Importing the Opioid Crisis? Trade, Smuggling, and Fentanyl Overdoses *

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Abstract

Recent increases in U.S. drug overdose deaths are primarily due to fentanyl, a powerful synthetic opioid that now accounts for two-thirds of opioid overdose deaths. Nearly all fentanyl is smuggled into the U.S., but little is known about how this occurs. In this paper, we show that states with high legal import flows have more fentanyl overdose deaths. This relationship coincides with the rise of fentanyl since 2014 and is not explained by factors potentially affecting demand, including local economic conditions and job losses due to import competition. By 2018, the elasticity of states' fentanyl deaths to import flows is 0.4, while other causes of death do not increase with imports. We assess the role of different types of imports which provides clues about how specifically fentanyl is being smuggled.

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1 Introduction

We are in the midst of the worst drug overdose epidemic in U.S. history, which has been primarily driven by opioid deaths (Alpert et al. [2019], Maclean et al. [2020]). The U.S. Department of Health Human Services declared the opioid crisis a nationwide public health emergency in October of 2017 and issued a 5-point strategy which included the need for better research.[1] Fentanyl, which is a highly addictive synthetic opioid that is 50 times more potent than heroin and 100 times more potent that morphine, has played a key role in this crisis.[2] The rise of fentanyl has been dramatic: overdose deaths due to fentanyl increased by over 900 percent over a five year period (from 2013 to 2018). Fentanyl accounted for just 12 percent of opioid deaths in 2013 but 67 percent of opioid deaths in 2018.[3] Furthermore, early evidence indicates that fentanyl overdoses have increased during the COVID-19 pandemic.[4]

Research often focuses on demand-side determinants of the opioid crisis (Case and Deaton [2015], Case and Deaton [2017], Pierce and Schott [2020]), while new evidence indicates that supply-side factors may be even more important (Ruhm [2019], Alpert et al. [2019]).[5] This is especially relevant for fentanyl because, unlike previous drug epidemics which were driven by an increase in demand, opioid users are not specifically demanding fentanyl and in fact they seldom know they are even consuming it (Pardo et al. [2019]). Variation in the supply of fentanyl is key to understanding this most recent wave of the opioid crisis, as the high geographic concentration of fentanyl indicates (Zoorob [2019]). Given illicit fentanyl is primarily produced abroad, we explore whether trade patterns make it easier to smuggling fentanyl into some U.S. locations.

According to law enforcement nearly all illicit fentanyl is produced abroad, primarily in China (O'Connor [2017]). A number of features of the Chinese pharmaceutical industry make it an ideal location for production. It is the second largest pharmaceutical industry in the world, it tends to

[1] Illicit drugs is not exclusively a U.S. problem, with 270 million people (or 5.5 percent of the global 15-64 year old population) using drugs in the last year (World Drug Report, UNODC 2019). Global drug trafficking was valued at $539 (Global Financial Integrity) which represents 2.9 percent of global exports in 2014 (World Trade Organization).

[2] https://www.cdc.gov/drugoverdose/data/fentanyl.html

[3] For instance, the musician Prince, the musician Tom Petty, and MLB pitcher Tyler Skaggs have all recently died due to fentanyl.

[4] Fentanyl overdose deaths increased 29.2% from April 2019 to April 2020 (NVSS Vital Statistics Rapid Release Report).

[5] The interplay between supply-side and demand-side factors may create self-reinforcing feedback loops between economic conditions and opioid use (Maclean et al. [2020]).

focus on the mass production of generic drugs, the industry has been largely unregulated, and even with new regulations oversight is notoriously difficult (Pardo [2018]). All of these factors created an environment where the illicit production of fentanyl could flourish. Thus, largely for reasons exogenous to the U.S., there was an dramatic increase post-2014 in the global supply of illicit fentanyl that began making its way to the United States.[6]

Given foreign production and overdose deaths in the United States, fentanyl is clearly being smuggled into the country. However, due to the inherently secretive nature of drug smuggling, little is known about how precisely this is done. One possibility is that existing import flows make it easier to illegally transport fentanyl into the United States. We circumvent the limited and problematic seizure data and directly examine whether smuggling is related to patterns of international trade. Specifically, an event-study approach is used to estimate how changes in synthetic opioid overdose deaths within a state relate to changes in imports from abroad before and after the rise of fentanyl in 2014.[7]

Our empirical analysis utilizes mortality data from the National Vital Statistics System at the Centers for Disease Control and Prevention (CDC) and import data from the U.S. Census by state over the period 2008-2017. These data are particularly well-suited for examining our question because they span the plausibly exogenous rise of fentanyl beginning in 2015 and they exploit substantial variation across U.S. states. For example, overdose deaths due to fentanyl increased in Maryland from 0.6 per 100,000 people in 2008 to 31.3 in 2018 but in Colorado they increased from 0.8 to only 2.3. Fentanyl is much more geographically concentrated than other opioids, which suggests that the supply of fentanyl differs across U.S. states.[8] One possible explanation for this geographic variation is that existing trade patterns, which vary by state, provide an opportunity to smuggle fentanyl.[9]

[6]Consistent with this global supply shock, synthetic opioids are a growing problem in a wide range of countries throughout Asia, Europe, Oceania, and Africa ("Understanding the Global Opioid Crisis" UNODC, Vol. 21, March 2019).

[7]Initially we focus on total imports because more imports, regardless of type, likely decreases the probability that smuggling will be detected, but later we look at imports by product, country, and mode to make inferences about important smuggling routes.

[8]Figure 4 shows that fentanyl deaths are concentrated in the Northeast and Midwest, while Oxycodone deaths are more evenly distributed across the country.

[9]Of course, it is possible that once fentanyl reaches the U.S. it is then transported domestically to neighboring states. However, this should if anything attenuate our findings

The results show that there is no statistically significant relationship between state-level imports and opioid deaths before 2014. However, post-2014 a significant positive relationship emerges that gets larger over time. By 2018 a ten percent increase in imports is associated with a 1.4 percent increase in overall opioid deaths within a state. Since fentanyl is primarily produced abroad it should be even more sensitive to trade flows than other opioids, especially those produced domestically. The findings support this prediction by showing an even larger positive relationship between imports and fentanyl deaths. This effect is non-existent before the global supply shock, and then grows larger over time post-2014. In 2018 a ten percent increase in imports is associated with a 3.9 percent increase in fentanyl overdose deaths.

These findings are not due to broader declines in population health. As expected, there is no evidence that imports influence other causes of deaths due to heart attacks, cancer, of motor vehicle accidents. Furthermore, we find no evidence that imports affect other 'deaths of despair,' such as alcoholism or suicide. Imports have no impact deaths due to other opioids, such as oxycodone which is produced domestically and does not need to be smuggled into the country.[10] In sum, our findings are specific to fentanyl and are not driven by broader health outcomes in the state.

It is possible that import competition adversely effects labor market conditions (Autor et al. [2013]) which then increases demand for opioids (Pierce and Schott [2020]). While our analysis accounts for local economic conditions, as an additional check we also include a measure of import competition, which is constructed using industry-level imports in a given year and the states share of industry employment in the pre-sample year of 2000. This import competition measure is theoretically and methodologically different from our main import measure, because it focuses on the location of production within U.S. states. In short, regions that import a lot of goods from abroad are not necessarily the regions whose workforce is disrupted by import competition. Results including both measures show that fentanyl deaths continue to be positively related to imports post-2014, but are uncorrelated with import competition. These findings indicate that the recent increases in fentanyl deaths are more sensitive to the supply-side factor of drug smuggling than the demand-side factor of import competition.

[10]Purdue Pharma, a large U.S. pharmaceutical company, developed and produces OxyContin the major brand name type of oxycodone (Alpert et al. [2019]).

To address the possibility that import flows may respond endogenously to fentanyl demand, a subsequent analysis utilizes pre-sample imports. The results show that states that had larger import inflows in 2008 subsequently had more fentanyl deaths after the plausibly exogenous rise of this synthetic opioid post-2014. This approach eliminates this endogeneity concern and yet the positive relationship between imports and fentanyl deaths remains similar in magnitude.

The paper also provides insights into important smuggling routes. Our approach circumvents potentially endogenous drug seizure data, and rather provides direct evidence on the link between fentanyl deaths and imports by product, country, and mode of transport. We utilize both an event-study and a machine learning empirical approach, which reassuringly generates similar results. Fentanyl deaths are found to be more closely linked to agricultural and manufactured imports, but not surprisingly are unrelated to natural resource imports, which are not conducive to smuggling.

Fentanyl deaths are found to be particularly sensitive to Canadian imports, which is consistent with U.S. Drug Enforcement Agency (DEA) claims that fentanyl may be smuggled in from Canada. Specifically, fentanyl overdoses are most highly correlated with Canadian manufacturing and agricultural imports arriving via land post-2014. These findings are plausible given that Canada has experienced a similar fentanyl crisis over this period (i.e. in Ontario which is close to Midwest and Northeast states); customs screening efforts differs in the U.S. and Canada; and Canadian smuggling may be an endogenous response to the U.S.-China trade war and new Chinese regulations that have reduced fentanyl smuggling via airmail. Overall, fentanyl smuggling across the U.S.-Canadian border appears to be a more important route than previously realized.

This paper makes a number of important contributions. First, we relate to a broader literature studying illegal drugs and in particular determinants of the opioid crisis. Research has typically focused on demand-side factors like deteriorating social and economic conditions which have led to 'deaths of despair' and opioid deaths in particular (Case and Deaton [2015], Case and Deaton [2017], Hollingsworth et al. [2017]). Other have studied how demand for opioids transitioned from legal prescription pain killers to illicit opioids (Ruhm [2019], Alpert et al. [2019]). We contribute to this literature by focusing specifically on fentanyl, which has been a driving force behind the recent opioid epidemic. Furthermore, we focus on a supply-side factor, which appears to be especially

important for understanding the fentanyl crisis (Pardo et al. [2019]). Specifically, we examine whether international trade flows influence fentanyl smuggling and thus overdoses.

Second, we contribute to a large literature studying how globalization has affected local regions within the U.S. However, rather than focusing, for example, on how import competition has affected labor market outcomes, political outcomes, and marriage markets (Autor et al. [2013], Autor et al. [2017], and Autor et al. [2019]), we study how imports affect health outcomes. This provides new insights on the link between two of the most contentious public policy issues: globalization and the opioid crisis.

Third, we differ from the few studies on the link between trade and deaths of despair (Pierce and Schott [2020]), by proposing a different mechanism. Our results show that imports are affecting fentanyl deaths through increased smuggling opportunities. Unlike Pierce and Schott [2020], we find little impact of import competition on opioid deaths in our setting. One explanation for this difference is that we are studying a more recent period (i.e. 2008-2017 compared to Pierce and Schott [2020] who use 1990-2013), when the adverse labor market impacts of import competition have disappeared (Bloom et al. [2019]). Overall, our paper provides new evidence on the link between globalization and the opioid crisis, by highlighting the importance of the supply-side mechanism of drug smuggling.[11]

Finally, our findings carry important policy implications. The results show that international trade is contributing to the opioid crisis by facilitating the smuggling of fentanyl into U.S. states. The inflow of goods is found to be far more important for fentanyl deaths than the inflow of people crossing the border, for example. However, these findings should not be interpreted as a justification for trade protection as a way of limiting the availability of fentanyl. Stopping the flow of illicit drugs is notoriously difficult (Dobkin and Nicosia [2009]) and protectionist policies have broader adverse welfare consequences (Amiti et al. [2019] and Fajgelbaum et al. [2020]).[12] Instead, policy makers could use the gains from trade and these findings to implement more targeted demand-side interventions like drug treatment [Swensen, 2015].

[11] Russo [2014] finds some cross-country evidence that imports reduce cocaine prices, which he argues is due to increased smuggling opportunities.

[12] Blocked smuggling routes are quickly replaced by others, which is consistent with our own results indicating that smuggling via Canada may have replaced routes directly from China.

The paper proceeds as follows. Section 2 provides background on fentanyl and insights into the production of this synthetic opioid. Section 3 describes the data used in our empirical analysis, and descriptive evidence on the evolution of trade and overdose deaths over time and across U.S. states is shown in section 4. Our event-study empirical specification is described in section 5. The key relationship between imports and fentanyl deaths is explored in section 6, and a variety of other possible explanations are examined. Section 7 provides evidence on the importance of various smuggling routes using both an event-study and machine learning approach. Finally, some concluding thoughts and policy recommendations are provided in section 8.

2 Background on Fentanyl

Paul Janssen, a Belgian physician and chemist, discovered and synthesized fentanyl in 1960 (Stanley 1992). The US Food and Drug Administration (FDA) approved fentanyl in 1968 and it was used initially as an intravenous anesthetic often for cardiac surgery and then more recently as a transdermal patch or lozenge to treat chronic pain, typically for advanced cancer patients (O'Connor [2017]).

