Environmental Regulation at What Cost? The Case of Drayage Trucking in the Port of Los Angeles

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Abstract

This paper evaluates the local emissions reductions from the Clean Air Action Plan implemented at the Port of Los Angeles. By breaking down the air quality improvements in the drayage sector into productivity gains by truckers and engine emissions ratings by year of manufacture, I seek to describe the relative contribution of each of these mechanisms to pollution abatement at the ports. I will then turn to welfare and distributional impacts of the regulation. First, I will establish the local health benefits versus the cost borne by players in the industry to determine overall welfare effects. Then I will ask did regulation create, eliminate, or have no effect on market share of firms in the drayage industry?

Introduction

The San Pedro Bay ports are the largest single source of air pollution in Southern California, generating about 10% of the region's smog-forming emissions, according to the South Coast Air Quality Management District. Sources of this 10% include docked ships, diesel powered cranes and trucks involved in the transport of cargo onshore. In 2015, when the Los Angeles and Long Beach ports were closed due to a labor strike, NOX emissions in the South Coast basin decreased 10% (51 tons of 506 tons total) (Los Angeles Times, 2015). Leading up to the date of the strike, observers worried about increased emissions from idling diesel container ships off the coast. However, air quality monitoring stations in the Port of Los Angeles and neighboring Wilmington and San Pedro measured pollution levels similar to or lower than they were at the same time in 2014. This drop was attributed primarily to a decrease in truck traffic to and from the ports.

The Los Angeles/Long Beach ports have taken the most aggressive approach to reduce diesel emissions and other pollutants in drayage trucking – the hauling of containerized cargo from ports to distribution centers, railyards or wherever else a container begins the next leg of its journey. The Clear Air Action Plan, first implemented in 2008, barred any truck with an engine manufacture year earlier than 1994 from entering the gates. This standard was ratcheted up over time so that now all drayage trucks entering the gates have an engine manufactured in 2007 or later (Port of Los Angeles, 2007). California state regulators and port stakeholders point to a more than 80% reduction in emissions due to this local regulation. NOx, a contributor to ozone, has also shown to cause adverse health effects including respiratory irritation, suppression of the immune system, and asthma exacerbation (Port of Los Angeles, 2017).

I am interested in how this regulation, compared to overall productivity gains in the industry at large like decreased idling for fuel efficiency purposes, contributed to the overall decline in NOX and diesel particulate matter emissions at Los Angeles-Long Beach port. Using data collected at individual ports in Oakland, Tacoma, Newark, Houston, Boston, New Orleans, Miami and Los Angeles, I will use a synthetic control approach with NOX emissions as the dependent variable.

Over the sample period, the drayage industry has recognized the need for more efficient coordination as they represent a bottleneck in the supply chain that companies looking to import goods cannot avoid. I am interested in how much of this reduction can be directly attributed to the regulation requiring truck engines be manufactured after a certain year and how much of this can be attributed to better technology being used in the ports to coordinate productivity (and emissions reduction) gains.

I will then turn to considerations of welfare gains and distributional effects by constructing a partial equilibrium model of the drayage sector. I would like to first discuss the benefits, like a decrease in lung and cardiovascular disease versus the costs borne on different segments of the industry. Then I will turn to developing a partial equilibrium model of employment effects due to the regulation in terms of costs borne on workers in the industry, who are in most cases also residents of the area.

Background and Industry Setting

EPA's decades-long effort to reduce criteria pollutants, air toxics and other harmful emissions from diesel fuel used in transportation have resulted in significant health and environmental benefits while advancing technology, and minimizing cost. These benefits come from both rulemaking standards like the Diesel Standards implemented in 1993 when EPA began regulating sulfur content in diesel fuel and from voluntary programs (Environmental Protection Agency, 2017). Greenhouse gas emissions regulations cover most segments of onroad vehicles with regulatory burden differentiating light-duty (passenger vehicles and motorcycles) and heavy duty (commercial trucks and buses) vehicles. These regulations nation-wide have exempted a few sectors, a prominent one being the drayage truck industry.

