Environmental Protection or Environmental Protectionism? Evidence from Tailpipe Emission Standards in China

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Environmental protectionism - implementing environmental policies to favor domestic industries - is usually disguised and hard to detect (Levinson, 2017). Since 2008, many cities in China have restricted the import of used vehicles whose tailpipe emissions exceed certain standards; the stated aim was to protect local air quality. In May 2016, however, the central government of China ordered cities to end such restrictions, calling them an "abuse of administrative power to exclude or restrict competition". Nevertheless, by the end of 2018, 35% of the cities had yet to comply. This study takes advantage of this quasi-natural experiment to examine the impacts of the restrictions on local air quality and vehicle sales. Our work sheds light on the motivation for and costs of environmental protectionism.

Our empirical analysis leverages a unique dataset on monthly trade flows of used vehicles by city pair and monthly new vehicle sales by city, both at the vehicle-model level in China. We combine these data with hourly air quality data from 2016 to 2018. The identification exploits the staggered removal of the restriction across cities. To address the concern of potential endogenous timing of the policy removal, we use two strategies. First, the baseline specification restricts our sample to 100 cities where the restriction was lifted by the provincial government and uniformly applied to all cities in the same province. For this sample, the timing of the removal should be driven less by time-varying shocks at each individual city. Second, we include a rich set of economic and political variables at the city-year level, and flexible time trends interacted with initial conditions to control for time-varying unobservables. To balance the trade-off between over-fitting the model and controlling for omitted variable bias, we use the post-double-selection (PDS) method (Belloni et al., 2012) to select a parsimonious set of control variables.

We find that the removal of restrictions led to a significant increase in cross-city trade of used vehicles but no significant decline in air quality. We see no statistically significant impact on ambient pollution concentrations of $PM_{2.5}$, PM_{10}, CO, and NO_2.[1] Results on new vehicle sales further highlight a "prisoner's dilemma." That is, while a unilateral removal of the restriction reduced new vehicle sales locally, especially among major automobile-producing cities, a coordinated, multi-lateral removal of the restriction could instead boost local sales of new vehicles.

This research contributes to several strands of the literature. First, our study is closely related to the work of Davis and Kahn (2010), who document the impact of bilateral trade of used vehicles between the United States and Mexico after NAFTA on CO_2 emissions. A key difference, however, is that our study examines the impact of intranational trade of used vehicles on air quality. Second, our study adds to the empirical literature on the environmental impacts of environmental and transportation regulations (Davis, 2008; Auffhammer and Kellogg, 2011; Wolff, 2014; Viard and Fu, 2015; Zhang, Lawell and Umanskaya, 2017; Salvo and Wang, 2017; Li et al., 2020). Our study highlights the interac-

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[1] China's tailpipe emissions standards set limits (per km) on CO, HC, NO_x, and PM.

tion between the primary and secondary vehicle markets under regulations (Gruenspecht, 1982; Jacobsen and Van Benthem, 2015). Third, this paper provides a case study of local protectionism, in which governments implement various regulations to implicitly protect local industries (Levinson, 2017; Miravete, Moral and Thurk, 2018; Young, 2000; Bai et al., 2004; Barwick, Cao and Li, 2021; Bai and Liu, 2019).

I. Data and Methodology

We obtain data on new and used vehicle transactions: (1) the universe of used vehicle registrations in China from 2015 to 2018. For each used vehicle traded, we observe the origin and destination cities of the vehicle, and (2) new vehicle sales by city at the vehicle-model level (e.g., Toyota Camry) from 2015 to 2018. For our main analysis, we aggregate used vehicle data (imports/exports) and new vehicle sales to a given city by year-quarter. We obtain hourly air quality data from over 1600 monitoring stations in China from 2016 to 2018 from the Data Center of the Ministry of Ecology and Environment (MEE); we collapse the information to city-month level by averaging across stations and hours within a city-month. In addition, we collect data on meteorological conditions (wind speed, temperature, atmospheric pressure, relative humidity, precipitation, and wind direction), social-economic indicators (GDP per capita, population, government expenditure, government revenue, unemployment, number of motor vehicles) and characteristics of city leaders (the age, education and tenure length of the city mayor and party secretary). The timing of the restriction removal by city was collected from governmental websites and news reports.

To quantify the impact of lifting the trade restriction on air pollution and vehicle sales, we focus on the time window of 2016 to 2018, during which the restriction was lifted in a staggered manner across cities. The main identification challenge is the potential endogeneity of policy removal; this could be a concern if cities strategically chose to lift the restriction in response to changes in outcome variables (e.g., air pollution or vehicle demand), or if time-varying unobservables correlate with these variables.

We address the challenge using two strategies. First, in our baseline analysis, we restrict our sample to 100 cities where the restriction was lifted by the provincial government rather than by the local government. Twelve provincial jurisdictions (provinces and autonomous regions) lifted the restriction at the provincial level. Our results are robust to the full sample with all cities. Second, we add a rich set of control variables including social-economic variables, characteristics of city leaders (city mayor and party secretary), weather conditions, quadratic terms and interactions of these variables, in addition to city fixed effects, year-quarter fixed effects, and province-by-year fixed effects.