Early critics were concerned that fentanyl would be susceptible to abuse given its potency and cheapness. Fentanyl is fifty times stronger than heroin and one hundred times more potent than morphine. Inadvertently touching or inhaling even two milligrams (about two grains of salt) can be lethal (O'Connor [2017]). Furthermore, it is relatively inexpensive to produce. For example, the price of fentanyl is 90% cheaper than an equivalent dose of heroin (Miller [2020]).

According to law enforcement, nearly all illicit fentanyl is produced abroad, primarily in China (O'Connor [2017], Pardo [2018]). A number of features of the Chinese pharmaceutical industry made it an ideal location for the early illicit production of fentanyl and its precursors beginning in 2015. First, the Chinese pharmaceutical industry is the second largest in the world (behind only the U.S.) and tends to focus on the mass production of generic drugs. The U.S. Department of State estimates that there are about 160,000 legal and illegal Chinese chemical companies, producing large quantities of chemicals and pills.[13] The Chinese government has identified the pharmaceutical

[13]U.S. Department of State, 2014 International Narcotics Control Strategy Report (INCSR), March 2014

sector as a high value-added industry and promoted it through tax rebates and export promotion (O'Connor [2017]).

Second the Chinese chemical and pharmaceutical industry was largely unregulated. Illicit fentanyl is not widely used in China and thus there was little incentive to restrict it. China finally declare that the production and possession of fentanyl was illegal in 2015 (Pardo [2018]). Even then the two main ingredients used in fentanyl production, N-Phenethyl-4-piperidinone (NPP) and anilino-N-phenethylpiperidine (ANPP), were not subject to control. According to the U.S. Department of State half of the world's suppliers of NPP and ANPP are located in China, and they petitioned the U.N Commission on Narcotic Drugs to control these fentanyl precursors, which it did in 2017.[14]

Third, it has been notoriously difficult for Chinese law enforcement and investigators to oversee the pharmaceutical industry, even with new regulations. The size of the industry, regulatory loopholes, the fragmented nature of the regulatory agencies, and corruption have made oversight challenging (O'Connor [2017] and Pardo [2018]). Furthermore, legitimate pharmaceutical companies often will produce fentanyl and its precursors on the side which makes drug enforcement more difficult.

In sum, all of these factors created an environment where the illicit production of fentanyl could flourish. Thus, largely for reasons exogenous to the U.S., there was a dramatic increase in the global supply of illicit fentanyl that began making its way to the United States. According to the DEA's National Forensic Laboratory Information System (NFLIS) fentanyl seizures increased from 934 in 2013 to 14,440 in 2015.[15] This indicates that illicit fentanyl began arriving in the U.S. in 2015.[16]

Given the inherently secretive nature of drug smuggling it is challenging to know how precisely fentanyl is smuggled into the U.S. Anecdotal stories indicate that American consumers obtain fentanyl by purchasing it online directly from Chinese producers. Fentanyl packages are also "placed

[14]"U.S. Seeks Curb on Chemicals Used to Make Fentanyl, a Powerful Opioid," The Wall Street Journal, Jeanne Whalen, Oct. 14, 2016

[15]"National Drug Threat Assessment," Drug Enforcement Administration, U.S. Department of Justice, December 2019. Of course, seizures can also depend on law enforcement efforts, which is one reason we prefer to look at overdose deaths.

[16]Given the illicit nature of production it is challenging to identify why global supply increases specifically in 2015, but certainly both Chinese production capabilities as well as global demand for this synthetic opioid play a role. The important point is that this global supply shock is not driven by demand in specific U.S. states, which would also need to be correlated with imports to be problematic.

alongside everyday items" that are then imported into the U.S. (O'Connor [2017]). This indicates that existing trade patterns offer a potential opportunity to smuggle fentanyl into the United States. Furthermore, fentanyl is often shipped to other foreign countries, like Mexico and Canada, and then smuggled into the U.S.

These historical features of fentanyl provide a quasi-natural experiment that informs our identification strategy. To summarize, first the supply of illicit fentanyl is largely driven by conditions abroad (i.e. the Chinese pharmaceutical industry and a lack of regulatory oversight) which are unrelated to U.S. conditions. Second, fentanyl is uncommon until 2015 when this plausibly exogenous supply shock increases the availability of this opioid. Third, given that fentanyl production occurs abroad, it needs to be smuggled into the United States. Fourth, existing import flows vary by state and may provide a channel through which fentanyl smuggling occurs.

3 Data

Mortality data by U.S. states for the years 1999 to 2018 comes from the National Vital Statistics System at the CDC. We follow the CDC's coding to categorize deaths due to opioids. Fortunately, data on overdose deaths by type of opioid is available, including oxycodone, heroin, fentanyl, and methadone. We focus on overdose deaths due to fentanyl, but other opioids, especially those that do not need to be smuggled into the country, are used as a comparison group. As a point of reference, we also gather mortality data for other causes of death, such as heart attack, cancer, motor vehicle accidents, alcohol cirrhosis, and non-drug suicide. Our analysis includes all fifty states, but in Figure A4 we restrict the sample to those states that have at least 'good' or at least 'very good' mortality data according to the CDC and find similar results.

Data on the value of import flows by final destination state comes from the U.S. Census' Trade Online portal. While import data is not available at the city or county level, the state-level unit of observation is appealing given that opioid programs are typically implemented at the state-level (i.e. PDMP and triplicate rules) and mobility is less of an issue.[17] Imports are available

[17] According to the U.S. International Trade Administration: "The zip code information needed to track the imports at a metropolitan area level is not collected at this time."

for the years 2008-2017, which spans the rise of fentanyl. The import data is also available by foreign trading partner country/region, by commodity, by mode of transport, and by weight. Our empirical analysis accounts for state-level exports, which is obtained from the U.S. Census as well.

We account a variety of time-varying state-level economic and demographic factors that could influence overdose deaths. Real Gross Domestic Product (GDP) data, in millions of chained 2012 dollars, comes from the Bureau of Economic Analysis (BEA). The labor force participation rate and the unemployment rate in each state comes from the Local Area Unemployment Statistics from the Bureau of Labor Statistics (BLS). These measures account for economic conditions within a state that could affect the demand for opioids and thus contribute to fentanyl deaths. Population within the state comes from the U.S. Census, and accounts for the possibility that fentanyl may differentially affect urban and rural areas. We also control for demographic characteristics of the state, including the percent of the population that is non-Hispanic white, non-Hispanic black, Hispanic, aged 25-44, aged 45-64, aged 65+, and the percent of the population that has a college degree, all of which comes from the American Community Survey (ACS). To address the possibility that people smuggle opioids across the border, we control for border crossings by state using data from the Bureau of Transportation Statistics (BTS).[18]

The analysis also accounts for a variety of time-varying state-level factors related to drug abuse. This includes the implementation date of a state's Prescription Drug Monitoring Program (PDMPs), which are centralized databases containing patient prescription information (Buchmueller and Carey [2018], Holmgren et al. [2020]). The legal supply of fentanyl is also accounted for using data from the DEA's Automation of Reports and Consolidated Orders System (ARCOS). OxyContin marketing efforts by Purdue Pharma in the 1990s may have influenced the subsequent fentanyl crisis. Following Alpert et al. [2019] we identify California, Idaho, Illinois, New York, and Texas as "triplicate" states. When OxyContin was introduced in 1996, these states required doctors to fill out triplicate prescription forms when prescribing OxyContin, with one being kept by the physician, one going to the pharmacy, and one being sent to the state who maintained a

[18]This includes people crossing the Canadian or Mexican border via car, bus, train, or foot. Furthermore, Figure A8 examines the time-varying impact of border crossings, by interacting Canadian and Mexican crossings with year fixed effects.

database to monitor irregularities. Purdue Pharma viewed this as enough of an impediment to OxyContin that they focused their marketing efforts on "non-triplicate" states which may have had lasting effects on opioid addiction. We account for the time-varying effects of being in a non-triplicate state. Finally, as an external check of our hypothesis we incorporate data on the number of fentanyl reports from the DEA's National Forensic Laboratory Information System (NFLIS) to examine the relationship between imports and fentanyl police seizures.[19]

In addition to import flows, we also measure import competition using the common approach of calculating a state's exposure to national industry-level imports in a given year based on their share of industry employment in the pre-sample year of 2000:

$$ImpComp_{st} = \sum_{n} \left(\frac{empl_{sn2000}}{empl_{n2000}} * imports_{nt} \right) \tag{1}$$

where s is a state, t is a year, and n is a 6-digit NAICS industry.[20] Unlike our main import measure, which measures import inflows into a state, the import competition measure reflects how national imports effect some states more than others based on the location of production eight years prior to the start of our sample.

We also account for other possible methods of drug smuggling. To address the possibility that people carry fentanyl into the country, we control for Mexican and Canadian border crossings by state using data from the Bureau of Transportation Statistics (BTS).This includes people crossing the border via car, bus, train, or foot. Furthermore, Figure A8 examines the time-varying impact of border crossings, by interacting Canadian and Mexican crossings with year fixed effects.

4 Descriptive Statistics

Merging these variables generates a data set spanning all 50 U.S. states over an 11 year period (2008-2018). Summary statistics of the key mortality variables, the globalization variables, and the

[19]The NFLIS data is preferable to both the Uniform Crime Reporting (UCR) data, which does not separate out fentanyl arrests, and the National Incident-Based Reporting System (NIBRS) data, which has poor geographic coverage.

[20]The industry-level import data comes from the U.S. Census via Peter Schott's webpage (Schott [2008]) and the state industry employment comes from the County Business Patterns dataset produced by the U.S. Census.

various economic and demographic controls are reported in Table A1.

The evolution of the opioid epidemic has been noteworthy over the last two decades. As seen in Figure 1, oxycodone was initially the leading cause of opioid related overdoses. This first wave of the opioid crisis consisted of the introduction and growing popularity of pain relievers like OxyContin in the 1990s (Maclean et al. [2020]). The second wave of this crisis began in 2010 and entailed the rise in heroin overdose deaths.[21] By 2015, heroin overdose deaths overtakes oxycodone deaths. The third and most recent wave of the opioid epidemic entailed the dramatic rise of fentanyl deaths. In 2013, overdose deaths due to fentanyl were far less frequent (about 1 death per 100,000 people) than either oxycodone or heroin (3.6 and 2.6 deaths per 100,000 people respectively). By 2018, fentanyl killed more people than oxycodone and heroin combined (9.6 versus 3.9 and 4.6 deaths per 100,000 people respectively).

The availability of fentanyl in the U.S. appears to rise quickly after 2015 (Figure 1), which is consistent with the timing of the global supply shock. Chinese fentanyl production increased rapidly during this period, although precise data on illicit drug production by year is, not surprisingly, unavailable. However, it is possible to compare fentanyl overdose deaths to a separate measure of fentanyl seizures from the NFLIS. Figure 2 shows that trends in fentanyl deaths and seizures are highly correlated over time. The fact that both measures increase quickly precisely at the same time (i.e. in 2015) indicates that this rise is driven by a global supply shock, and not for instance by changing mortality classifications or domestic drug enforcement efforts.[22]

Early in our sample period opioid overdose deaths are geographically dispersed across states within the U.S. Figure 3 shows opioid deaths are common in a wide variety of states, including in the west and the south. However, in 2018 opioid deaths are much more highly concentrated in the Northeast and Midwest. This points to supply side driver and the timing is consistent with the rise of fentanyl.

To explore this possibility more carefully Figure 4, shows the evolution of oxycodone and fentanyl deaths across U.S. states. In the top two maps, we see that oxycodone deaths are regionally

[21] The reformulation of OxyContin in 2010, which made it harder to abuse, may have inadvertently contributed to this increase in heroin overdoses (Evans et al. [2019]).

[22] The impact of imports on fentanyl seizures is examined in section 6.5.

dispersed and fairly persistent over time.[23] If this regional variation is driven by differences in the overall demand for opioids, then fentanyl deaths should exhibit a similar pattern. Furthermore, if there has been a transition from early OxyContin use to fentanyl more recently (Alpert et al. [2019]), then we would also expect the geographic variation in oxycodone and fentanyl deaths to be similar. Instead the bottom panel Figure 4 shows that fentanyl overdose deaths are non-existent in 2008 and then highly geographically concentrated in Midwestern and Northeastern states in 2018. For instance, West Virginia (32) and Maryland (31) have on average the most fentanyl overdose deaths per one hundred thousand people in 2018. Note that Fentanyl seizures are also highly concentrated in Northeastern and Great Lake states.[24] Overall, this evidence suggests that a supply-side determinant may be leading fentanyl to be more readily available in some locations. This paper investigates whether fentanyl is easier to obtain in these states due to drug smuggling via international trade.[25]

Figure A2 in the appendix presents scatter plots showing how the relationship between fentanyl deaths and imports has changed over time. In 2008 (left side), there is a positive relationship between imports and fentanyl deaths but it is small in magnitude (with a slope coefficient of 0.45). However, in 2018 (right side) the positive relationship is much larger, with a slope coefficient that is twice as large (0.90). This shows that the elasticity of fentanyl deaths with respect to imports has increased over time as the global supply of illicit fentanyl has grown.

