.2. Mortality trends

In late 2015, Case and Deaton published a startling finding related to mortality in the United States: the mortality rate for White non-Hispanic Americans between 45 and 54 years old have been rising since 1999 whereas the rate had been declining over the preceding two decades (Case and Deaton, 2015). Case and Deaton published a more detailed follow-up study in 2017 that delves into differences between race, gender, income, and education and covers a greater age range. Their 2017 findings support those of the 2015 paper and identify divergent trends between White non-Hispanic middle-aged Americans and Black non-Hispanic and Hispanic middle-aged Americans. Whereas mortality rates for Black non-Hispanic and Hispanic middle-aged Americans have continued their downward trend akin to those seen in comparable European countries, mortality rates for White non-Hispanic middle-aged Americans began to increase starting in the late 1990s. Figure 1 from Case and Deaton (2017) shows all-cause and age-adjusted mortality rates for White non-Hispanic Americans and compares it with rates for Austria, Canada, France, Germany, Sweden, and the United Kingdom from 1990 to 2015. The divergence between mortality rates for White non-Hispanic Americans and those for various European countries is striking and stark.

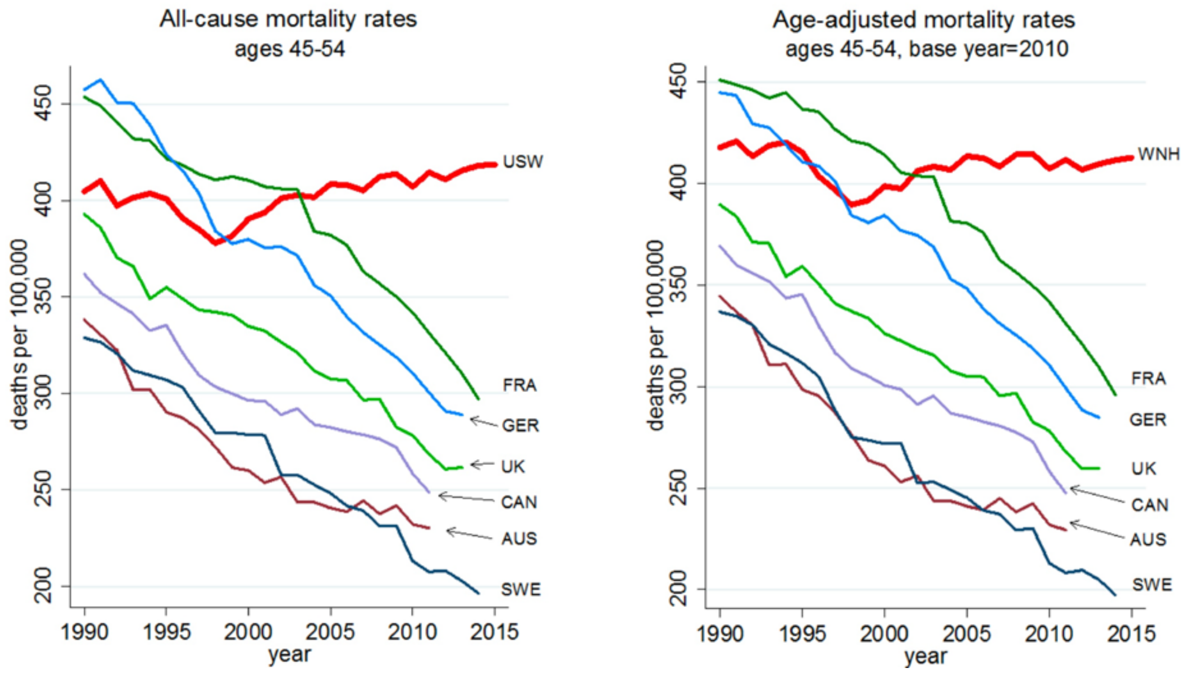

Figure 1 - All-cause and age-adjusted mortality rates

Source: (Case and Deaton, 2017).

In terms of education, mortality rates for less educated individuals began to rise, i.e., those with less than a college degree, whereas mortality rates for more educated individuals have had better outcomes, i.e., those with at least a college degree. Case and Deaton compare mortality results by income and discredit the hypothesis that income is driving the rise in mortality:

> For white non-Hispanics, the [income-based explanation] can be told, especially for those aged 50–54, and for the difference between this group and the elderly, but we are left with no explanation for why Blacks and Hispanics are doing so well, nor for the divergence in mortality between college and high-school graduates, whose mortality rates are not just diverging, but going in opposite directions. Nor does the European experience provide support, because the mortality trends show no signs of the Great Recession in spite of its marked effects on household median incomes in some countries but not in others. (Case and Deaton, 2017)

Case and Deaton hypothesize that the explanation behind divergent mortality trends for White non-Hispanic Americans and other races/ethnicities is that White non-Hispanics are suffering from "cumulative disadvantage from one birth cohort to the next, in the labor market, in marriage and child outcomes, and in health." Furthermore, the cumulative disadvantage "is triggered by progressively worsening labor market opportunities at the time of entry for whites with low levels of education" (Case and Deaton, 2017).