Our main specification is

$$\begin{aligned}\ln(y_{ct}) =&\beta D_{ct} + X'_{ct}\gamma + X'_{-c,t-1}\mu + \alpha_c \\ &+ \delta_t + \eta_{p,yr} + \varepsilon_{ct},\end{aligned}$$

where c is city index; t represents time (quarter or month); p denotes province; and yr denotes year. The dependent variable y_{ct} includes the imports of dirty used vehicles, ambient air pollutant concentrations, and new vehicle sales. D_{ct} is the key policy variable, which equals one if the restriction has been lifted in city c at time t. X_{ct} is a vector of controls in city c. $X_{-c,t}$ is a vector of weighted sum of controls in cities other than c.[2] α_c, δ_t and $\eta_{p,yr}$ are city fixed effects, year-quarter fixed effects, and province-by-year fixed effects, respectively.

II. Results

We first examine the direct effect of lifting the restriction on the imports of dirty used vehicles. Before 2016, most cities adopted the "China 4" standard (the fourth level of national tailpipe emission standards), and barred imports of used vehicles whose emissions exceeded that standard. Therefore, we define "dirty" vehicles to be those with emissions that exceed those allowed under the China 4 definition.[3]

Figure 1 plots the estimated coefficients from an event study that shows the changes in the imports of dirty used vehicles before and after the restriction ended. The estimates, based on

[2]The weights are the ratio of used vehicle trading between city c and another city in (pre-policy) 2015 over total used vehicle trading of city c in 2015.

[3]In 2015, the total vehicle stock in China was 162 million; dirty vehicles accounted for 68.1% of this stock (MEP, 2016).

the cities where the policy was removed at the provincial level, use the PDS method to select a smaller set of controls. Two interesting patterns emerge. First, we do not see any pre-trends across cities, suggesting that policy adoption is unlikely to be driven by time-varying unobservables; this lends support to our identification strategy. Second, the import of dirty used vehicles increased dramatically after the restriction was lifted. The estimated coefficients for one quarter, two quarters and three quarters after the restriction removal are 1.188, 1.842, and 2.369, respectively - translating to an increase of 228%, 531%, and 969%, respectively. On average, after three quarters of the restriction removal, the imports of dirty used vehicles increased by 505%. The results are robust across two alternative specifications: (1) if we use the full sample instead of the subsample of cities where the restriction was removed by the provincial government; or (2) if we use the fixed effects model including the full set of controls without the post double selection method. To understand the effect size, we extrapolate the estimates to encompass the 0.16 million dirty used vehicles that were traded across cities nationwide in 2016. Our estimates suggest that lifting the restriction would increase the trade of dirty used vehicles by about 0.81 million in the subsequent three quarters.

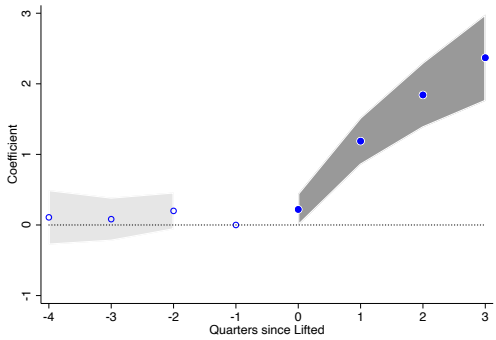

Figure 1. Event Study for Imports of Dirty Used Vehicles

Note: This graph shows the coefficient estimates obtained from an event-study regression that estimates the impact of removing restrictions on the city-level imports of dirty used vehicles by quarter. The dependent variable is (the logarithm of) the imports of dirty used vehicles at the city×year-quarter level. Dirty vehicles refer to vehicles with tailpipe emissions intensities above the national "China 4" standard. The regression controls for city FEs, year-quarter FEs, province-by-year FEs, and uses the PDS method to select controls from a rich set of variables described in the main text (Belloni et al., 2012). Shaded area shows the 95% confidence interval. Standard errors are clustered at the city level.

Next, we investigate whether the increase in the imports of dirty used vehicles reduces air quality - a potential concern for cities lifting the restriction, and a stated justification for keeping the policy. Table 1 shows the results. We find that lifting the restriction had neither statistically nor economically significant impacts on $PM_{2.5}$, PM_{10}, CO, or NO_2. These findings could be due to the small share of imported, dirty used vehicles within total vehicle stock in a given city. On average, dirty used vehicles from imports accounted for 0.15% of local vehicle stock in 2015, and the ratio rose to 0.29% in 2017 as more cities removed the restriction. Thus, the increase in the import of dirty used vehicles induced by trade liberalization only added to a small fraction of the existing vehicle stock per city, rendering the null effect on air pollution.