Overall, the descriptive evidence presented in this section points to an important relationship between fentanyl deaths and import flows. The subsequent empirical analysis will test this hypothesis more carefully.

[23] In this figure and the subsequent analysis we focus on deaths due only to oxycodone, to avoid the possibility that fentanyl was also listed as a cause of death.

[24] See Figure 3 in the "National Drug Threat Assessment," Drug Enforcement Administration, U.S. Department of Justice, December 2019.

[25] It may also be the case that the black tar heroin often found in the West is less conducive to being cut with fentanyl (Maclean et al. [2020]).

5 Empirical Specification

We utilize an event study approach to examine how changes in imports within a state have effected overdose opioid deaths before and after the global rise of fentanyl. The estimating equation is:

$$lnY_{st} = \beta_1 lnImports_{st} + \beta_t lnImports_{st} * 1(Year = t) + X_{st}^{'}\theta + \gamma_s + \gamma_t + \epsilon_{st} \quad (2)$$

where Y_{st} represents the number of opioid or fentanyl deaths in state s and in year t. $Imports_{st}$ are the value of imports flowing into state s in year t. Imports are also interacted with a full set of year fixed effects. Thus, the β_t coefficients provide insight into whether the impact of imports on opioid deaths has evolved over time. These point estimates along with their 95 percent confident intervals will be reported graphically in the figures that follow.[26]

We control for time-varying factors (X_{st}) within a state that could influence overdose deaths, including ln GDP, ln exports, the labor force participation rate, the unemployment rate, ln border crossings, ln population, and the share of the population that is non-Hispanic white, non-Hispanic black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated.[27] We also control for PDMPs, ln legal fentanyl, and the time-varying effects of being in a non-triplicate state (Alpert et al. [2019]). The specification accounts for state (γ_s) and year (γ_t) fixed effects. Finally, robust standard errors which are clustered at the state-level are reported throughout.

Placebo exercises use other causes of death as the dependent variable, such as heart attacks, cancer, car accidents, alcohol cirrhosis, non-drug suicides, and other opioids. In some specifications, we include import competition as an additional independent variable. The potentially endogenous response of import flows to fentanyl demand is addressed by interacting state-level pre-sample import flows with the year fixed effects in equation 2.

Our first set of results focus on the impact of total imports flowing into state s in year t, with the idea that more imports, regardless of type, decreases the probability that smuggling will be

[26] See Table A2 in the appendix for the full regression results.

[27] A ln-ln specification which controls for population is a more flexible and thus preferable approach, compared to using deaths per one hundred thousand people as the dependent variable. The latter approach implicitly assumes the coefficient on log population is one and it is more susceptible to outliers (see Figure A5). However, results using deaths per one hundred thousand people generates similar results (see Figure A6).

detected (Russo [2014]). We then explore how fentanyl deaths respond to detailed import flows by industry, country, and mode of transportation. We use both an event study specification (equation 2) and a machine learning approach (discussed in section 7.5), to provide insights into potentially important smuggling routes.

6 Results

6.1 Opioids

Our analysis begins by examining the relationship between imports and overall opioid overdose deaths. The yearly β_t point estimates as well as the 95% confidence intervals are reported in Figure 5.[28] We see that prior to 2014 there is no significant relationship between imports and opioid overdose deaths. After 2014 the import coefficient steadily increases over time, which is consistent with the global rise of fentanyl. By 2018 a ten percent increase in the inflow of imports is associated with a statistically significant 1.4 percent increase in opioid overdose deaths within the state. Note however that total opioids includes fentanyl, heroin, oxycodone, and methadone, which likely vary in their response to imports. Specifically, some of the opioids (i.e. fentanyl) are produced abroad, while others (i.e. oxycodone) are produced domestically and are thus unlikely to respond to imports. This may attenuate the findings in Figure 5.

6.2 Fentanyl

We now examine whether fentanyl deaths, which are driving the recent opioid epidemic, are related to imports. Specifically, equation 2 is re-estimated using fentanyl overdose deaths as the dependent variable. Since fentanyl is produced abroad and needs to be smuggled into the U.S., fentanyl overdose deaths should be more sensitive to import flows than other opioids.

Figure 6 plots the point estimates and confidence intervals of the time-varying relationship between imports and fentanyl overdose deaths. The findings are striking. There is no significant relationship before fentanyl becomes widely available in 2015. However, in 2015 and thereafter a positive relationship emerges which grows in magnitude over time. A ten percent increase in

[28] The underlying regression results are reported in column 1 of Table A3 in the appendix

imports is associated with a 1.5 percent increase in 2015, a 3.0 percent increase in 2016, and a 3.4 percent increase in 2017, and a 3.9 percent increase in fentanyl deaths in 2018. As expected, imports are more highly correlated with fentanyl overdose deaths (coefficient of 0.39 in 2018 in Figure 6) than with overall opioid overdose deaths (coefficient of 0.14 in 2018 in Figure 5).

These findings are robust to a variety of samples, different measures of imports and fentanyl deaths, and alternate specifications. Specifically, results in Figure A4 in the appendix show that restricting the sample to the 34 states with at least 'good' mortality data or the 26 states with at least 'very good' data (according to the CDC) generates even stronger results.[29] Qualitatively similar findings are obtained measuring imports using their weight rather than their value (see Figure A5 in the appendix). Using the rate of fentanyl deaths as the dependent variable is more sensitive to small outlier states like West Virginia, Delaware, and New Hampshire as shown in Figure A6. Nonetheless, the results are similar in Figure A7 using fentanyl deaths per one hundred thousand people.[30] Finally, the results in Figure A9 are the same using overdose deaths due only to fentanyl, which addresses the possibility that the baseline findings are influenced by polydrug use.[31]

6.3 Other Causes of Death

Perhaps the observed relationship is not driven by smuggling but rather due to imports being correlated with health outcomes in the state. This alternate hypothesis, however, cannot explain why the positive relationship in Figure 6 only emerges after 2014. To test for this possibility, a placebo exercise examines the relationship between imports and deaths due to other factors, such as heart attack and motor vehicle accidents. Figure 7 shows, as expected, that imports are unrelated to these other causes of death both before and after 2014. These findings indicate that our fentanyl findings are not driven by broader health outcomes in the state.

Another explanation for the opioid crisis is that it is a symptom of a larger health issue know

[29]For instance, in the 'very good' sample a ten percent increase in 2018 imports is associated with a 5.7 percent increase in fentanyl overdose deaths.

[30]The import coefficient becomes increasingly positive after 2015. This specification is weighted by the presample 2008 population but the standard errors are still large due to outlier observations.

[31]The import elasticity in 2018 is 0.39 if fentanyl is listed as a cause of death (see Figure 6), while it is 0.37 if fentanyl is the only listed cause of death.

as 'deaths of despair' (Case and Deaton [2015] and Case and Deaton [2017]). According to this hypothesis, deteriorating social and economic conditions in some states have led to an increase in opioid use, alcohol abuse, and suicides. To be problematic for us, deaths of despair would have to be correlated with imports. Furthermore, deaths of despair have been steadily increasing since 1998 (Case and Deaton [2017]), which is not consistent with the positive relationship that emerges only post-2014 in our analysis. Finally, GDP, unemployment rate, and labor force participation controls should account for economic conditions within the state. As an additional test, we pursue a placebo exercise which examines whether imports influence alcohol cirrhosis or non-drug suicides. Figure 7 shows no relationship between imports and these two other factors before or after 2014. In sum, there is no evidence that our fentanyl findings are driven by broader deaths of despair.

Perhaps our findings reflect a general increase in the demand for opioids? If so, then opioid overdose deaths should increase, regardless of where they are produced. Alternatively, if the observed positive relationship is driven by smuggling opportunities, then there should be no impact of imports on overdose deaths due to domestically produced opioids (i.e. oxycodone). In contrast to fentanyl, oxycodone does not need to be illegally transported into the country. To distinguish between these competing explanations, Figure 7 compares the impact of imports on the four types of opioid overdose deaths (i.e. fentanyl, heroin, oxycodone, and methadone). Unlike the fentanyl result, the relationship between imports and deaths due to the other three opioids is small and insignificant before and after 2014.[32] These contrasting findings indicate that our results are not due to a general increase opioid demand, but rather are specific to fentanyl, which needs to be smuggled into the country. Overall, Figure 7 shows that the findings are not driven by changes in health outcomes, deaths of despair, or opioid demand.

6.4 Import Competition

Import competition can adversely affect local labor markets (Autor et al. [2013], Pierce and Schott [2016]) and deteriorating job prospects may in turn increase deaths of despair and demand for illicit drugs (Case and Deaton [2015], Case and Deaton [2017], Pierce and Schott [2020]). To what extent

[32]These regression results are reported in in columns 2-5 of Table A2 in the appendix

are our findings due to this demand-side import competition story rather than a supply-side drug smuggling explanation?

Import competition is unlikely to be driving our results because we already control for economic conditions (i.e. GDP, unemployment rate, labor force participation rate), the lack of pre-2014 results is not consistent with the timing of import competition (Figure 6), and there is no reason to think import competition only affects fentanyl overdoses and not other opioid overdoses (Figure 7). Nonetheless, we explore this possibility by altering our estimation approach (equation 2) to also include the interaction of import competition with year fixed effects. We then plot both the time-varying import coefficients, as well as the time-varying import competition coefficients. Note that the former reflects smuggling opportunities based on state consumption patterns, while the latter captures labor market effects based on the location of production.

Figure 8 shows that imports and fentanyl deaths are positively related post-2014. The inclusion of import competition does not alter this key finding. Import competition itself has an insignificant impact on fentanyl deaths throughout our sample period. These findings indicate that trade influences fentanyl deaths through supply-side smuggling opportunities rather than through a demand-side import competition channel.

A number of factors reconcile our findings with previous results showing that import competition can increase mortality (Pierce and Schott [2020]). First, our analysis examines a more recent period (2008-2018 compared to 1990-2013 in Pierce and Schott [2020]), where import competition has been found to be less important. For instance, Bloom et al. [2019] show that the adverse labor market impact of import competition disappear after 2007. Second, we focus specifically on fentanyl, where smuggling may be especially important, while Pierce and Schott [2020] look more broadly at 'deaths of despair' which includes drug overdoses, suicides, and alcohol-related liver disease. Third, Pierce and Schott [2020]'s import competition measure may inadvertently be capturing the effect of smuggling, which is not a mechanism they account for in their analysis.[33] Finally, our measure includes all import competition, while Pierce and Schott [2020] focus on import competition related to the U.S. granting Permanent Normal Trade Relations (PNTR) to China in 2000. Overall, our

[33]Supporting this hypothesis, the estimated impact of import competition is more positive if imports are not included in the specification (results available upon request).

findings indicate that it is important to account for both the demand- and supply-side effects of imports on overdose deaths.

6.5 Opioid Seizures

As an external check on our overdose findings, we examine whether imports are also associated with an increase in fentanyl seizures. Figure 2 showed that both fentanyl deaths and seizures increased quickly after 2014, which is consistent with a global supply shock. This section exploits this time-series variation as well as geographic variation across U.S. states to examine whether imports have led to an increase in fentanyl reports from the DEA's National Forensic Laboratory Information System (NFLIS).

Comprehensive state-level NFLIS data begins in 2010 and we identify the time-varying effects of imports on fentanyl seizures using the empirical approach outlined in equation 2. The results reported in Figure 9 show that fentanyl seizures increase with imports post-2014 but not before. Furthermore, this relationship becomes larger in magnitude and more significant over time. By 2018, a ten percent increase in imports is associated with a 7.1 percent increase in fentanyl seizures. These findings are consistent with the impact of imports on fentanyl overdose deaths seen in Table 8.

As a placebo check we also explore whether the seizure of other types of opioids is sensitive to trade flows. Figure 9 shows that imports have no significant impact on the seizure of oxycodone, heroin, or methadone before or after 2014. This confirms the overdose results in Table 11, and confirms that only fentanyl, and not other opioids, is related to imports. Given that seizures are potentially endogenous to law enforcement efforts, we have a preference for using overdoses as our dependent variable. However, the results in Table 13 illustrate that our main results hold when using seizures instead.

6.6 Pre-Sample Imports

One potential concern is that rising fentanyl demand within a state could lead to more imports simply as a way of facilitating smuggling. To the extent this is an issue, it would generate a

spurious positive relationship between imports and overdose deaths. While it seems unlikely that the demand for fentanyl is large enough to influence the overall level of imports flowing into a state, it is a possibility we explore in this section.

To address endogeneity concerns we use 2008 state-level imports instead of the baseline time-varying measure. This presample import variable is then interacted with the year fixed effects as shown in equation 2.[34] This approach eliminates the possibility that fentanyl demand can influence subsequent import flows, and instead focuses on how the global supply shock deferentially impacts some states more than others based on presample import flows.