2.3. Unemployment and mortality

There exists a rich literature investigating the link between unemployment and mortality spanning the past four decades. Determining the direction of causality between unemployment and mortality is difficult and still far from settled. However, recent analysis has begun to identify different confounding, mediating, and moderating factors. Two main lines of research are (i) the role of health behaviors and (ii) the role of macroeconomic factors. Regarding the role of health behaviors, there are two hypotheses: the “coping hypothesis” and the “latent sickness hypothesis.” The coping hypothesis “argues that unemployment causes adverse changes in health behaviors which in turn lead to a deterioration of health” whereas the latent sickness hypothesis “suggests that the unemployment-mortality association is spurious because pre-existing health behaviors lead to both unemployment and adverse health” (Roelfs *et al.*, 2011). Regarding the role of macroeconomic factors, some studies find that “national welfare and unemployment policies are thought to play a moderating role, with the negative effects of unemployment being substantially reduced in nations with more generous financial support systems” while other studies find a paradoxical relationship: when the unemployment rate is high, dangerous health behaviors decline (Roelfs *et al.*, 2011).

Roelfs et al. (2011) investigate these two lines of research and their seemingly contradictory hypotheses by conducting a “random-effects meta-analysis and meta-regression designed to assess the association between unemployment and all-cause mortality among working-age persons” (Roelfs *et al.*, 2011). Using 42 studies covering 20 million persons, they extract more than 230 mortality risk estimates. Even after controlling for individuals not in the labor force, there exists an increased risk of death for individuals who are unemployed. Thus, “elevated risk levels among the unemployed were not simply an artifact of misclassification” (Roelfs *et al.*, 2011). Roelfs et al.’s findings suggest pre-existing conditions do not confound the link between unemployment and mortality due to a “lack of significant difference between the subset of [their] data where health was directly controlled and the remaining data” (Roelfs *et al.*, 2011).

They find some supportive evidence for the latent sickness hypothesis: “our regressions indicated that the 27 [hazard ratios (HRs)] that controlled for health behaviors were 24% lower than the remaining HRs.” Health-related behaviors existing at baseline account for a portion of the unemployment-mortality association and are clearly important to include in future studies. However, the coping hypothesis provides a better overall explanation as the lack of large differences in HR magnitude suggests that the post-unemployment pathway exerts a stronger effect on mortality outcomes."

In addition to the above, the meta-analysis revealed significant differences between populations along various dimensions including age, gender, follow-up duration, among other things. The unemployment-mortality differences between men and women is of particular interest to this study: "the magnitude of the association between unemployment and mortality is higher for men than for women (an increased risk of 78% vs. 37%)" (Roelfs *et al.*, 2011). The authors consider two possible explanations: (i) in most countries, women's labor force participation rates are lower than men's[4]; (ii) men's identities are grounded in their employment status to a greater extent than women's despite the growing trend for women to participate in the labor force. As of 2016, over 70 percent of the manufacturing labor force consisted of men[5]. Since trade-induced unemployment following the China shock affected manufacturing industries in which men represent a greater share of workers than women, I expect the China shock to affect men's mortality to a greater extent than it affects women's mortality.

2.4. Trade liberalization and mortality

Both (Autor, Dorn and Hanson, 2017) and (Case and Deaton, 2017) discuss the connection between unemployment and mortality, but neither paper explicitly studies the connection between a trade shock and mortality. Pierce and Schott (2016) is most similar to this paper but differs in several important ways.

First, their source of exogenous variation is the granting of Permanent Normal Trade Relations (PNTR) to China in October 2000. Prior to this change, China-US trade relations were subject to "politically contentious annual renewals of China's Normal Trade Relations (NTR) status" (Pierce and Schott, 2016). The uncertainty associated with possible tariff increases dampened trade between the two countries. By granting China PNTR status,

[4] While unpaid labor at home, part-time, or temporary employment might result in less health protection than full-time work, the data does not support this differential result. Using data from Scandinavian nations where there is a small difference between men's and women's labor force participation rates, Roelfs et al. find that there is a lack of significance for the interaction term between gender and Scandinavian region. This indicates "absolute differences in the labor force participation rate between men and women do not account for differences in the relative mortality risk" (Roelfs *et al.*, 2011).

[5] Available at: https://www.bls.gov/cps/cpsaat17.htm

Congress eliminated the uncertainty associated with possible tariff hikes and trade between the two countries flourished.

Second, Pierce and Schott employ a difference-in-differences (DID) identification strategy: counties differed in their exposure to "NTR gaps," defined as "the difference between the higher, non-NTR rates to which tariffs could have risen prior to PNTR and the lower NTR rates that were locked in by the change in policy" (Pierce and Schott, 2016). Using the variation in exposure to import competition, the authors examine whether higher-exposed counties experienced differences in mortality and labor market outcomes relative to lower-exposed counties.

Third, Pierce and Schott obtained more detailed mortality data from the US Centers for Disease Control and Prevention (CDC) than was available for this paper's analysis. Public-use data is censored to protect individuals' privacy which makes analysis by different causes of death and by different demographic groups more difficult. Pierce and Schott petitioned and obtained the full dataset which enabled their detailed analysis.

Their analysis reveals that counties exposed to greater import competition experienced (i) an increase in the annual suicide rate relative to the pre-analysis period; and (ii) an increase in mortality from accidental poisoning (which includes drug overdoses). They report that the evidence linking the policy change to alcohol-related liver diseases is mixed and is likely due to the lag between the change in policy and for the adverse effects associated with increased alcohol use to manifest. (Pierce and Schott, 2016).