In addition to cancer risk, port-related air pollution contributes to other acute and chronic health effects. About 15% of children in Long Beach suffer from asthma compared to 9% of children in the United States. The City of Long Beach Community Health Assessment 2013 further reflects the health burden on communities surrounding the Ports. According to the assessment, in 2011, about 55,000 Long Beach residents suffered from asthma. In 2007, about 1,200 hospitalizations in Long Beach were due to asthma and Chronic Obstructive Pulmonary Disease (COPD), which is also linked to poor air quality. Asthma hospitalization rates are greater in West Long Beach near the Ports and the 710 freeway than in East Long Beach. The average cost of an asthma-related hospitalization in 2010 according to the California Public Health Department was $33,749 (Port of Los Angeles, 2017).

According to the Environmental Defense Fund freight shipment creates 10% of all US greenhouse gas emissions and is among the fastest growing sectors of all major polluting industries (Environmental Protection Agency, 2017). As the air quality in major cities improves, environmental groups, community activists, and other stakeholders have pointed to the poor pollution standards around major shipping ports across the country as evidence that certain communities are missing the benefits of emissions standards implemented at the federal level.

Diesel emissions from idling trucks are a serious health concern for communities adjacent to seaports, especially deepwater ports. The Ports of Oakland [regulation promulgated through CARB], Tacoma and Newark have committed to some form of "Cleaner Trucks" initiative in order to improve air quality from idling drayage trucks in what is recognized by industry participants as a bottleneck in the goods transportation system. The study of drayage is relatively new. As the growth of globalized trade has dramatically increased imports and exports shipped in marine containers, more attention has been paid to this "low man on the totem pole" of the overall containerized shipping supply chain.

International shipments, measured in Twenty-Foot Equivalent Units or TEUs, have been consistently increasing with the exception of FY 2009 due to global recession. Cargo shipments in and out of the United States, following the global trend, have been increasing since 2010 as demonstrated by Figure 1.