Figure 10 shows that there is no significant relationship between this import measure and fentanyl overdose deaths prior to 2014. However, after the plausibly exogenous rise of illicit fentanyl in 2014, we find a positive relationship between presample imports and overdose deaths that grows over time. States that had larger import inflows in 2008 subsequently had more fentanyl overdose deaths after the synthetic opioid becomes widely available. The fact that the results in Figures 6 and 10 are similar indicates that there is little evidence that imports are responding endogenously to fentanyl demand.

7 Smuggling Routes

Due to the inherently secretive nature of the illicit drug trade it is hard to know exactly how fentanyl gets into the country. Our previous results indicate that fentanyl enters a state along with legal imports, but so far we have remained agnostic about specific smuggling routes. This was partly motivated by the likelihood that more imports, regardless of type, decreases the probability of detection (Russo [2014]). However, this section provides insight into possible routes by examining whether fentanyl deaths are more closely tied to particular types of imports. We focus on imports by industry, country, and mode of transport using our event study specification, and then we turn to a more general machine learning approach. While this analysis is more speculative in nature, it may be of interest to policy makers and law enforcement.

[34] Of course, the time-invariant import measure does not survive the state fixed effects on its own but these interaction terms do.

7.1 Imports by Industry

Drug traffickers are creative in their smuggling techniques, but there are some broader features of imported goods that may be appealing. Some imported goods may be more conducive to drug smuggling than others, based on their size, volume, weight, cavities, etc. For instance, fentanyl is unlikely to be transported into the country along with oil or coal. However, there are various anecdotal stories about fentanyl being smuggled in with agricultural and manufactured products.

The findings, reported in Figure 11, confirm that natural resource imports are not correlated with fentanyl deaths. However, agricultural and manufacturing imports are found to be positively related to fentanyl deaths post-2014. Consistent with anecdotal seizure evidence, these types of imports are more conducive to drug smuggling. This relationship is statistically significant and grows in magnitude over time. It is reassuring that the results in Figure 11 are strongest in the anticipated places.[35] In the analysis that follows we focus on agricultural and manaufactured imports.

7.2 Imports by Country

Law enforcement speculates that illicit fentanyl is smuggled into the U.S. either directly from China or indirectly through other countries, like Mexico and Canada. We provide insight into this issue by circumventing problematic seizure data and directly studying the relationship between fentanyl deaths and bilateral import data from these three countries.

Figure 12 plots the relationship between fentanyl deaths and imports from China, Canada, and Mexico. Interestingly, the results show that fentanyl deaths increase with imports from Canada post-2014, but not before. In contrast, Chinese and Mexican imports have an insignificant impact on fentanyl deaths throughout the period. Contrary to popular concerns about Chinese and Mexican smuggling, these results indicate that smuggling of fentanyl across the U.S.-Canadian border is more highly correlated with fentanyl overdoses. This finding is consistent with the descriptive evidence (Figure 4) showing that states close to the Canadian border have more fentanyl overdose deaths.

Smuggling of fentanyl across the U.S.-Canada border is plausible for a few reasons. First,

[35] While this event study approach is not conducive to a detailed industry-level analysis, the machine learning results in Table 2 decompose agricultural and manufacturing imports by 3-digit NAICS industry.

Canada is experiencing its own opioid epidemic, whose timing coincides with the U.S. crisis. Canadian fentanyl overdose deaths increased by 115 percent from 2016 to 2018 and accounted for 70 percent of all opioid deaths in 2018.[36] Second, the geographic variation of this crisis in Canada shows a high rate of opioid overdose deaths in British Columbia and Ontario, and the rise of fentanyl is pronounced in these two provinces (Pardo et al. [2019]). Note that the former province is close to China while the latter is close to Northeast and Midwest states, which points to a possible smuggling route across the country and into the U.S.. Third, the United States and China are Canada's top two trading partner countries, which may make smuggling easier. Fourth, stricter customs screening in the U.S. (i.e. they spend fifteen times more on border protection than Canada) may make Canada an appealing entry point.[37] Fifth, Canadian fentanyl smuggling may be an endogenous response to the U.S.-China trade war and recent critiques by the U.S. government of Chinese fentanyl production. The former has reduced Chinese imports and the latter may have led to more rigorous screening of Chinese imports. Sixth, our empirical approach identifies smuggling via legal imports, while it is possible that fentanyl arrives from other countries via different modes (i.e. Chinese airmail). Finally, new regulations in China appear to have reduced smuggling via mail while smuggling via legal cargo and smuggling via Canada persists.[38]

7.3 Imports by Country and Mode

Is fentanyl smuggling easier via some modes of transportation than others? To investigate this possibility, we examine whether fentanyl deaths are more highly correlated with imports transported via air, sea, or land. Specifically, we focus on agricultural and manufactured imports from China via air and sea, from Canada via air, sea, and land, and from Mexico via air, sea, and land.[39] These are the import flows that are most likely to be used to smuggle fentanyl.

The results in Figure 13 show that fentanyl overdose deaths is most sensitive to Canadian agricultural and manufactured imports arriving via land post-2014. The positive point estimate

[36] Calculations using Opioid Related Harms data produced by the Government of Canada.

[37] The U.S. spent 25 billion dollars on CBP and ICE in 2019, while Canada Border Services Agency spent 2.2 billion Canadian dollars or about 1.68 billion US dollars in 2019.

[38] "Fentanyl and Geopolitics: Controlling Opioid Supply from China" Vanda Felbab-Brown, Brookings, July 2020.

[39] Land imports for Canada and Mexico are measured as the difference between total imports and sea plus air imports.

for Canadian land imports is far larger and more significant than any other import flow. In 2018, a ten percent increase in Canadian land imports is associated with an 8.3 percent increase in fentanyl overdose deaths. Overall, these findings indicate that not only is fentanyl smuggled across the U.S.-Canadian border (Figure 12), but it appears to be smuggled in with agricultural and manufactured imports that arrive via truck and rail.

To ensure that the Canadian land import result in Figure 13 is not inadvertently capturing people smuggling fentanyl across the border, we separate border crossings into Canadian and Mexican border crossings and interact both with year fixed effects.[40] This captures the time-varying effects of border crossings from particular foreign countries. As shown in Figure A8 in the appendix, both Canadian and Mexican border crossings have a small and insignificant impact on fentanyl overdose deaths. Furthermore, the inclusion of these measures has no bearing on the import results, where Canadian land imports remain highly correlated with fentanyl deaths post-2014. These results indicate that fentanyl deaths are more closely related to the inflow of goods than to the inflow of people.

7.4 Machine Learning

We have relied on anecdotal evidence from law enforcement to inform our effort to identify important smuggling routes. This has provided interesting new insights. We complement these findings with a more objective 'machine learning' approach (Mullainathan and Spiess [2016]). Rather than imposing our own preconceived notions on which import flows are conducive to smuggling, a machine learning approach allows the data to tell us which smuggling channels are most important.

We use the Least Absolute Shrinkage and Selection Operator (LASSO) to identify which import flows are best at predicting fentanyl overdose deaths within a state. This is a computationally challenging problem that is well-suited for a machine learning approach. We begin by examining which routes are most important at predicting fentanyl deaths, among 198 possible import flows that vary by country, mode of transport, industry, and year.[41] The full set of controls and fixed

[40] Border crossings are included as a control in all our specifications and are found to be unrelated to fentanyl deaths.

[41] These agricultural and manufacturing import flows vary by country/region [China, Canada, Mexico, Africa, Australia/Oceania, Europe, South and Central America, and Asia (not including China)], by mode of transport [air,

effects from equation 2 are always included in the analysis.[42]

The results are reported in Table 1. Of the nearly two hundred import variables, LASSO selects four that are useful in predicting fentanyl overdose deaths. All four are imports from Canada. Specifically, agricultural and manufactured imports from Canada arriving via sea in 2017 and arriving via land in 2013, 2016, and 2017. Canadian land imports in 2016-2017 are positive and have post-estimation OLS coefficients that are large in magnitude.[43] This indicates that Canadian land imports during these years are closely tied to fentanyl overdoses.

To gain further insight into potential Canadian smuggling routes, we decompose agricultural and manufacturing imports into twenty-five 3-digit NAICS industries. Adding these detailed Canadian industry import flows by mode and year to the existing import flows, leads to the inclusion of 990 possible import variables. As we see in Table 2, the LASSO procedure selects only seven import flows, all of which come from Canada. This includes Canadian Chemical Manufacturing (NAICS 325) arriving via sea in 2017, Plastics and Rubber Products Manufacturing (NAICS 326) arriving via land in 2013, 2017, and 2018, Nonmetallic Mineral Product Manufacturing (NAICS 327) arriving via land in 2016, and Fabricated Metal Product Manufacturing (NAICS 332) arriving via Land in 2016 and 2017. Imports of these products are highly correlated with fentanyl overdose deaths. Overall, these machine learning findings are consistent with earlier results and show that Canadian imports post-2014 (especially via land) are an important predictor of fentanyl deaths.

8 Conclusions

The opioid crisis, and in particular the recent rise of fentanyl, is a ongoing public health emergency. Unlike earlier drug epidemics that were demand driven, fentanyl is driven by supply differences, as the high geographic concentration of this opioid illustrates. We examine whether globalization is a supply-side determinant of the fentanyl epidemic.

Our empirical analysis uses an event-study approach to exploit the dramatic and plausibly

sea, and land (for Canada and Mexico)], and by year [2008-2018].

[42]The LASSO lambda coefficient is set to 65 but the findings are robust to other choices.

[43]Machine learning is not designed for parameter estimation, so these coefficient estimates should be interpreted with caution.

exogenous rise of fentanyl after 2014. Furthermore, since this synthetic opioid is mostly produced abroad it needs to be smuggled into the country, but little is known about precisely how this is done. One possibility is that existing patterns of U.S. trade make it easier to smuggle fentanyl into the country. We test this theory by examining whether fentanyl deaths are related to import flows into a state after 2014.

The findings show that there is a significant positive relationship between imports and fentanyl deaths that increases each year post-2014, and that is not apparent earlier. This result is not due to broader declines in health, deaths of despair, import competition, or demand for opioids within the state. Overall, the findings show that imports do indeed provide a conduit for fentanyl smuggling which then leads to more fentanyl overdose deaths.

We complement these results with an analysis of possible fentanyl smuggling routes. We overcome the inherently secretive nature of drug smuggling and the lack of relevant data, by directly examining which types of imports are most highly correlated with fentanyl deaths. Both an event study and a machine learning approach show that Canadian manufactured imports arriving via land post-2014 are positively related to fentanyl deaths. These findings indicate that fentanyl smuggling across the U.S.-Canadian border is potentially more important than previously realized.

While the findings suggest that the fentanyl epidemic is at least partially explained by drug smuggling via existing trade linkages, we do not advocate restricting trade as a means to limit the supply of fentanyl. This would forgo the overall benefits of trade to address one small but important side effect. Moreover, supply-side interventions in illegal drug markets have shown at best to have temporary effects (Dobkin and Nicosia [2009]).[44] Nor are we suggesting that the U.S.'s fentanyl epidemic is China's fault. In fact, China's brief attempt to shut down black market fentanyl sellers resulted in hundreds of new entrants on dark web markets [Miller, 2020]. Overall, we do not endorse a "trade war on drugs."

Instead, the findings of this paper provide policy makers useful insight into how to target demand-side interventions. For instance, drug treatment facilities could be expanded in states more exposed to fentanyl via international trade [Swensen, 2015]. In other words, the gains from

[44]Likewise, while drug trafficking can be violent (Dell [2015]) eliminating leaders of drug cartels in Mexico gave way to increased violence (Lindo and Padilla-Romo [2018]).

trade could be used to assist those adversely effected by globalization, which in this case are fentanyl addicts whose addiction may have begun or became increasingly dangerous with the availability of a cheap new synthetic opioid.