Pierce and Schott confirm that the effect of a trade shock on mortality is mediated through the labor market by estimating the relationship between NTR gaps and various labor market outcomes. Using a DID-specification, they find that counties exposed to a more intensive policy change is "associated with persistent relative increases in counties' unemployment rates and persistent relative declines in counties' manufacturing employment, overall employment, labor force participation rates, and per capita personal income." This finding particularly supports the hypothesis of this thesis: that the labor market is the channel through which a trade shock effects mortality. (Pierce and Schott, 2016).

Pierce and Schott's analysis also considers mortality outcomes by gender, race, and age. For all three causes of death, the estimated policy change effect on mortality is higher for whites than it is for all other racial groups. The effects also differ by gender: the estimates for suicides and alcohol-related liver diseases are statistically significant for white men but is insignificant for white women. The estimates for accidental poisoning is statistically significant for both white men and white women. By contrast, no relationship exists between the policy change and suicide, alcohol-related liver diseases, or accidental poisoning for blacks, Asians, or American Indians. Pierce and Schott's findings both support and contradict the findings of this paper. Whereas they find a significant effect for white men and not for white women, I find a significant effect for women. Furthermore, the effect is greater for women than it is for men. This could be related to the fact that they obtained more detailed mortality data or could be related to their use of specific causes of death. Their findings that other races are seemingly unaffected by a trade shock to manufacturing employment supports the findings in this paper. (Pierce and Schott, 2016).

3. Data

I collect annual data on trade, labor, and mortality statistics to estimate whether increased Chinese import penetration had an adverse effect on mortality in the US, mediated through the labor market. Following the methodology outlined in Autor, Dorn, and Hanson (2013), I collect trade data from United Nations (UN) Comtrade Database and labor data from the US Census' County Business Patterns (CBP) database. Following the example of Case and Deaton, (2017), I collect mortality data from the Centers for Disease Control and Prevention (CDC) Wonder database. Table 1 presents the summary statistics for the data used throughout this study. The following sections contain information regarding transformations applied to this data.

Table 1 - Summary statistics

Variables	N	Mean	SD
	A. Explanatory variables		
Δ Import Penetration, USA, 2002-2007	2,747	5.158	5.071
Δ Import Penetration, USA, 2002-2012	2,747	7.202	8.903
Δ Import Penetration, OTH, 2002-2007	2,747	5.225	4.867
Δ Import Penetration, OTH, 2002-2012	2,747	8.222	7.319
	B. Dependent variables		
Δ Mortality, 2002-2007	2,747	13.86	91.14
Δ Mortality, 2002-2012	2,747	39.39	92.28
	C. Control variables		
Population in 2002	2,747	46,251	117,206
Change in population, 2002-2007	2,747	2,828	8,775
Change in population, 2002-2012	2,747	4,875	15,901
Manufacturing share of labor, 1997	2,737	0.595	1.078
Δ Manufacturing Employment, 2002-2007	2,737	-0.000576	0.123
Δ Manufacturing Employment, 2002-2012	2,737	-0.178	0.454
Δ Mortality, 1997-2002	2,747	20.67	98.43

3.1. Trade data

I use UN Comtrade data on trade between China, the US, and eight other developed countries at the six-digit Harmonized System (HS) product level between 1997 and 2016. Unfortunately, UN Comtrade data does not identify to which Standard Industrial Classification (SIC) the product belongs. I use David Dorn's crosswalk file[6] order to map the HS product level data to SIC industry data. Then, I identify manufacturing trade by the SIC industry classification, i.e., SIC codes between 2000 and 4000. Doing so allows me to identify Chinese imports at the industry level which can then be matched with labor data.

Figure 2 plots the evolution of US manufacturing imports from China from 1997 to 2015. As can be seen from the graph, imports grew at an average of 19 percent per year from 1997 to 2006. The effect of the Global Financial Crisis explains the downturn in the series from 2007 to 2009. Following 2010, the US manufacturing imports accelerated again, albeit at a slower pace of growth than before the crisis (an average of 8 percent per year from 2010 to 2015).

[6] Available at: http://www.ddorn.net/data.htm

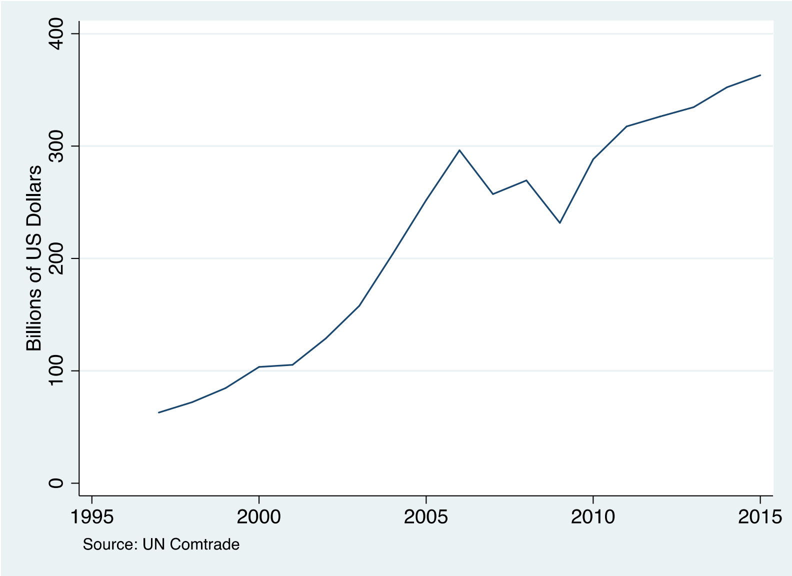

Figure 2 - US manufacturing imports from China

3.2. Labor data

The US Census Bureau's County Business Patterns database contains data on subnational employment data by industry and includes the number of establishments, employment, first quarter payroll, and annual payroll. For the purposes of this paper, I am only concerned with employment by industry at the county level. CBP data is reported at the county level using Federal Information Processing Standard (FIPS) codes and at the industry level using SIC codes. I collect employment data spanning 1997 to 2014, the latest year for which data is available. Since employment numbers are often reported only in brackets, I use Dorn's data cleaner files[7] to estimate employment numbers within brackets. Due to the complexity associated with applying Dorn's cleaner files to the CBP data, I only produce imputed employment figures for 1997, 2002, 2007, and 2012. Since this data contains county level information, it can be matched with the mortality data.