Table 1. Effect on Air Pollution

Dep. Var.	ln($PM_{2.5}$)	ln(PM_{10})	ln(CO)	ln(NO_2)
	(1)	(2)	(3)	(4)
Lifted	0.019	0.001	0.006	0.025
	(0.018)	(0.016)	(0.023)	(0.017)
N	3149	3149	3149	3149

Note: This table reports the effects on air quality from lifting the import restrictions. The unit of observation is city by month. "Lifted" is the policy indicator that equals one if a city has lifted the restriction. The regressions control for city FEs, year-month FEs, province-by-quarter FEs; weather conditions; and upwind pollution. We use the post-double-selection (PDS) method to select controls from a rich set of variables described in the main text (Belloni et al., 2012). Standard errors are clustered at the city level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

If lifting the restriction did not actually impact air quality, why were local governments reluctant to comply? And, why was the restriction adopted in the first place? A cynical view could be that local governments might be misinformed. Another explanation is that local governments were at least partially intended to use the restriction to protect the new vehicle market from import competition of used vehicles, a common incentive in enacting trade barriers. A robust new vehicle market implies a larger tax base from sales and from production especially for cities with automobile manufacturing. To shed light on this explanation, we examine the impact of lifting the restriction on the new vehicle market and on strategic interactions across jurisdictions.

We extend our main specification to allow for policy spillovers; that is, new vehicle sales in a city could be affected by other cities' decisions

to remove restrictions. We include in our regressions an index that measures the exposure of the home city to the restriction removal policy in other cities. This policy exposure measure for a city c is constructed as the weighted sum of the restriction removal indicator in all other cities (Millimet and Roy, 2016). The weights are defined as the ratio of used vehicle trading between city c and another city in (pre-policy) 2015 over total used vehicle trading of city c in 2015. Larger trading partners are weighted more heavily in the policy exposure index.

Table 2. Effects on New Vehicle Sales

Dep. Var.	ln(New Vehicle Sales)		
	(1)	(2)	(3)
Home Lifted	0.006	0.013	0.014
	(0.020)	(0.021)	(0.022)
Other Lifted	0.103**	0.077*	0.081*
	(0.042)	(0.043)	(0.042)
Home Lifted		-0.007	
×1(Large Importer)		(0.032)	
Other Lifted		0.098*	
×1(Large Exporter)		(0.050)	
Home Lifted			-0.078**
×1(Home w/ Auto Plant)			(0.036)
Other Lifted			0.184***
×1(Home w/ Auto Plant)			(0.061)
N	1155	1155	1155

Note: This table reports the effects on new vehicle sales from removing restrictions on imports of used vehicles. The unit of observation is city by quarter. "Home Lifted" is the policy indicator that equals one if a city has lifted the restriction. "Other Lifted" is the lag of the weighted sum of policy indicators in other cities. "1(Large Importer)" is a dummy variable that equals one if a city's imports of used vehicles in 2015 was among the top 25% across cities. "1(Large Exporter)" is a dummy variable that equals one if a city's exports of used vehicles in 2015 was among the top 25%. "1(Home w/ Auto plant)" is a dummy that equals one if the home city has auto plant(s). The regressions control for city, year-quarter, and province-by-year fixed effects. We use a post-double-selection (PDS) method to select controls from a rich set of variables described in the main text. Standard errors are clustered at the city level.

Column (1) of Table 2 shows that lifting the restriction in the home city did not lead to a significant change in new vehicle sales; nevertheless, policy spillovers are large and significant. If all other cities were to lift the restriction, new vehicle sales in a city would increase by 10.3%. As more cities open their markets, owners of dirty used vehicles become more likely to sell their used vehicles and to buy new vehicles (Porter and Sattler, 1999), thus stimulating the sales of new vehicles. Column (2) shows that the spillover effect is larger for cities that exports more used vehicles - a finding that is likely driven by the linkage between the used and the new vehicle markets. Column (3) shows the heterogeneous effects across cities with and without automobile manufacturing. For cities with auto plants, removing the restrictions would lead to a decrease in new vehicle sales of 7.8%, but would lead to an increase of 18.4% if all other cities lifted the restriction. This result could be driven by the substantial home bias documented in Barwick, Cao and Li (2021) and points to an interesting "prisoner's dilemma" for local governments. While unilaterally removing restrictions could harm the local new vehicle market, a coordinated, multi-lateral removal could benefit all. These findings could rationalize the adoption of the restriction policy in the first place, and could explain the slow removal of the restriction that took place despite the mandate from the central government.

III. Conclusion

This paper examines a case in which city governments in China undertake practices that protect local markets under the guise of environmental protection measures. Our analysis focuses on the impacts of local policies that restrict inter-city sales of used vehicles that do not meet certain tailpipe emissions standards. Our findings suggest that such trade restrictions not only hinder the development of the vehicle market and limit the gains from trade, but could also distract attention from the need for effective regulations in order to combat pressing environmental challenges. This research points to the important role of the central government in addressing policy spillovers across jurisdictions and sheds light on the debate of environmental federalism (Lipscomb and Mobarak, 2016; Shobe, 2020). Future research could use a general equilibrium framework to further examine the equilibrium effect of trade liberalization on both used and new vehicle markets and to quantify the efficiency and equity effects.

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