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Figure 1
Opioid Overdose Deaths

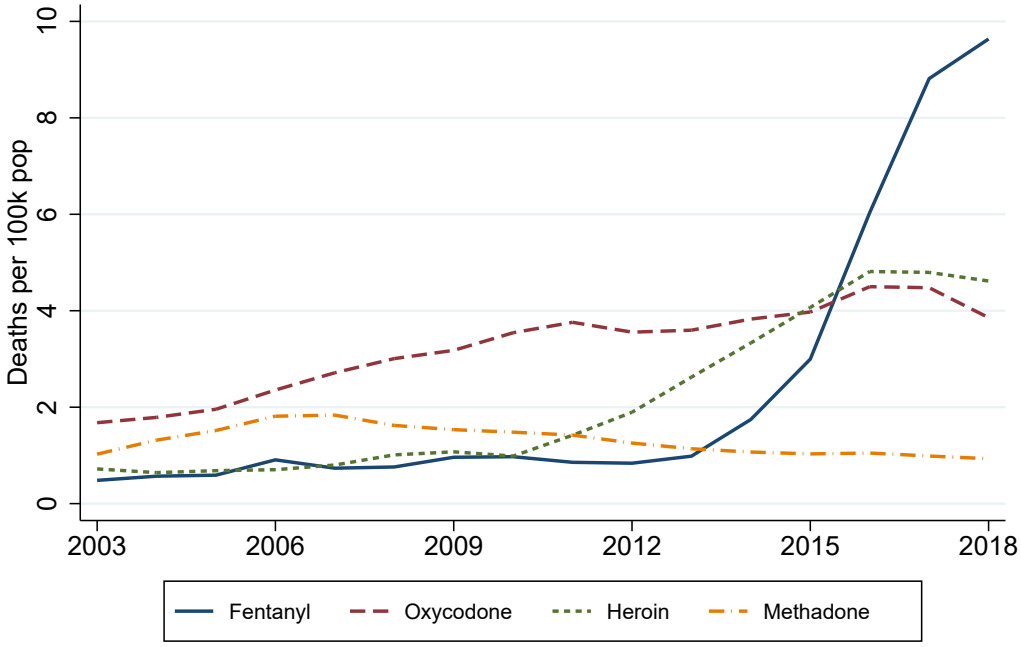


Figure 2
Fentanyl Overdoses and Seizures

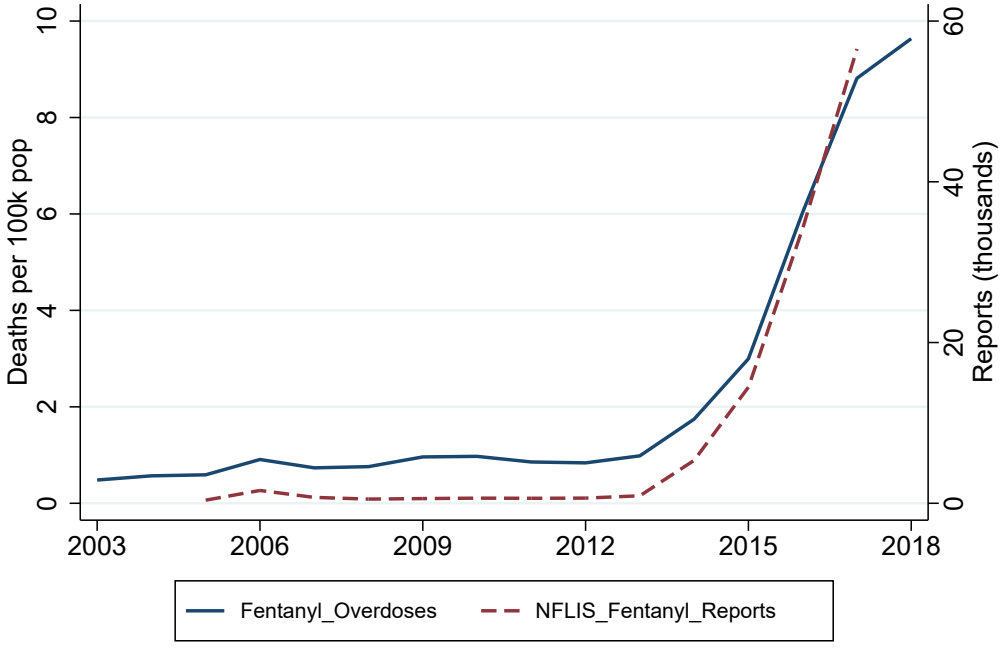
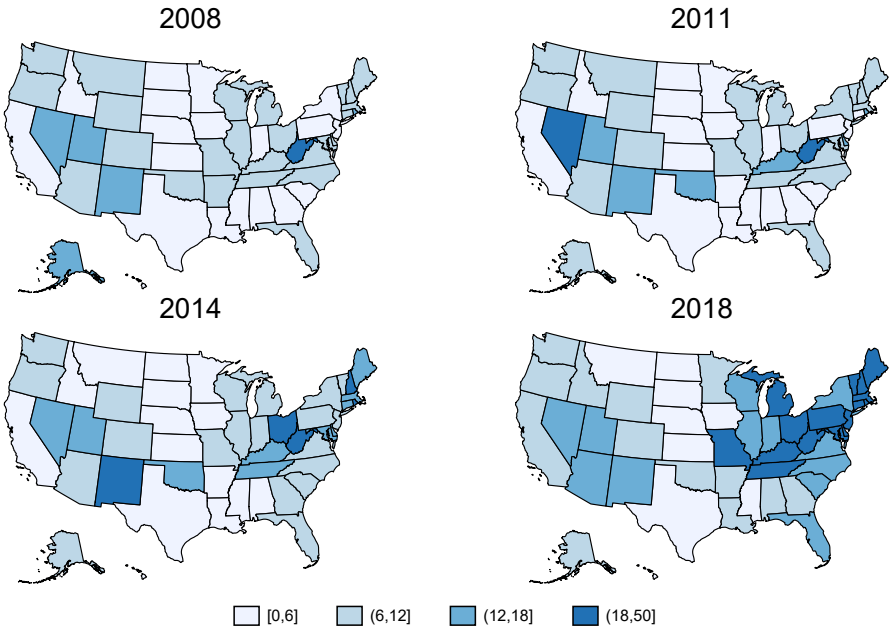
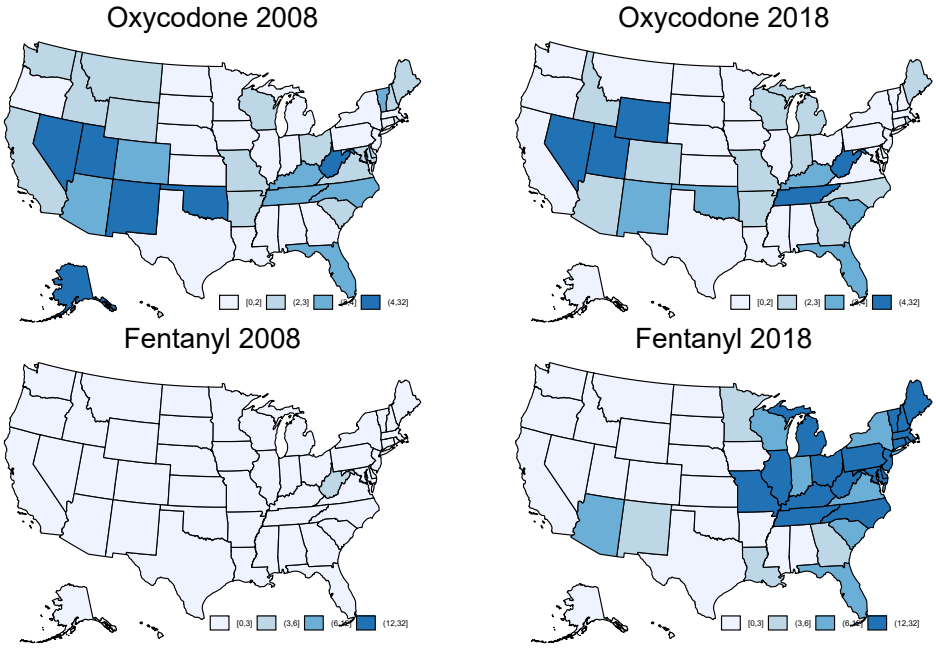


Figure 3
Opioid Deaths



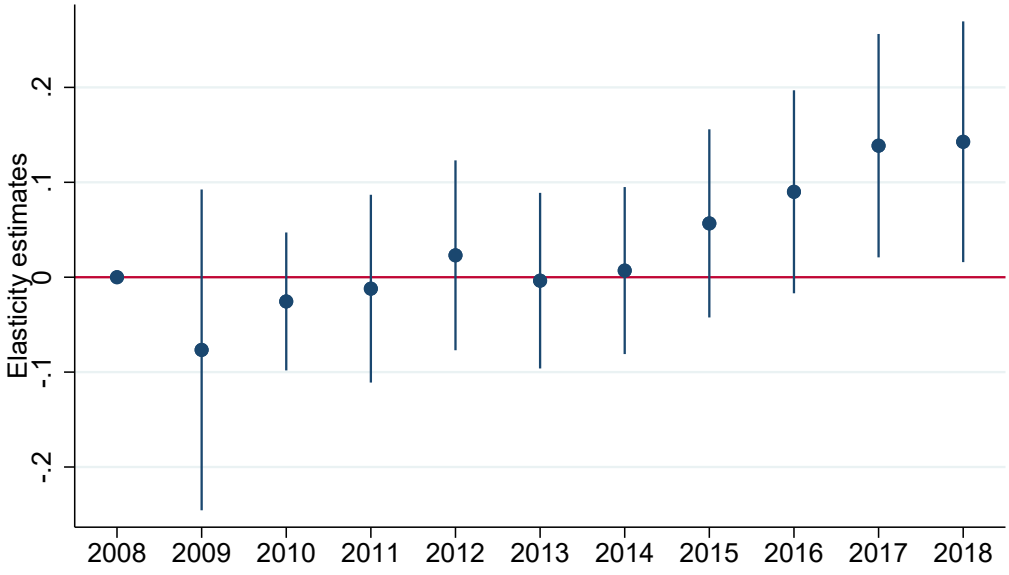
Notes: Deaths per 100k population by state.

Figure 4
Oxycodone and Fentanyl Deaths



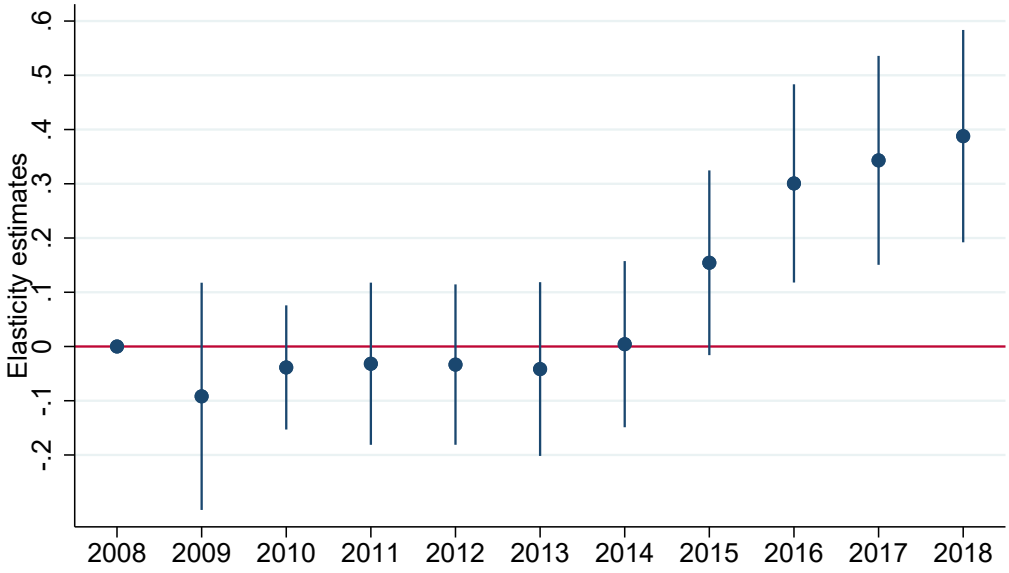
Notes: Deaths per 100k population by state

Figure 5
Impact of Imports on Opioid Overdose Deaths



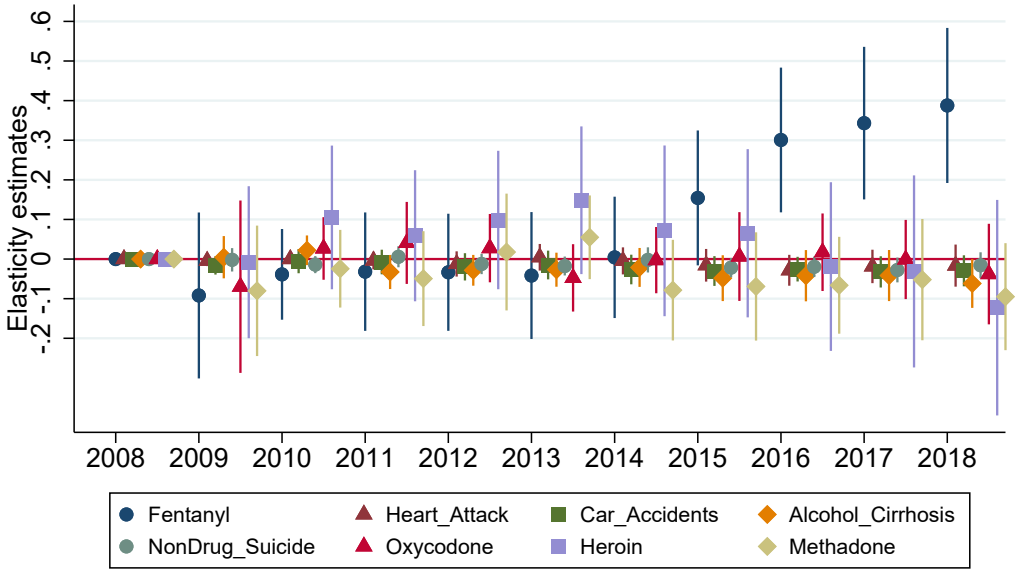
Notes: Dependent variable is ln opioid deaths. Regression controls for ln real GDP, ln population, ln exports, ln border crossings, unemployment rate, LF participation rate, PDMP, ln legal fentanyl, the percent of the population that is non-Hispanic white, non-Hispani black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated, state FE, year FE, and non-triplicate states*year FE. Sample includes 50 states and 2008-2018. Robust standard errors clustered at the state-level.