Figure 3 shows how total manufacturing employment in the US steadily declined from 1997 to 2007. Interestingly, it seems manufacturing employment recovered somewhat between 2007 and 2012. It could be that the US experienced a resurgence in manufacturing following the Global Financial Crisis which would explain this recovery. While investigating this phenomenon is a bit outside the scope of this thesis, it does provide material for future research.

[7] Available at: http://www.ddorn.net/data.htm

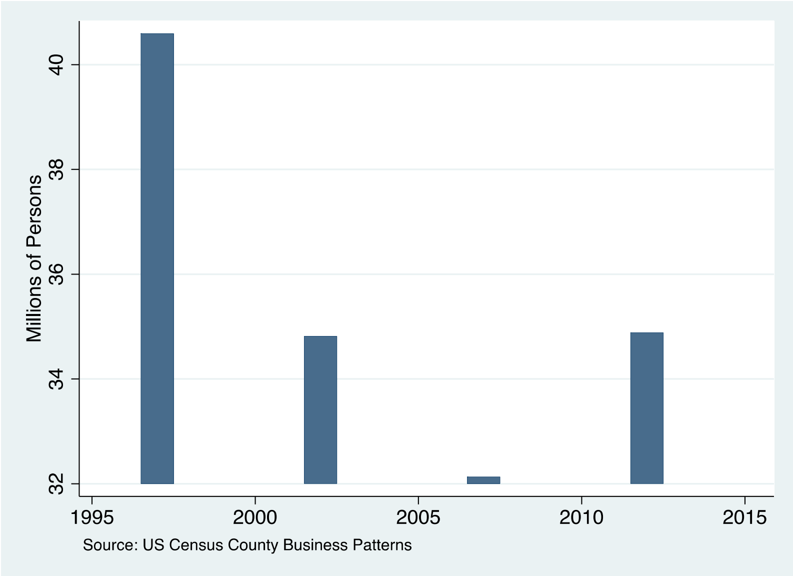

Figure 3 - Total US manufacturing employment

3.3. Mortality data

The CDC Wonder database contains compressed mortality data: a county-level national mortality and population database and includes data on the number of deaths, crude death rates by age group, race, Hispanic origin, gender, year of death, and underlying cause of death. For my baseline analysis, I collect all-cause mortality for individuals between 25 and 64 years old from 1997 to 2015 at the county level. I focus on individuals between 25 and 64 years of age since individuals younger than 25 are likely still in school or are on their parents' health insurance and individuals older than 64 are likely retired or have otherwise left the labor force. For further analysis, I use all-cause mortality for individuals between 25 and 64 years old by gender, race, and Hispanic origin.

Figure 4 plots all-cause mortality for individuals between 25 and 64 years old. Since 1998, all-cause mortality has grown at an average rate of 1 percent per year. The growth rate approached or exceeded 3 percent per year in 2001, 2005, and 2011.

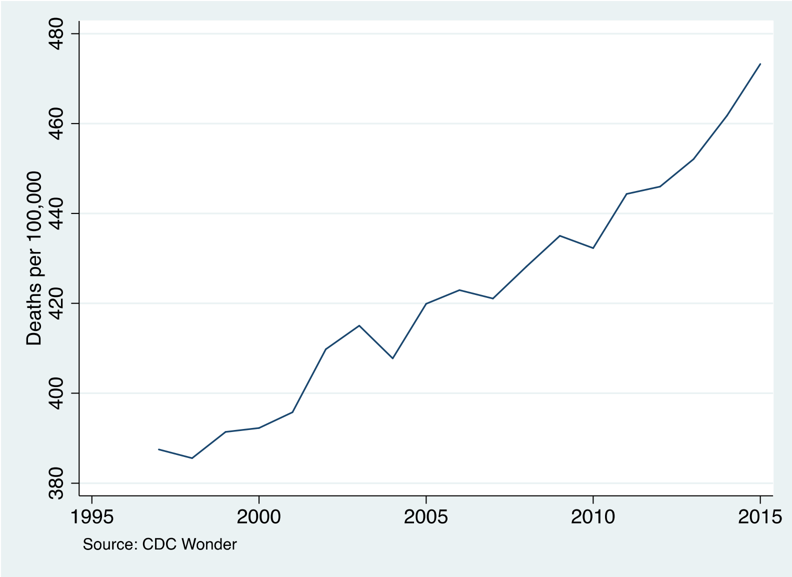

Figure 4 - All-cause mortality for individuals between 25 and 64 years old

4. Methodology

4.1. Analytical framework

To address the question of interest – whether increased Chinese import penetration affected mortality through an effect on the labor market – I follow the methodology first outlined in Autor, Dorn and Hanson (2013) and extended in subsequent papers (Autor *et al.*, 2016; Autor, Dorn and Hanson, 2017). The explanatory variable is defined as the change in industry-specific regional import penetration:

$$\Delta IPW_{uit} = \Sigma_j \frac{L_{ijt}}{L_{ujt}} \frac{\Delta M_{ucjt}}{L_{it}} \quad (1)$$