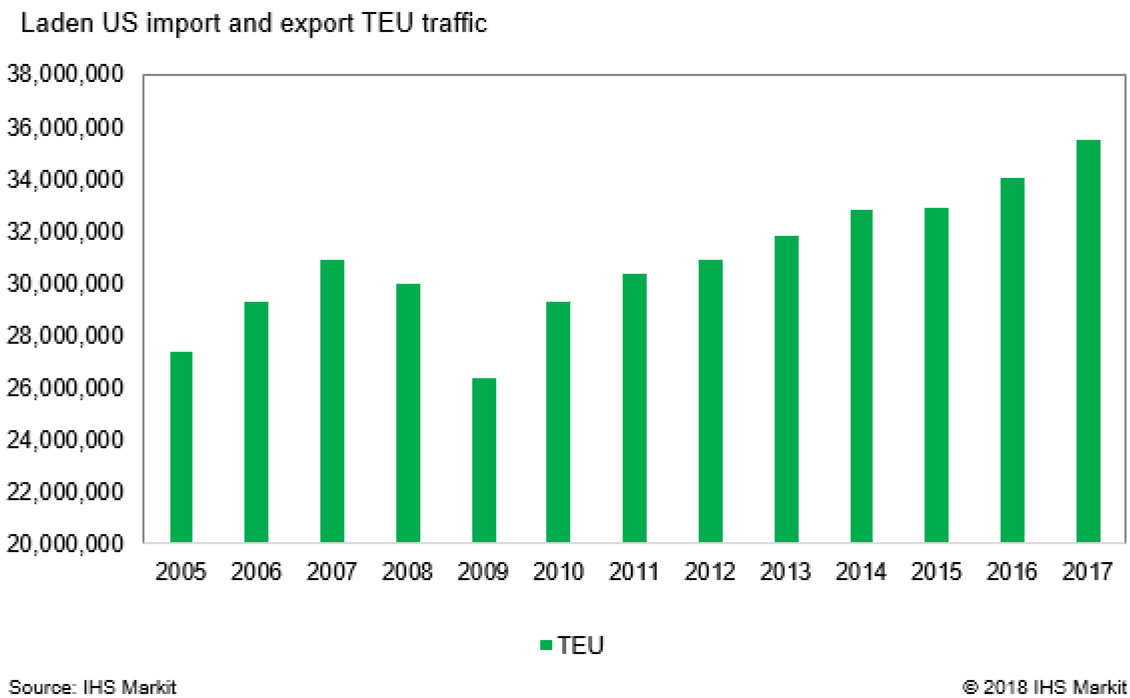

Figure 1. Total TEUs United States Internationl Ports, Source: IHS

The port complex at Los Angeles and Long Beach handles approximately 30% of the goods entering the United States annually. In 2014, the Port of Los Angeles/Long Beach was the leading seaport nationwide in terms of container volume and cargo value, facilitating $290 billion in trade. According to port officials, operations and commerce at the port facilitate more than 148,000 jobs (about one in 12) in the City of Los Angeles Port of Los Angeles (2017).

The growing container traffic observed nationwide increased airborne emissions dramatically near ports with many residents in adjacent communities reporting increased incidence of asthma in children. Classified as Very High Density by the Census Bureau, East Long Beach with 9,191.3 people per square mile in 2018, is one of the most densely populated areas in the United States Census, ERIS (2017). Much of the increased pressure the ports received related to air quality concerns was directly from stakeholders in the community through written comments, letters and other communication with CARB and other state regulators. Diesel emissions throughout the

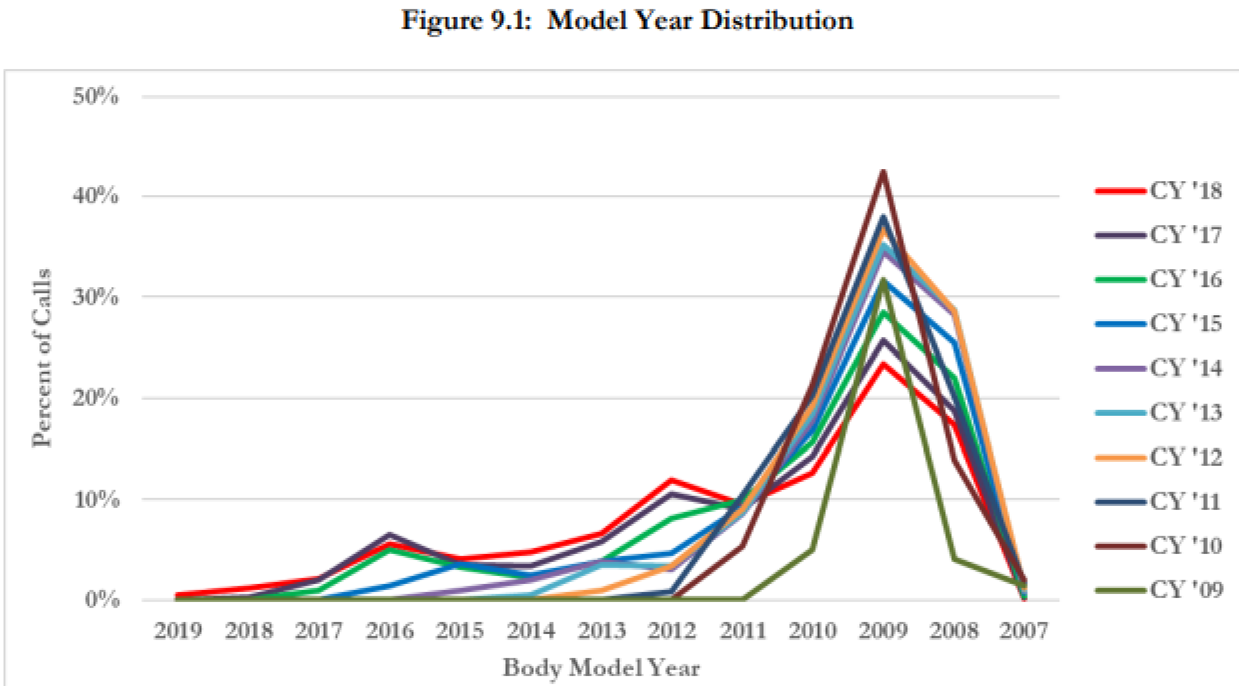

FIGURE 2. Engine Model-year of Manufacture Distributions from Port of Los Angeles

shipping process contribute to increased air pollution however the movement of trucks out of the ports to distribution centers is one of the most localized and visible sources of pollution.