Figure 6
Impact of Imports on Fentanyl Overdoses



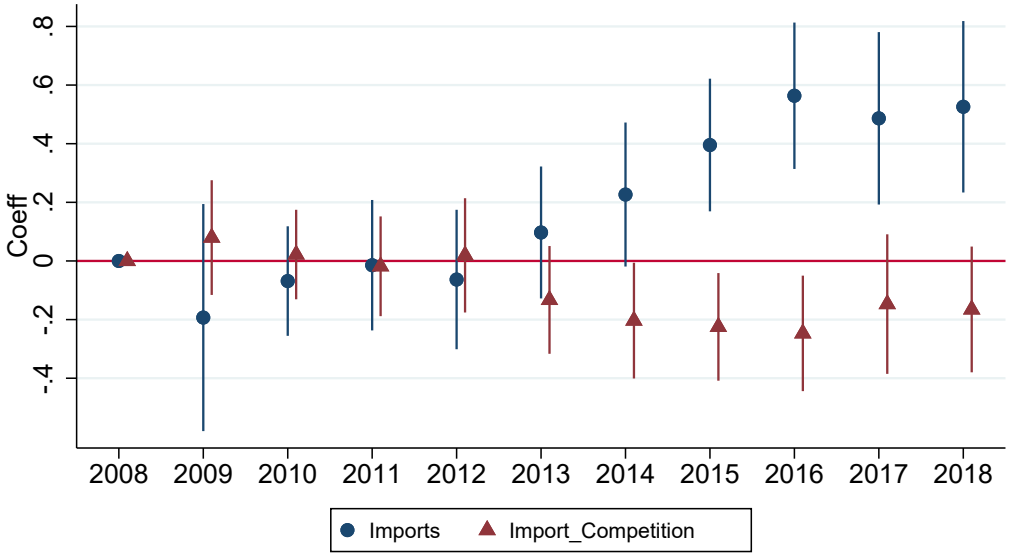
Notes: Dependent variable is ln fentanyl deaths. Regression controls for ln real GDP, ln population, ln exports, ln border crossings, unemployment rate, LF participation rate, PDMP, ln legal fentanyl, the percent of the population that is non-Hispanic white, non-Hispani black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated, state FE, year FE, and non-triplicate states*year FE. Sample includes 50 states and 2008-2018. Robust standard errors clustered at the state-level.

Figure 7
Fentanyl versus Other Causes of Death



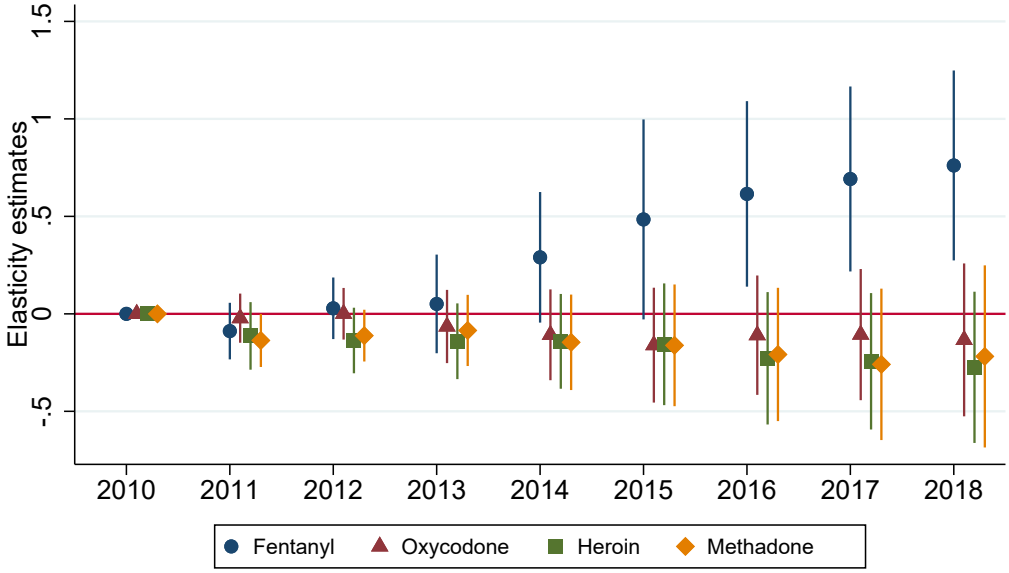
Notes: Dependent variable is ln deaths by each cause. Regression controls for ln real GDP, ln population, ln exports, ln border crossing unemployment rate, LF participation rate, PDMP, ln legal fentanyl, the percent of the population that is non-Hispanic white, non-Hispani black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated, state FE, year FE, and non-triplicate states*year FE.
Sample includes 50 states and 2008-2018. Robust standard errors clustered at the state-level.

Figure 8
Impact of Imports and Import Competition on Fentanyl Overdoses



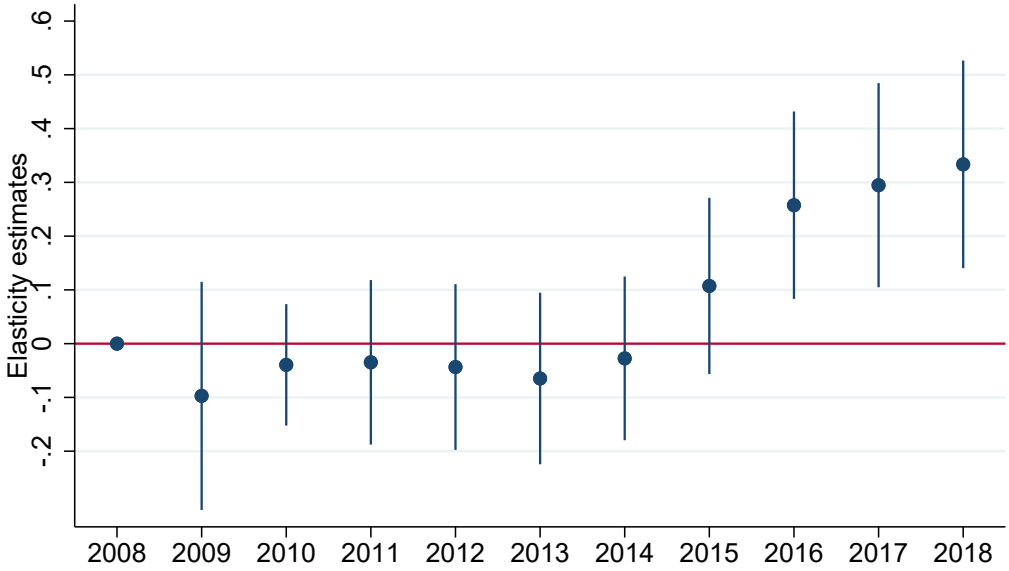
Notes: Dependent variable is ln fentanyl deaths. Import Competition is calculated using industry imports and state-level presample industry employment shares. Regression controls for ln real GDP, ln population, ln exports, ln border crossings, unemployment rate, LF participation rate, PDMP, ln legal fentanyl, the percent of the population that is non-Hispanic white, non-Hispanic black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated, state FE, year FE, and non-triplicate states*year FE.
Sample includes 50 states and 2008-2018. Robust standard errors clustered at the state-level.

Figure 9
Fentanyl Seizures versus Other Opioid Seizures



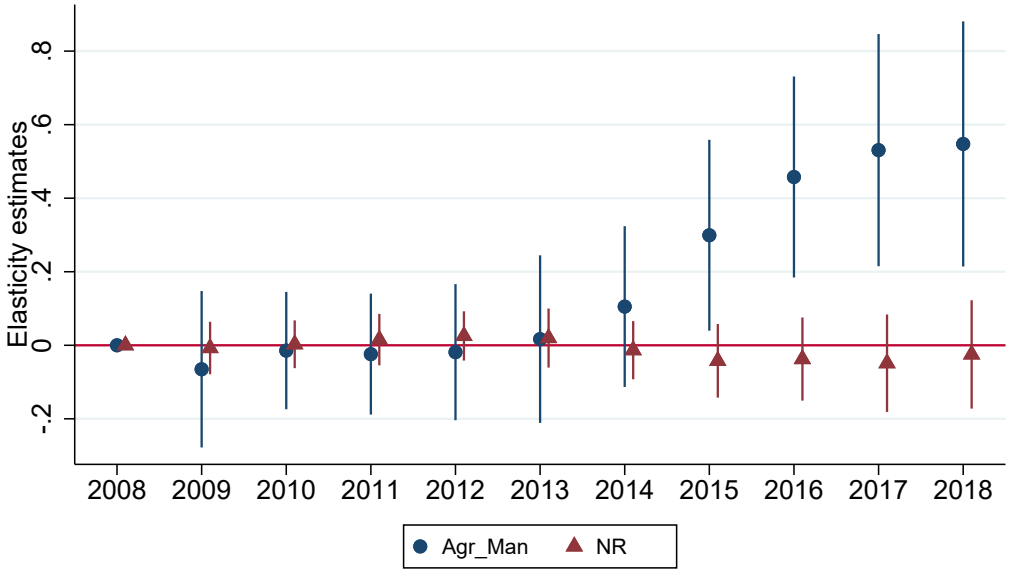
Notes: Dependent variable is ln opioid seizures. Regression controls for ln real GDP, ln population, ln exports, ln border crossings, unemployment rate, LF participation rate, PDMP, ln legal fentanyl, the percent of the population that is non-Hispanic white, non-Hispani black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated, state FE, year FE, and non-triplicate states*year FE. Sample includes 50 states and 2010-2018. Robust standard errors clustered at the state-level.

Figure 10
Impact of 2008 Imports on Fentanyl Overdoses



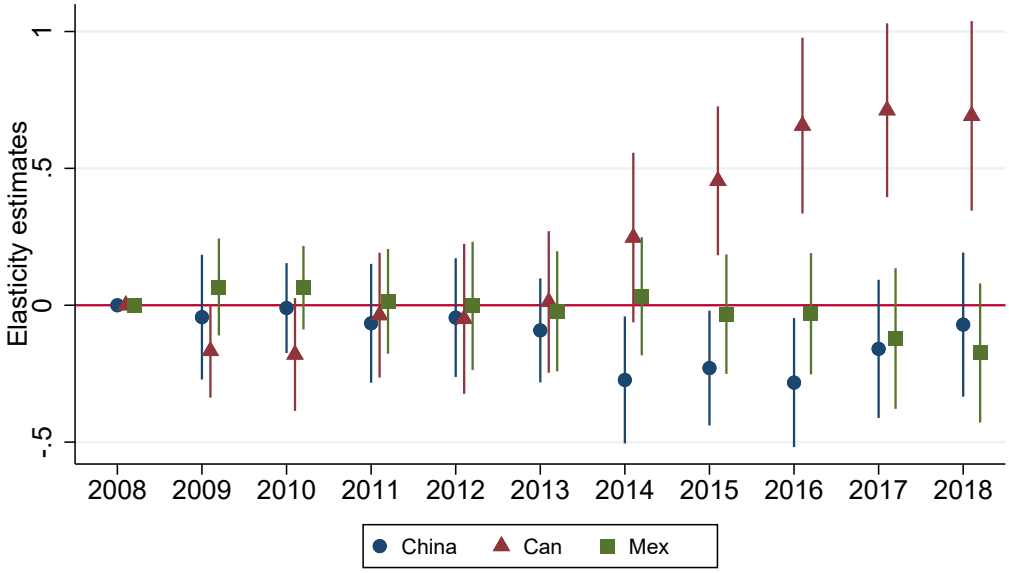
Notes: Dependent variable is ln fentanyl deaths. Regression controls for ln real GDP, ln population, ln exports, ln border crossings, unemployment rate, LF participation rate, PDMP, ln legal fentanyl, the percent of the population that is non-Hispanic white, non-Hispani black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated, state FE, year FE, and non-triplicate states*year FE. Sample includes 50 states and 2008-2018. Robust standard errors clustered at the state-level.