ΔM_{ucjt} is defined as the change in US manufacturing imports from China, u, by industry, j, commuting zone, c, over time, t. It is calculated by taking the difference between US manufacturing imports from China at the start of period and end of period.[8] I normalize the trade data by dividing it by L_{it}, the start-of-period manufacturing employment in the region. I weight this term by L_{ijt}/L_{ujt} which is equivalent to each industry's start-of-period share of total employment in the commuting zone. Thus, the difference in ΔIPW_{uit} across various local labor markets arises from differences in start-of-period local industry employment structure.

[8] I consider two time frames: the change in US manufacturing imports from China between 2002 and 2007 and between 2002 and 2012. I also consider changes in mortality between 2002 and 2007/2012.

It is likely that there are confounding factors associated with US-China trade and US labor market conditions that could possibly affect mortality, so I construct an instrumental variable as in Autor, Dorn and Hanson (2013). For example, “realized US imports from China may be correlated with industry import demand shocks” (Autor, Dorn and Hanson, 2013). If trade between the US and China was also associated with an offsetting increase in Chinese demand for US goods, then the OLS estimate of increased Chinese imports’ effect on US manufacturing employment would be less than the true effect. Furthermore, since the OLS estimate understates the true effect of import penetration on manufacturing employment, the estimate of the effect of a change in manufacturing employment due to trade on mortality would also be understated. Thus, constructing an instrumental variable using Chinese imports to eight other developed countries allows me to circumvent the endogeneity related to using US-China trade. The eight comparison countries, also employed in Autor, Dorn and Hanson (2013), are: Australia, Denmark, Finland, Germany, Japan, New Zealand, Spain, and Switzerland. The instrumental variable is constructed in a similar manner as equation (1):

$$\Delta IPW_{oit} = \Sigma_j \frac{L_{ijt}}{L_{ojt}} \frac{\Delta M_{ocjt}}{L_{it}} \quad (2)$$

The difference between equations (1) and (2) is that ΔM_{ucjt} is replaced with ΔM_{ocjt}, which captures the change in Chinese import penetration to the aforementioned other developed countries.

The validity of the instrument relies upon two assumptions: (1) that Chinese import penetration to eight other developed countries (the exogenous Z-variable) is highly correlated with Chinese import penetration to the US (the endogenous X-variable); and (2) that the first-stage is the only reason for a relationship between outcome variable and the instrument. The first assumption ensures that the instrument has a strong first-stage effect, i.e., $Cov(\Delta IPW_{uit}, \Delta IPW_{oit}) \neq 0)$. The second ensures that the instrument fulfills the exclusion restriction, i.e., $Cov(\Delta IPW_{oit} | \varepsilon_{it}) \neq 0)$.

I convert equations (1) and (2) into a regression framework of the form:

$$\Delta M_{it} = \beta \cdot \Delta IPW_{uit} + \varepsilon_{it} \quad (3)$$

The Y-variable, ΔM_{it}, is the change in mortality between 2002 and 2007 and the X-variable, ΔIPW_{uit}, is the change in China-USA import penetration between 2002 and 2007. The first stage equation is the effect of the instrument on the endogenous x-variable:

$$\Delta IPW_{uit} = \alpha \cdot IPW_{oit} + \nu_{it} \quad (4)$$

The reduced form equation takes equation 3 and replaces the endogenous x-variable with the instrumental z-variable:

$$\Delta M_{it} = \beta \cdot \Delta IPW_{oit} + \varepsilon_{it} \quad (5)$$

I verify that the effect of increased Chinese import penetration is mediated through the labor market by replicating the findings of Autor, Dorn and Hanson (2013). A significant negative relationship between China-OTH[9] import penetration, ΔIPW_{oit}, and changes in total manufacturing employment, ΔL_{it}, indicates the validity of this assumption. The regression equation takes the form:

$$\Delta \mathrm{L}_{it} = \delta \cdot \Delta IPW_{oit} + \varepsilon_{it} \quad (6)$$

Although trade relations between the US and China began to normalize several decades prior to China's ascension to the WTO, I define the base period as 2002 which is the year after China joined the WTO and gained preferential trading status among WTO member countries. By doing so, I hope to isolate the effect of increased trade between China, the US, and eight other developed countries separate from pre-ascension trends. I compare labor market conditions and mortality between two periods: 2002 and 2007; and 2002 and 2012. Thus, I can analyze whether the effect of trade with China on labor and mortality was short-lived or longer-lasting.

4.2. Limitations

My primary challenge in conducting this study was data availability. My three main sources of data, UN Comtrade, County Business Patterns, and CDC Wonder, reported data at different levels of analysis. That is, UN Comtrade reports trade data at the product level; CBP reports labor data at the industry and county level; and CDC Wonder reports mortality data at the county level. To be able to sensibly analyze the data at these different reporting levels, I had to transform the data using Dorn's crosswalk files, as I mentioned earlier. Construction of a suitable database is hampered as a natural consequence of conducting analysis along multiple dimensions. I encountered several obstacles when attempting to collect control variables. For example, I would have liked to control for education or income levels. I attempted to download this information from various databases including American Fact Finder, American Community Survey, and Behavioral Risk Factor Surveillance System. Although some of these databases include county information, I was not successful since some do not report explicitly at the county level (AFF and ACS) and others do not use the standard county FIPS code.