The ports regulatory authority, banning trucks with engines manufactured before 2007, had immediate effect of changing the composition of the drayage truck fleet. Figure 2 presents how the engine year make has evolved over time. There is a strong peak of engines manufactured in 2009 that steadily decreases over the years as newer trucks enter the overall fleet. According to the ports, the 2007 cut-off was chosen due to a large decrease in cost of pollution abatement technologies in engines of manufacture year 2007 and later, making near zero emission trucks more affordable for owner operators to purchase.

While the expense may have been lower than had CAAP been implemented a few years earlier, this regulation was still costly. Unit costs for trucks in the range of $130,000 to $165,000. And given the owner operator structure of the industry, costs were expected to fall on operators and/or small coordination drayage companies. The Los Angeles Port, used 16807 unique diesel trucks in cost estimates for evaluating the viability of CAAP (Port of Los Angeles, 2007). Assuming the midrange of these estimates, the total cost of the upgrade to drayage trucks alone is about $2.5 billion USD. With the drayage sector being a competitive industry with thin profit margins, it is unclear if all firms, with differing levels of productivity, are able to absorb such a large cost increase.

The typical trucking company specializing in port drayage relies heavily on owner-operators as sub-haulers, operating under contract with the drayage company providing dispatching, management, and commercial functions. Some firms also have company (employee) drivers.

Drayage companies can be a single-owner operator but most of the business is done by small firms with 10 to 100 drivers. Important to note is that drayage is done solely by trucks equipped to transport containerized cargo. Specifically, drayage refers to short distance movements as part of the supply chain process. In drayage, departure and arrival points are typically part of the same metropolitan area, as opposed to the regional or national movements seen in other forms of shipping.

LA/LB ports have adopted more strict regulations compared to the California ARB which has mandated its own version of a Clean Trucks program which in 2010 prohibited trucks with engines manufactured prior to 1993 from entering any port in the state. Starting in 2014 any truck manufactured between 1994 and 2004 must have an ARB-approved soot trap installed in order to enter the gates at any port. This regulation, while onerous does not place nearly the regulatory burden on drayage companies as the CAAP in Los Angeles. According to the ARB, certified soot traps are expected to cost in the range of $12,000 to $25,000 (Port of Los Angeles, 2017).

Data Summary

There is no national data repository of drayage activity so I will be relying on data collected at the ports. The ports keep their own data repositories for what is known as Gate Move Analysis. Trucks each have a sticker indicating which company they are operating with, driver, and some specifications like engine manufacture year. Most ports also compile estimates of NOX emissions of in-port and on-road contributions of trucks involved.

The Los Angeles and Long Beach ports have the most comprehensive data collected on all levels of air quality and emissions related to port activity. Much of this is legally mandated by CARB and also in practice at Oakland's port other parts are unique. This may become an issue when constructing a weighted average of pre-period control ports as LA/LB is capturing more of the variation in the actual state of the world than some ports on the Gulf for example may be able to capture.

Price data comes from a Craigslist-like website called the Drayage Directory. All prices are readily viewable by all participants in the industry and any other interested party. They also collect and display data on clicks on each firm and ad listed on the site as a proxy for demand of a particular service. Firms can pay $600 per year to be placed near the top of the list in their city. The service is free to use for anyone and is sorted by date for shippers to find drayage workers on short notice (Drayage Directory, 2019).

Synthetic Control

Of the comments received from owners of larger firms in the drayage industry – many of the themes circled around zero-emissions regulations vs near-zero emissions regulations. They argue that the benefits from either approach are similar but the cost for near-zero is much less. They argue that emissions reductions are achievable through productivity advancements, for example through better coordination in the face of increased congestion at ports across USA. The policy setting of the passage of CAAP at Los Angeles-Long Beach provides a way to test that theory. Using synthetic control I will seek to understand what productivity gains - pursued at large ports as part of the competitive cost minimizing drayage sector – contributes to lower emissions versus command and control legislation like CAAP.