Figure 11
Impact of Imports by Industry on Fentanyl Overdoses



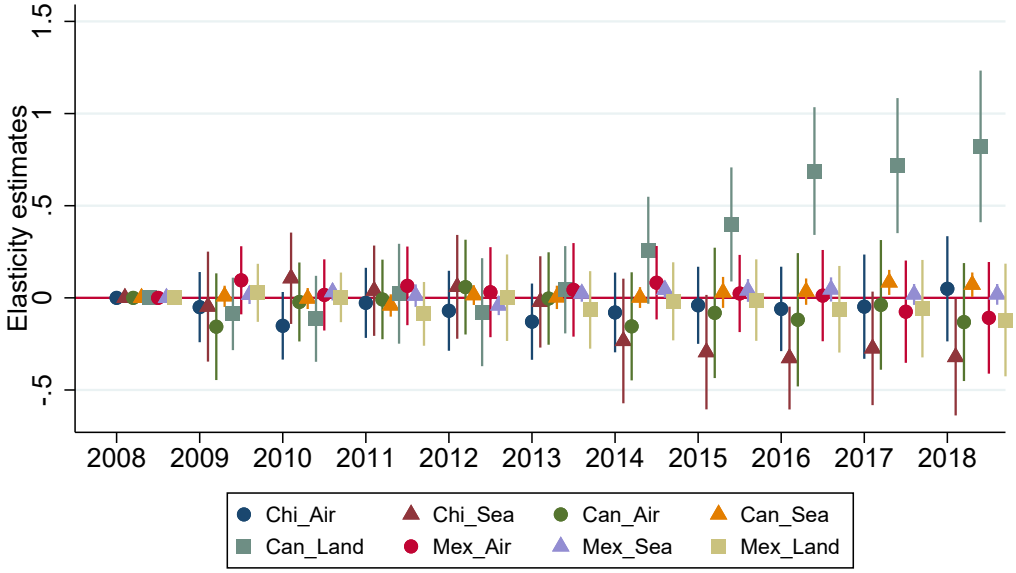
Notes: Dependent variable is ln fentanyl deaths. Regression controls for ln real GDP, ln population, ln exports, ln border crossings, unemployment rate, LF participation rate, PDMP, ln legal fentanyl, the percent of the population that is non-Hispanic white, non-Hispani black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated, state FE, year FE, and non-triplicate states*year FE. Sample includes 50 states and 2008-2018. Robust standard errors clustered at the state-level.

Figure 12
Impact of Imports by Country on Fentanyl Overdoses



Notes: Dependent variable is ln fentanyl deaths. Agricultural (naics 1) and manufactured (naics 3) imports. Regression controls for ln real GDP, ln population, ln unemployment rate, ln exports, ln border crossings, PDMP, ln legal fentanyl, the percent of the population that is non-Hispanic white, non-Hispanic black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated, state FE, year FE, and non-triplicate states*year FE. Sample includes 50 states and 2008-2018. Robust standard errors clustered at the state-level.

Figure 13
Impact of Imports by Country and Mode on Fentanyl Overdoses



Notes: Dependent variable is ln fentanyl deaths. Agricultural (naics 1) and manufactured (naics 3) imports. Regression controls for ln real GDP, ln population, ln unemployment rate, ln exports, ln border crossings, PDMP, ln legal fentanyl, the percent of the population that is non-Hispanic white, non-Hispanic black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated, state FE, year FE, and non-triplicate states*year FE. Sample includes 50 states and 2008-2018. Robust standard errors clustered at the state-level.

TABLE 1
Machine Learning (Lasso) Results
Agr. and Manuf. Imports by Country/Region, Mode, and Year

	ln Fentanyl Overdoses
Selected Variables	
Canadian Agr & Man Imports via:	
Sea 2017	0.047
Land 2013	-0.129
Land 2016	0.197
Land 2017	0.146
Partialled-out Variables	
ln GDP, ln pop, ln exports, ln border crossings, LF participation rate, unemployment rate, PDMP, ln legal fentanyl, % non-Hispanic white, % non-Hispanic black, % Hispanic, % ages 25-44, ages 45-64, ages 65+, % college degree, state FE, year FE, and non-triplicate*year FE	

Post-estimation OLS estimates reported. Lasso selects the import variables that are best at predicting fentanyl overdose deaths. The 198 possible import variables included in the analysis are agricultural and manufacturing imports by country/region [China, Canada, Mexico, Africa, Australia/Oceania, Europe, South and Central America, and Asia (not including China)], by mode of transport [air, sea, and land], and by year [2008-2018]. Lasso does not select among the "partialled-out" variables, which are always included. The penalization tuning parameter $\lambda = 61$.

TABLE 2
Machine Learning (Lasso) Results
Canadian Imports by 3-digit NAICS Agr. and Manuf. Industry

	ln Fentanyl Overdoses
Selected Variables	
Canadian Imports of	
Chemical Manuf (325) via Sea 2017	0.027
Plastics & Rubber Manuf (326) via Land 2013	-0.087
Plastics & Rubber Manuf (326) via Land 2017	0.245
Plastics & Rubber Manuf (326) via Land 2018	0.368
Nonmetallic Mineral Manuf (327) via Land 2016	0.156
Fabricated Metal Manuf (332) via Land 2016	0.191
Fabricated Metal Manuf (332) via Land 2017	0.060
Partialled-out Variables	
ln GDP, ln pop, ln exports, ln border crossings, LF participation rate, unemployment rate, PDMP, ln legal fentanyl, % non-Hispanic white, % non-Hispanic black, % Hispanic, % ages 25-44, ages 45-64, ages 65+, % college degree, state FE, year FE, and non-triplicate*year FE	

Post-estimation OLS estimates reported. Lasso selects the import variables that are best at predicting fentanyl overdose deaths. The 990 possible import variables included in the analysis are agricultural and manufacturing imports by country/region [China, Mexico, Africa, Australia/Oceania, Europe, South and Central America, and Asia (not including China)], by mode of transport [air, sea, and land], and by year [2008-2018], as well as Canadian imports by mode, year, and 3-digit NAICS agricultural and manufacturing industry. Lasso does not select among the "partialled-out" variables, which are always included. The penalization tuning parameter $\lambda = 61$.

9 Online Appendix

TABLE A1
Summary Statistics

	Obs	Mean	Std. Dev.	Min	Max
ln (Opioid Overdoses)	550	5.8	1.2	2.1	8.4
ln (Fentanyl Overdoses)	550	4.2	1.4	0.7	8.2
ln (Imports)	550	23.6	1.4	20.2	26.8
ln (GDP)	550	12.2	1.0	10.2	14.8
LF Participation Rate	550	64.5	4.2	52.8	74.4
Unempl Rate	550	6.2	2.2	2.4	13.7
ln (Exports)	550	23.3	1.3	20.1	26.5
PDMP	550	0.7	0.4	0.0	1.0
ln (Legal Fentanyl)	550	8.6	1.0	6.2	10.9
ln (Border Crossings)	550	4.3	7.0	0.0	18.5
ln (Population)	550	15.2	1.0	13.2	17.5
% Non-Hisp White	550	70.4	15.4	21.8	94.8
% Non-Hisp Black	550	10.3	9.4	0.4	37.4
% Hispanic	550	11.2	10.1	1.2	49.1
% Aged 25-44	550	25.9	1.4	22.7	29.4
% Aged 45-64	550	26.5	1.8	19.7	31.2
% Aged 65+	550	14.5	2.1	7.3	20.6
% College Degree	550	29.0	5.1	17.1	44.5

Figure A2
Fentanyl Deaths versus Imports



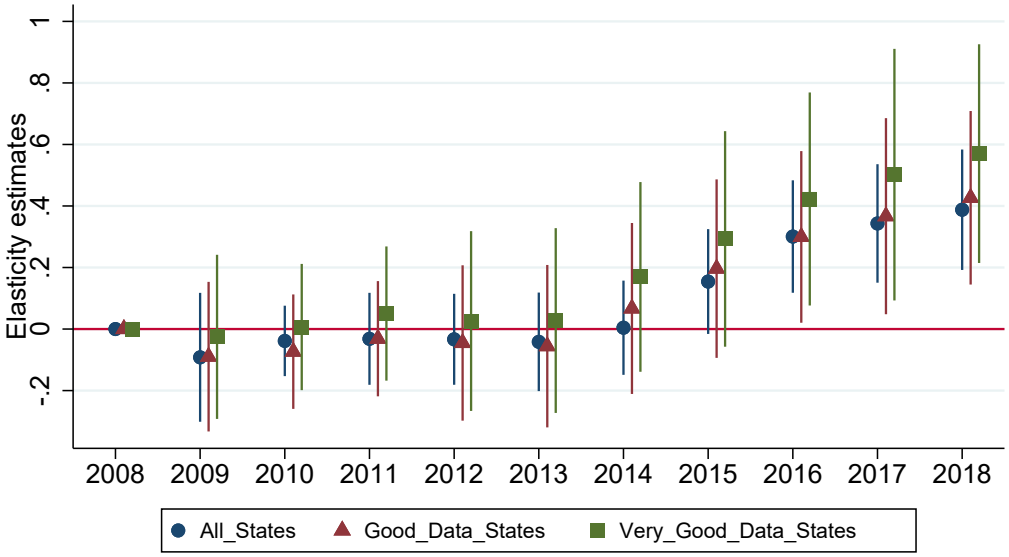
Notes: Sample includes 50 states and the years 2008 and 2018.

TABLE A3
Opioid Overdose Deaths by Type

	ln Opioids OD	ln Fentanyl OD	ln Oxycodone OD	ln Heroin OD	ln Methadone OD
	(1)	(2)	(3)	(4)	(5)
ln Imports	-0.133	0.009	-0.130	0.044	-0.110
	[0.118]	[0.216]	[0.111]	[0.240]	[0.137]
ln Imports * Year 2009	-0.077	-0.092	-0.070	-0.008	-0.080
	[0.084]	[0.104]	[0.108]	[0.095]	[0.082]
ln Imports * Year 2010	-0.026	-0.039	0.027	0.105	-0.024
	[0.036]	[0.057]	[0.039]	[0.090]	[0.049]
ln Imports * Year 2011	-0.012	-0.032	0.041	0.059	-0.049
	[0.049]	[0.074]	[0.052]	[0.082]	[0.060]
ln Imports * Year 2012	0.023	-0.033	0.028	0.099	0.018
	[0.050]	[0.074]	[0.043]	[0.087]	[0.073]
ln Imports * Year 2013	-0.004	-0.042	-0.048	0.148	0.055
	[0.046]	[0.080]	[0.042]	[0.093]	[0.053]
ln Imports * Year 2014	0.007	0.004	-0.003	0.071	-0.078
	[0.044]	[0.076]	[0.042]	[0.107]	[0.063]
ln Imports * Year 2015	0.057	0.154*	0.006	0.065	-0.069
	[0.049]	[0.085]	[0.056]	[0.106]	[0.068]
ln Imports * Year 2016	0.090*	0.301***	0.017	-0.019	-0.066
	[0.053]	[0.091]	[0.049]	[0.106]	[0.061]
ln Imports * Year 2017	0.139**	0.343***	-0.001	-0.031	-0.052
	[0.059]	[0.096]	[0.050]	[0.121]	[0.076]
ln Imports * Year 2018	0.143**	0.388***	-0.038	-0.123	-0.095
	[0.063]	[0.097]	[0.063]	[0.135]	[0.067]
ln GDP	-0.350	0.425	-0.505	-1.910	1.552**
	[0.665]	[1.456]	[0.514]	[1.548]	[0.690]
LF Participation Rate	0.018	0.050	-0.032	-0.056	0.009
	[0.027]	[0.047]	[0.024]	[0.048]	[0.028]
Unemployment Rate	0.063*	0.055	0.022	0.038	0.041
	[0.031]	[0.052]	[0.029]	[0.060]	[0.028]
ln Exports	0.175	0.033	0.443**	-0.196	0.149
	[0.179]	[0.260]	[0.184]	[0.319]	[0.296]
PDMP	-0.103	-0.053	-0.118*	-0.358**	-0.138*
	[0.074]	[0.149]	[0.064]	[0.169]	[0.076]
ln Legal Fentanyl	-0.084	-0.258	0.075	0.263	0.059
	[0.139]	[0.316]	[0.081]	[0.249]	[0.086]
ln Border Crossings	-1.043**	-1.328*	-0.882***	-0.518	-0.528
	[0.405]	[0.662]	[0.266]	[0.397]	[0.352]
ln Population	-3.464**	-11.191***	-0.565	9.134***	-2.195
	[1.558]	[2.519]	[1.413]	[2.691]	[1.793]
% Non-Hisp White	0.032	0.121	0.118	0.415***	0.001
	[0.115]	[0.184]	[0.073]	[0.149]	[0.080]
% Non-Hisp Black	0.045	0.363	0.018	0.337	0.002
	[0.247]	[0.380]	[0.189]	[0.286]	[0.206]
% Hispanic	0.125	0.599***	0.141	0.075	0.185
	[0.140]	[0.205]	[0.112]	[0.171]	[0.121]
% Aged 25-44	-0.029	-0.095	-0.019	-0.001	-0.027
	[0.118]	[0.207]	[0.124]	[0.223]	[0.147]
% Aged 45-64	0.196*	0.200	0.177*	0.359	0.147
	[0.115]	[0.212]	[0.094]	[0.246]	[0.124]
% Aged 65+	0.028	0.307	-0.292***	-0.285	-0.017
	[0.115]	[0.189]	[0.089]	[0.202]	[0.122]
% College Degree	0.049	0.083	0.065	-0.031	-0.019
	[0.047]	[0.078]	[0.039]	[0.058]	[0.060]
State FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Triplicate * Year FE	Yes	Yes	Yes	Yes	Yes
Observations	550	550	550	550	550
R-squared	0.966	0.930	0.952	0.935	0.938