[9] China-OTH is the abbreviation for the eight comparison countries' manufacturing imports from China; China-USA is the abbreviation for US manufacturing imports from China.

A second challenge I faced had to do with underlying changes to database structures. For example, the CBP database changed variable names from year-to-year which requires more manual manipulation of the data than is efficient. Third, I would have liked to conduct further analysis along additional dimensions, including more demographic groups for comparison and various causes of death, but was unable to do so given the time in which I had to conduct the study. Lastly, the CDC Wonder database restricts publishing data for sub-national deaths of fewer than 10 persons to protect individuals' identities. While this threshold is quite low, it does mean that some information has been lost due to collecting disaggregated data.

5. Results

5.1. Baseline specifications

According to the theory outlined in Section 4, an increase in import penetration leads to a deterioration in local labor market conditions. Table 2 replicates Autor, Dorn and Hanson's (2013) findings using equation (6). The reason my results do not perfectly replicate those of Autor, Dorn, and Hanson is that I use a different base period. Despite this, both the OLS and IV regressions provide evidence that greater exposure to Chinese import penetration led to a decline in the commuting zone's share of total manufacturing employment. It is noteworthy that the results are insignificant over the 5-year short-run horizon but are significant at the 5 percent level over the 10-year short-run horizon. It is also worth noting that the estimated effect is quite small. A $1000 increase in Chinese import penetration results in a decline in commuting zone's share of manufacturing employment of 0.805 percent.

Table 2 - Effect of a trade shock on manufacturing employment

	A. OLS Regressions	
	Δ Manufacturing Employment, 2002-2007	Δ Manufacturing Employment, 2002-2012
Δ Import Penetration, OTH, 2002-2007	-0.000576	-0.00805***
	(0.000352)	(0.00145)
	B. IV Regressions	
	Δ Manufacturing Employment, 2002-2007	Δ Manufacturing Employment, 2002-2012
Δ Import Penetration, OTH, 2002-2007	-0.000716	-0.0100***
	(0.000438)	(0.00146)

Number of observations in each regression: 2,737.
Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Panel A from Table 3 shows the effect that increased China-USA and China-OTH import penetration have on changes in mortality between various time horizons. The first row shows the 5-year short-run and the long-run relationship between China-USA import penetration and mortality. For a $1000 increase in China-USA import penetration between 2002 and 2007, mortality increases by 0.600 per 100,000 persons between 2002 and 2007 and increases by 1.041 per 100,000 between 2002 and 2012. While this result is interesting, the use of OLS means there could be possible confounding factors which invalidate the result. Turning now to the second row, I find the 5-year short-run effect is statistically insignificant, whereas the long-run effect is significant at the 5 percent level. This seems to indicate that the effect of import penetration between 2002 and 2007 had long lasting effects on mortality trends. The fourth row of Panel A presents the findings over the 10-year short-run: an increase in import penetration between 2002 and 2012 resulted in an increase in mortality of 0.539 per 100,000 persons.

Panel B from Table 3 shows the first stage and reduced form regression results using equations 4 and 5. There exists a strong positive and statistically significant relationship between China-USA import penetration and China-OTH import penetration. For a $1000 increase in China-OTH import penetration, China-USA import penetration increases by 0.805 per 100,000 persons. Finally, Panel C presents the results using the instrumental variables two-stage least squares (IV 2SLS) approach. Once again, the 5-year short-run relationship is statistically insignificant whereas the long-run and 10-year short-run relationships are statistically significant at the 5 percent level. For a $1000 increase in China-OTH import penetration, mortality increases by 1.076 per 100,000 persons over the long-run and increases by 0.545 per 100,000 persons over the 10-year short-run.

Table 3 - Effect of a trade shock on mortality

	A. OLS Regressions	
	Δ Mortality, 2002-2007	Δ Mortality, 2002-2012
Δ Import Penetration, USA, 2002-2007	0.600**	1.041***
	(0.302)	(0.335)
Δ Import Penetration, OTH, 2002-2007	0.541	0.866**
	(0.342)	(0.374)
Δ Import Penetration, USA, 2002-2012	...	0.411***
	...	(0.158)
Δ Import Penetration, OTH, 2002-2012	...	0.539**
	...	(0.250)
	B. First Stage and Reduced Form Regressions	
	Δ Import Penetration, USA, 2002-2007	
Δ Import Penetration, OTH, 2002-2007	0.805***	
	(0.0803)	
	Δ Mortality, 2002-2007	Δ Mortality, 2002-2012
Δ Import Penetration, OTH, 2002-2007	0.541	0.866**
	(0.342)	(0.374)
	C. IV Regressions	
	Δ Mortality, 2002-2007	Δ Mortality, 2002-2012
Δ Import Penetration, OTH, 2002-2007	0.672	1.076**
	(0.414)	(0.450)
Δ Import Penetration, OTH, 2002-2012	...	0.545**
	...	(0.255)

Number of observations in each regression: 2,747.
Robust standard errors in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The associated literature revealed demographic differences in labor and mortality outcomes between various demographic groups, so I collected mortality data for various demographic groups to analyze how the trade shock affects different demographic groups. I continue to use all-cause mortality for individuals between 25 and 64 years old but collect it separately for White non-Hispanics, Black non-Hispanics, Other non-Hispanics, Hispanics, males, and females. I also compare outcomes for males of different races versus White non-Hispanic females. I did not collect data for women of other racial or Hispanic backgrounds (i) since women represent a significantly smaller share of the manufacturing labor force; (ii) since the effect for women was expected to be insignificant relative to that for men; and (iii) due to time constraints.