To estimate the effects of a policy intervention, social scientists often use comparative case studies. In the face of difficulties arising when comparing an outcome of interest between units affected by some policy change to units unaffected by the shift, researchers have introduced data-driven procedures to reduce discretion in the choice of comparison units. Synthetic control, which uses a combination of units, provides a better comparison for the unit exposed to the intervention than any single unit alone (Abadie et al., 2010).

Individual ports can reduce emissions through regulations placed on use of capital machinery, like prohibiting idling cranes and trucks, or through productivity gains moving containers faster through the ports. Since emissions reductions at the ports are often considered in terms of the total TEUs handled, productivity gains by streamlining the supply chain through the drayage system will contribute to emissions reductions. To disentangle the productivity gains across the industry over time from the effect of the command and control regulation imposed by LA/LB port, I will apply synthetic control methods.

I will use annual port-level panel data of NOX emissions per TEU, or emissions efficiency, for the period of 2000 to 2018. CAAP first went into effect in 2008 giving me 8 years of preintervention data. While other ports passed legislation regulating diesel particulate matter and other emissions that contribute to VOC's, none took as large a step as banning trucks of a certain vintage from entering the gates of the port as did LA/LB. Synthetic LA/LB will be a weighted average of potential control ports, with weights chosen so that the resulting synthetic LA/LB best reproduces the set of chosen predictors of ports in terms of emissions.

I observe emissions data for J + 1 ports. LA/LB port is the only port in the sample which faces this regulation placed on manufactured year of truck engine, so J ports remain as controls. There

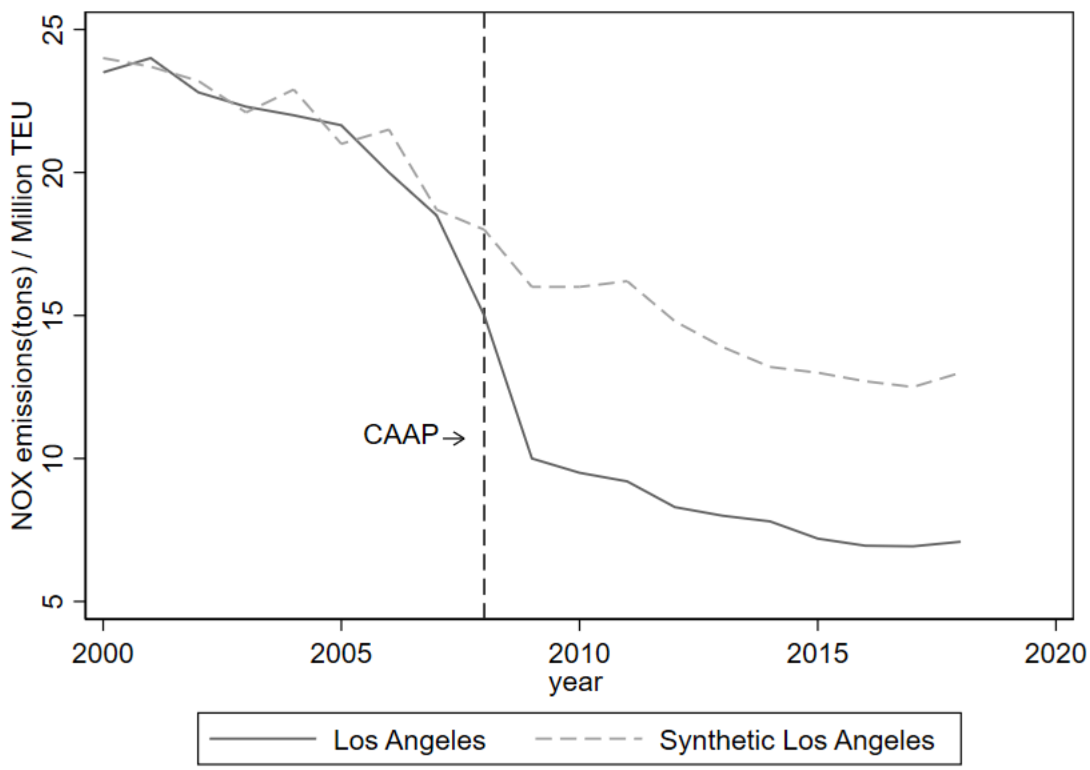

Figure 3

are T time periods with t = 1,. . . ,T in which t_1 = 2008 is the first year where LA/LB bars trucks with engines manufactured before 2007 from entering the port. Following Abadie et al. 2015, I assume the policy has no effect on the outcome before t_1 for all T=1,. . . ,t_1 and all j of 1,. . . ,N. In practice, firms anticipating incoming regulation may adopt the stringency targets before the date of implementation. Later I will demonstrate that this was likely a response on the part of some firms however there is a large discontinuity at t_1 for engine manufacture year where 2007 spikes.