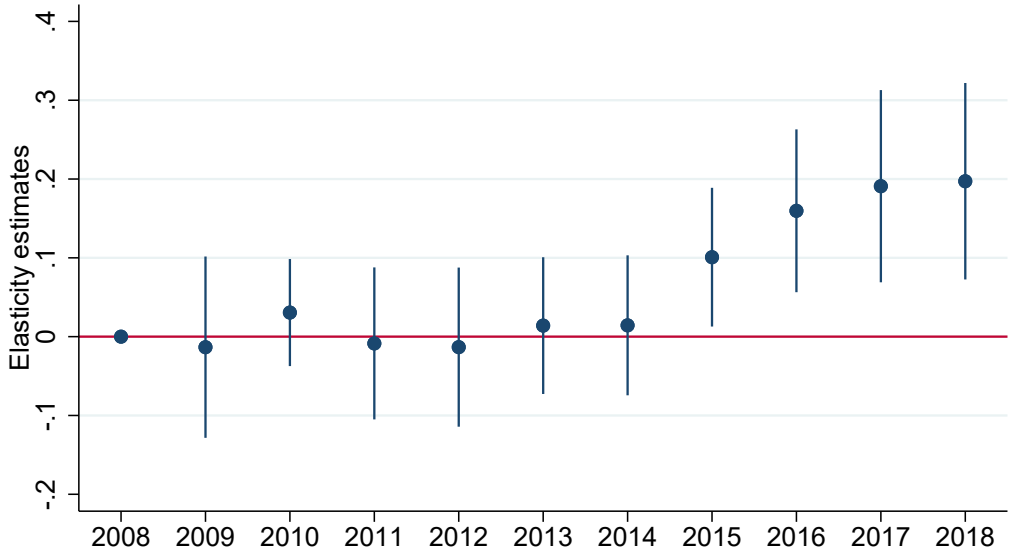
Robust standard errors clustered at the state level in brackets. ***p<0.01, ** p<0.05, * p<0.1.

Figure A4
Imports and Fentanyl Overdoses using Alternate Samples



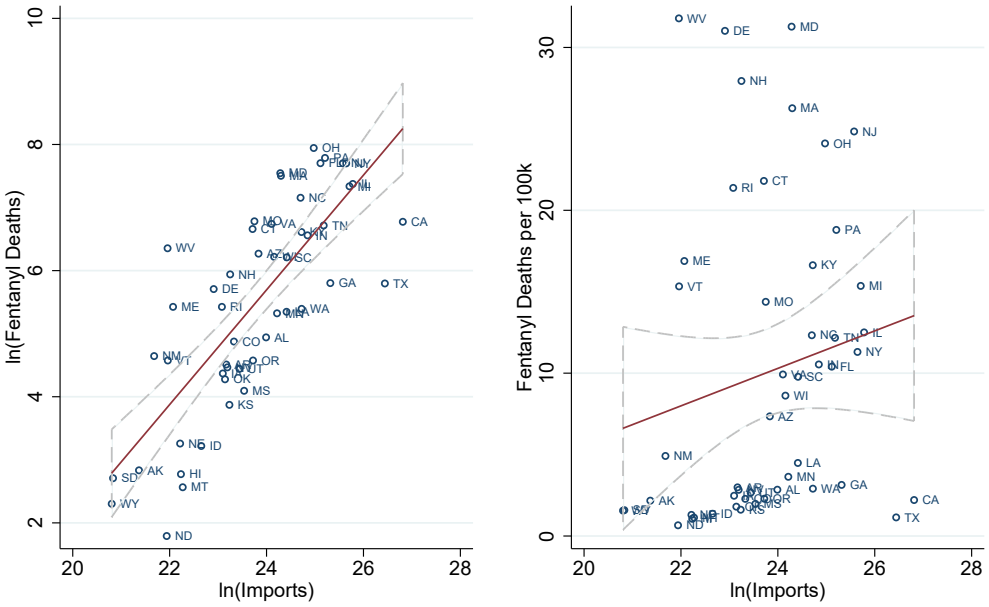
Notes: Dependent variable is ln deaths by each cause. Regressions control for ln real GDP, ln population, ln exports, ln border crossing unemployment rate, LF participation rate, PDMP, ln legal fentanyl, the percent of the population that is non-Hispanic white, non-Hispani black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated, state FE, year FE, and non-triplicate states*year FE. Sample includes 50 states, 34 states with at least Good mortality data, and 26 states with at least Very Good mortality data, over the years 2008-2018. Robust standard errors clustered at the state-level.

Figure A5
Impact of Import Weight on Fentanyl Overdoses



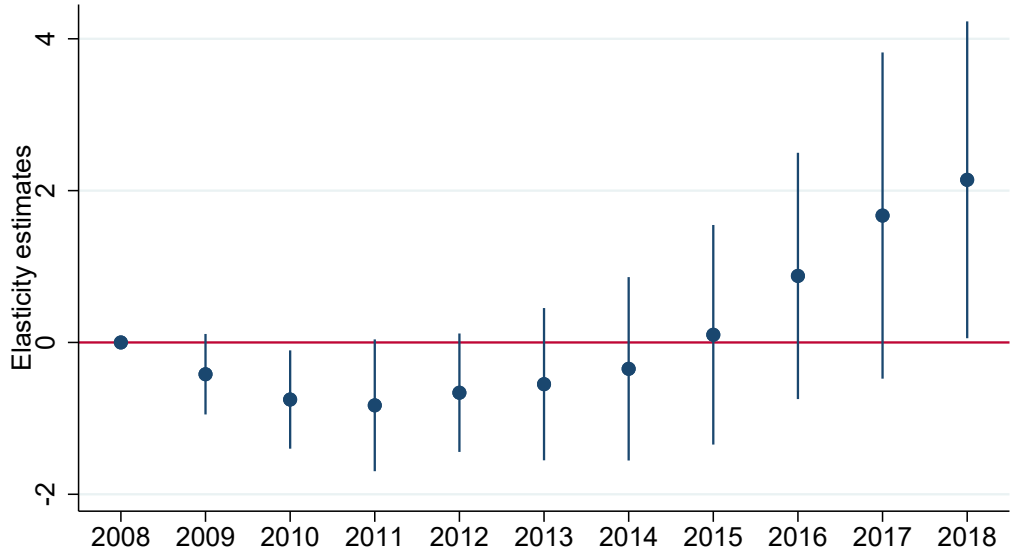
Notes: Dependent variable is ln fentanyl deaths. Trade flows measured using their weight (kg) rather than their value. Regression controls for ln real GDP, ln population, ln exports, ln border crossings, unemployment rate, LF participation rate, PDMP, ln legal fentanyl, the percent of the population that is non-Hispanic white, non-Hispanic black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated, state FE, year FE, and non-triplicate states*year FE. Sample includes 50 states and 2008-2018. Robust standard errors clustered at the state-level.

Figure A6
Fentanyl Deaths versus Imports



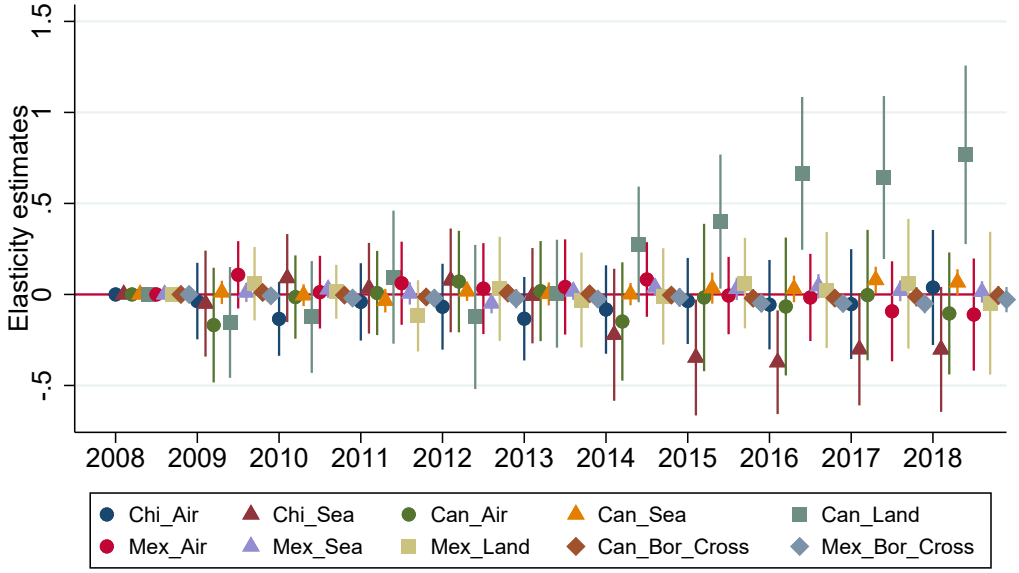
Notes: Sample includes 50 states and 2018.

Figure A7
Impact of Imports on Fentanyl Overdoses per 100k



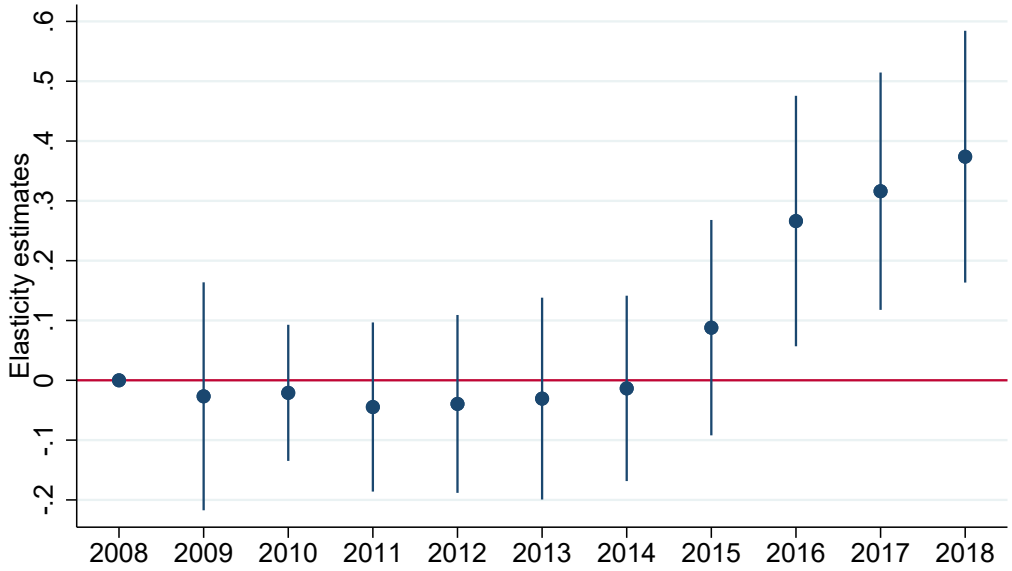
Notes: Dependent variable is fentanyl deaths per 100k people. Regression controls for ln real GDP, ln population, ln exports, ln border crossings, unemployment rate, LF participation rate, PDMP, ln legal fentanyl, the percent of the population that is non-Hispani white, non-Hispanic black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated, state FE, year FE, and non-triplicate states*year FE. Sample includes 50 states and 2008-2018. Robust standard errors clustered at the state-level. Regressions weighted by 2008 state population.

Figure A8
Impact of Imports and Border Crossings on Fentanyl Overdoses



Notes: Dependent variable is ln fentanyl deaths. Agricultural (naics 1) and manufactured (naics 3) imports. Regression controls for ln real GDP, ln population, ln unemployment rate, ln exports, ln border crossings, PDMP, ln legal fentanyl, the percent of the popula that is non-Hispanic white, non-Hispanic black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated, state FE, year FE, and non-triplicate states*year FE. Sample includes 50 states and 2008-2018. Robust standard errors clustered at the state-level.

Figure A9
Impact of Imports on Only Fentanyl Overdoses



Notes: Dependent variable is ln fentanyl deaths. Regression controls for ln real GDP, ln population, ln exports, ln border crossings, unemployment rate, LF participation rate, PDMP, ln legal fentanyl, the percent of the population that is non-Hispanic white, non-Hispani black, Hispanic, aged 25-44, aged 45-64, aged 65+, and college educated, state FE, year FE, and non-triplicate states*year FE. Sample includes 50 states and 2008-2018. Robust standard errors clustered at the state-level.