Table 4 presents the findings for the various demographic groups over the 5-year short-run, 10-year short-run, and long-run using IV 2SLS. Firstly, there are fewer observations per regression due to fewer deaths per demographic group versus the whole sample. Secondly, very few specifications produce statistically significant results. It could be that the data is so disaggregated that the data quality suffers. Furthermore, none of the 5-year short-run specifications are statistically significant. Of the statistically significant results, White non-Hispanic men and women were affected by Chinese import penetration to a greater extent than individuals of other races and Hispanic origin.

Panel A presents results for overall mortality and by gender; Panel B presents results by race; and Panel C presents results by gender, race, and Hispanic origin. The long-run relationship between Chinese import penetration and mortality is 1.300 per 100,000 persons for all genders and races; is 1.615 per 100,000 persons for women of all races; and statistically insignificant for men of all races. Of all the results by various demographic sub-populations, this is the most interesting effect. My findings contrast with other labor and mortality papers which indicate women should have better mortality outcomes than men since women represent a small share of the manufacturing labor force and since women tend to handle unemployment better than men (see Autor, Dorn and Hanson, 2013; Krueger, 2016). There could be a few possible reasons why my results differ from that of other papers. One possible explanation could stem from using different measures of mortality: I use all-cause mortality whereas most other papers use specific causes of death: suicide, accidental poisoning, and alcohol-related liver diseases. An asymmetric rise in other causes of mortality than the "deaths of despair" could explain the difference in findings. Another hypothesis, which I cannot test with my dataset, is that as more men were laid off from work, a greater share of the household burden fell to women. The added stress associated with being a household's sole breadwinner might have driven women to engage in riskier health behaviors as a coping mechanism which would explain the higher mortality rates for women than men. This differential result would be an interesting area for future research. Turning to Panel B, mortality rates for White non-Hispanics increased by 1.962 per 100,000 persons per $1000 increase in import penetration over the long-run and increased by 1.034 per 100,000 over the 10-year short-run. Mortality rates for other demographic groups were not statistically different from zero. However, the regressions for these other demographic groups also used many fewer observations which could explain the insignificance of the estimates.

Table 4 - Effect of a trade shock on mortality by gender, race, and Hispanic origin

	A. Overall Mortality and by Gender			
	Overall	Male	Female	
	Δ Import Penetration, 2002-2007			
Δ Mortality, 2002-2007	0.566	-0.652	0.978	
	(0.422)	(0.814)	(0.604)	
	[1,977]	[1,977]	[1,842]	
Δ Mortality, 2002-2012	1.300***	0.258	1.615**	
	(0.420)	(0.754)	(0.699)	
	[1,977]	[1,977]	[1,842]	
	Δ Import Penetration, 2002-2012			
Δ Mortality, 2002-2012	0.664***	-0.0174	0.791**	
	(0.227)	(0.407)	(0.374)	
	[1,977]	[1,977]	[1,842]	
	B. Mortality by Race			
	White non-Hispanic	Black non-Hispanic	Hispanic	Other non-Hispanic
	Δ Import Penetration, 2002-2007			
Δ Mortality, 2002-2007	0.156	1.407	1.350	4.955
	(0.503)	(1.628)	(1.457)	(3.269)
	[1,947]	[934]	[568]	[439]
Δ Mortality, 2002-2012	1.962***	1.361	-2.026	1.925
	(0.519)	(1.422)	(1.645)	(3.377)
	[1,947]	[934]	[568]	[439]
	Δ Import Penetration, 2002-2012			
Δ Mortality, 2002-2012	1.034***	1.016	-1.248	0.962
	(0.280)	(0.956)	(0.888)	(1.733)
	[1,947]	[934]	[568]	[439]
	C. Mortality by Gender and Race			
	Male White non-Hispanic	Male Black non-Hispanic	Male Hispanic	Male Other non-Hispanic
	Δ Import Penetration, 2002-2007			
Δ Mortality, 2002-2007	-0.448	-2.376	2.724	-3.877
	(0.779)	(2.368)	(2.438)	(5.071)
	[1,912]	[843]	[465]	[315]
Δ Mortality, 2002-2012	1.066	2.214	-3.637	-5.200
	(0.852)	(2.330)	(2.399)	(5.916)
	[1,912]	[843]	[465]	[315]
	Δ Import Penetration, 2002-2012			
Δ Mortality, 2002-2012	0.594	-0.136	-1.664	-4.014
	(0.456)	(1.544)	(1.274)	(2.922)
	[1,912]	[843]	[465]	[315]
	Female White non-hispanic			
	Δ Import Penetration, 2002-2007			
Δ Mortality, 2002-2007	0.383	...	...	...
	(0.725)	...	...	...
	[1,755]	...	...	...
Δ Mortality, 2002-2012	2.198***	...	...	...
	(0.707)	...	...	...
	[1,755]	...	...	...
	Δ Import Penetration, 2002-2012			
Δ Mortality, 2002-2012	1.358***	...	...	...
	(0.374)	...	...	...
	[1,755]	...	...	...