To construct a control group, I will set up a weighted average of other major ports in the United states that mirrors LA/LB port in the pre-period. These include San Francisco/Oakland, Seattle/Tacoma, Newark/NYC, Houston, Boston, New Orleans, Charleston, and Miami. To choose these sets of ports I focus on three key dimensions: TEUs handled by the port, model year distribution of the heavy-duty truck fleet, and average number of trucks in each drayage company's fleet. This last dimension is important as I would like to create a control group that best matches to the competitive nature of the drayage industry at the LA/LB ports, where no one company or group of companies sets the going rate. TEUs handled is a best measurement of port capacity, in terms of containers moved.

Figure 3 plots observed data for emissions efficiency of Los Angeles/Long Beach port and a "Synthetic Los Angeles". I don't have data for other ports emissions yet so the Synthetic line is using made up data to demonstrate graphically the synthetic control approach. The similar pre-CAAP trend of a weighted average of other ports will be determined by the port specific dimensions I mention earlier. I will also present a table showing the weight of each contribution of the other ports that make up Synthetic Los Angeles.

Welfare and Distributional Effects of CAAP

I will next turn to focus on the benefits versus observed initial cost of CAAP. The local benefits of decreased air pollution have been estimated by CARB to be in the order of $7.5 billion while cost estimated by Los Angeles-Long Beach port is estimated at $2.5 billion.

According to CARB, emissions reductions primarily attributable to CAAP are in Port DPM emissions and NOx emissions with some co-benefits of reduced CO2 emissions in the face of rising TEUs going through LA/LB port.

A typical listing on Drayage Directory, used by shipping companies to contract out orders, contains the origin point (either the exact port location or inland distribution centre), the type of cargo a truck can take, the destination, price offered for services, and contact information for the drayage company. For the period I was able to retrieve 4000 postings were listed for Oakland's port and 4508 were posted for LA/Long Beach.

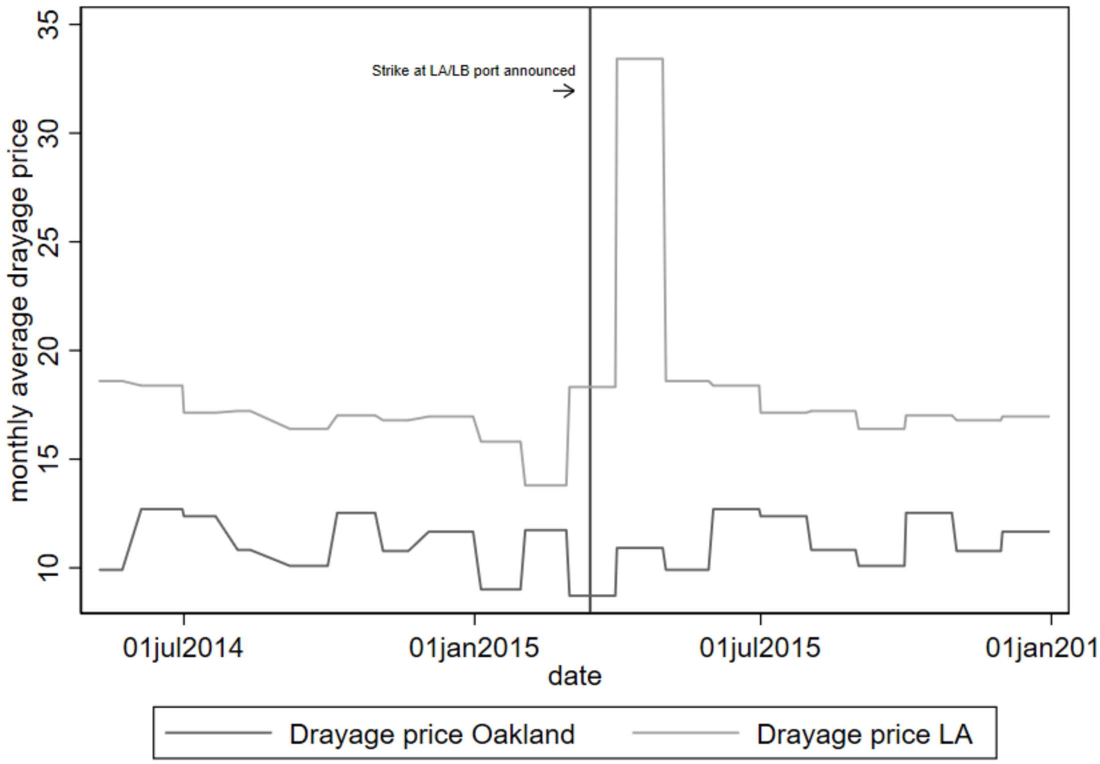

FIGURE 4

I scraped the websites for recent data from LA/LB port and Oakland port. For the top ten destinations, I searched the fastest driving route assuming regular mid-day traffic from each port using Google Maps to get an estimate for vehicle miles travelled following the city listed by the individual drayage firms. The mean distance a drayage truck travelled from 2014 to November 2019 from LB/LA is 44.5 miles (N=1845) while at Oakland the mean distance is 73.25 (N=2336). Ideally, I would like to have data back to before 2009 to demonstrate the price increase observed over time between these two ports. Using the Wayback Machine I was unable to retrieve the same data I present below.

Looking at price paths over the two ports in Figure 4, there is indeed a premium charged to ship a container through LA/LB compared to Oakland as can be seen in the graph of monthly average drayage prices over the sample period. With the exception of a large price spike when port workers called a strike in March 2015, the two series follow a similar trend with LA/LB prices consistently above those at Oakland.

A Partial Equilibrium Model

In a simple partial equilibrium model, a pollution tax will increase the total cost of production thus raise the output price by an amount that depends on the pollution intensity of production (Fullerton and Muehlegger, 2019). This regulation, while not being a direct tax on the magnitude of emissions involved in production, can be considered a tax on the transport of goods to market. Under perfect competition the economic incidence of the tax depends on the relative demand and supply elasticities for the good, where the more inelastic side of the market bears a greater share of the burden of the policy. Here the 'good' in question is a container, the supply of which is coming from a logistics company abroad and received by a company. The consumer in this case is the end receiver of the container and the producer is the shipping company.

Tracing the price path of freight rate through shipping market models, researchers have found that price processes generated by an equilibrium model with fairly standard supply and demand relations prove to be very close to popular mean reverting stochastic price processes that are used in the finance or real option literature. It is argued that rigidities in either the construction of new tonnage or yard capacity significantly contribute to the mean reverting property of freight rates (Tvedt, 2003).

Considering the changes in elasticities due to the regulation along the supply chain requires taking into consideration the possible substitutes to the taxable input to production. At the ports, some containers can be transported by rail however the current capacity of railyards in California's ports is dwarfed by the growing amount of total container shipments received. In 2008 at the Los Angeles/Long Beach port, there were about 4000 trains in-bound and out-bound during the year, compared to the 1900 trucks in an average month.

As demand increases train drayage could become more important, especially as prices for truck drayage increase. However, the two lines that run out of LA/LB owned by BNSF and UP, are often run at capacity and take a route that is much more circuitous than the Alameda Corridor trucks take, reflected in the price per container. Researchers have also demonstrated the market power the two firms exert also contributes to the price premium seen in rail shipping (Cicala, 2015). Thus, the regulatory burden is falling on a part of the supply chain that is relatively inelastic compared to other nodes of the supply chain where at a certain cost, intermodal transport becomes competitive.