Robust standard errors in parentheses; number of observations in brackets.
*** p<0.01, ** p<0.05, * p<0.1

Panel C indicates that mortality rates rose for White non-Hispanic women over the long-run and 10-year short-run. Once again, none of the other specifications produced statistically significant results. Previously, I argued that the insignificant results had to do with having fewer observations with which to conduct my analysis. However, the fact that White non-Hispanic men and women had approximately the same number of observations seems to dispute this hypothesis. In this case, I suppose that my first hypothesis is correct, i.e., women increasingly bore the burden of maintaining households as men were laid off from work. The added stress induced women to engage in increasingly poor health behaviors. At this point, I would have liked to compare the results for women of other racial and Hispanic backgrounds. Unfortunately, due to time constraints, I was not able to collect this data. Nonetheless, it remains an interesting area for future research.

5.2. Robustness checks

I conduct a few robustness checks to provide further credibility to my results. For example, I ran a few regressions including various control variables: the total population level in 2002; the change in population from 2002 to 2007 and 2002 to 2012; and the manufacturing share of total labor in 1997. This table can be found in the appendix (see Appendix Table 1). Of the control variables, the total population level in 2002 and the change in population over time were statistically significant at the 1 percent level, however, the estimates themselves were close to or approximately equal to zero. The manufacturing share of total labor in 1997 control variable was also statistically significant at the 1- and 5-percent levels and had a strong, negative effect on mortality in all the specifications. Although the control variables were statistically significant in all specifications, my coefficient of interest does not change magnitude or sign. Thus, these controls are meaningful but do not invalidate my identification strategy.

Lastly, I conduct a placebo test in which I regress the usual instrumental variable, China-OTH import penetration, against changes in mortality from 1997 to 2002. If I were to find a statistically significant result, it would indicate my identification strategy is invalid. Table 5 shows that the instrumental variable has no effect on the placebo-test variable. Thus, I can conclude that I have appropriately identified the specification.

Table 5 - Placebo test

	A. OLS Regression
	Δ Mortality, 1997-2002
Δ Import Penetration, OTH, 2002-2007	0.336
	(0.342)
	B. IV Regression
	Δ Mortality, 1997-2002
Δ Import Penetration, OTH, 2002-2007	0.417
	(0.424)

Number of observations in each regression: 2,737.
Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

6. Conclusion

During the past few years, a number of economists have published papers revealing surprising trends in labor and health economics. Autor, Dorn and Hanson (2013) revealed that the costs associated with increased trade integration are much higher/worse than previously assumed. Case and Deaton (2017) showed that mortality for White non-Hispanic Americans has been rising for the past few decades, reversing a decades long declining trend. This paper sought to determine whether these two results were related. It has provided evidence supporting a link between the two: a significant trade shock in the form of increased trade with China had a large and significant positive effect on mortality in the United States.

This finding has serious policy implications for policymakers in the US. Given that the US manufacturing labor market has already absorbed the effect of the China trade shock, the question policymakers now face isn't whether to withdraw from global markets or trade agreements, but rather what policies should be implemented to (i) help individuals who have already born the cost of integration and (ii) prevent more people from suffering as a result from integration in the future.

The US should look to other developed countries that also experienced a large trade shock to manufacturing employment but that did not suffer the same rise in mortality. Future research should be directed towards investigating the institutions and policies that prevented other developed countries from suffering a similar mortality outcome. Furthermore, more research on the differential outcomes between subpopulations, i.e., outcomes by gender, race, Hispanic origin, education, etc., could help ensure the US implements the most effective policies to help the worst-affected individuals.

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8. Appendix

Appendix Table 1 - Regressions including control variables

	A. OLS Regressions	
	Δ Mortality, 2002-2007	Δ Mortality, 2002-2012
Δ Import Penetration, OTH, 2002-2007	0.521	0.804**
	(0.345)	(0.375)
Population in 2002	-2.68e-05***	-8.26e-05***
	(7.07e-06)	(1.14e-05)
	Δ Mortality, 2002-2007	Δ Mortality, 2002-2012
Δ Import Penetration, OTH, 2002-2007	0.493	0.746**
	(0.348)	(0.374)
Change in Population, 2002-2007 (2002-2012)	-0.000413***	-0.000697***
	(9.83e-05)	(7.92e-05)
	Δ Mortality, 2002-2007	Δ Mortality, 2002-2012
Δ Import Penetration, OTH, 2002-2007	0.563*	0.948**
	(0.337)	(0.371)
Manufacturing Share of Labor, 1997	-2.060**	-6.961***
	(0.829)	(0.883)
	B. IV Regressions	
	Δ Mortality, 2002-2007	Δ Mortality, 2002-2012
Δ Import Penetration, OTH, 2002-2007	0.647	0.999**
	(0.418)	(0.451)
Population in 2002	-2.68e-05***	-8.25e-05***
	(7.05e-06)	(1.13e-05)
	Δ Mortality, 2002-2007	Δ Mortality, 2002-2012
Δ Import Penetration, OTH, 2002-2007	0.613	0.926**
	(0.422)	(0.452)
Change in Population, 2002-2007 (2002-2012)	-0.000410***	-0.000696***
	(9.90e-05)	(7.89e-05)
	Δ Mortality, 2002-2007	Δ Mortality, 2002-2012
Δ Import Penetration, OTH, 2002-2007	0.700*	1.180***
	(0.408)	(0.443)
Manufacturing Share of Labor, 1997	-2.154***	-7.120***
	(0.795)	(0.861)

Number of observations in each regression: 2,747.
Robust standard errors in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$