Furthermore, in March 2008 EPA adopted its final regulation – "Control of Emissions of Air Pollution from Locomotive and Marine Compression Ignited Engines Less than 30 Liters per Cylinder". When fully implemented, this rule will cut PM emissions from these engines by as much as 90% and NOx emissions by as much as 80% (Environmental Protection Agency, 2017). This regulation, affecting all trains across the country, increases the relative price of drayage by train as the costs of the regulation cannot be spread over long hauls as drayage trips at most consist of 200 miles. Following this rigidity in substitution ability vis-a-vis shipping method, I will focus on the impact of regulation on the specific factors of the drayage sector.

In order to provide more structure to the partial equilibrium model, I will consider some empirical observations in relation to factor mobility. In the long run model, economists have analyzed both the price impacts and the factor returns after all adjustments have taken place. As one input becomes more expensive, the others, labor and capital, will readjust to reflect the increased production cost. Perfect sectoral mobility implies that any laid off workers easier find work in a different industry at the equilibrium wage in the industry. At the other end, factor immobility means that either capital or labor absorbs the extra cost reducing wages for labor or the asset value for capital.

Workers in the drayage industry are mostly male (up to 96%) and in Southern California up to 90% of the workers in the industry are Latino (Chernova, 2018). They are a relatively low educated pool of workers and low paid. The skills required to drive a drayage truck, while being somewhat industry-specific are not entirely are not industry-specific skills that are totally non-transferrable, like coal mining. An obvious way for factors to reallocate after being hit by a large cost increase is for drayage truck drivers, in the face of wage decreases to switch to long haul trucking. According to FRED, the average selling price for services incidental to long haul trucking as indexed by the PPI has been steadily increasing since 2009. It is difficult to disentangle both the local effects of trucking given its trans-boundary nature and the effect of the regulation on employment given the recession in the same year.

Rent to own schemes in the drayage industry are becoming increasingly common. Individual owner operators working for specific drayage companies have the option to debt finance future ownership of a truck paying a fixed, and in some cases variable, cut of their paycheck. In most industries this would be illegal. Drayage truck drivers are for wage purposes considered independent contractors, employed on a run-by-run basis by drayage companies. While they are not considered employees, once they enter into a rent to own deal with a drayage company, they are no longer permitted to drive for other drayage companies at the same port or any other port.

I would then extend the analysis to consider contracting as a mode of decreasing factor mobility. Relying on an explicit sorting model, I will seek to understand how the standard regression model diverges from empirical observations in the industry. The key assumption to be challenged in the fixed effect regression is that wages increase monotonically with productivity. Following the observations of Hagedorn et al. (2017), I will present a sorting model where productive firms may hire less productive workers only if that worker agrees to accept a lower than equilibrium wage. Since the worker and firm characteristics that make up this dynamic are not fully observable, to model the search dynamic I will use data on employee level wages and employment at trucking firms. I will then carry out analysis on three production functions which account for positive assortative matching (or matching on specific shared traits/values), negative assortative matching and neither (a flip from one type of matching to another over the domain of characteristics). I will then run a Monte Carlo simulation to see which of these three production functions provides the best prediction results to understand more of how this contract employment element affects the job search process.

Conclusion

The unprecedented regulations the port at Los Angeles-Long Beach took to curb emissions from international shipping has been a resounding success in terms of the welfare increase from cleaner air for residents of the South Coast basin. While the shipping industry has recognized the crucial role it plays in contribution to global emissions, more could be done to spread the benefits of cleaner air to all people who live near ports. As shipping of not only container goods but also oil and gas increases as the United States becomes a net exporter of fossil fuels, the ports will be a key node to introduce environmental policy.

Through analysis of CAAP I have shown that command and control policy for reducing emissions at the ports has been successful. While this result is not fully generalizable to each port, it does provide suggestive evidence that the welfare gains for clean air in densely populated port-adjacent regions outweigh the onerous costs placed on drayage companies. While the benefits outweigh the costs in the short term, there is at least anecdotal evidence that much of the cost of this regulation has fallen on those least able to pay it – workers contracted through drayage companies.

Further research to understand how firms outlay costs onto contracted labor in the face of a onetime cost shock could help to explain some of the lack of industry concentration I observe in the data after passage of CAAP. Another research frontier I hope to explore is how preferences for environmental regulation observed through voting behavior change when individuals have different levels of information related to the benefits and costs of some regulation.

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