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Who Will Be Affected by a Congestion Pricing Scheme in Beijing?

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Abstract

Equity concerns have been an important obstacle to adopting congestion pricing, both in developed and developing countries. However, the existing evidence on the equity effects of congestion pricing has come from developed countries. In this paper, we shed light on the distributional consequences of a congestion pricing scheme currently under consideration in Beijing. We find that under the congestion pricing scheme, which covers the areas within the city's 3rd Ring Road, a very small proportion of Beijing commuters will have to pay the full congestion charge. More important, these directly affected commuters typically have higher household incomes and are wealthier than individuals who are not directly affected by the congestion pricing scheme. Our finding reflects the fact that individuals who drive to work in Beijing are relatively wealthy.

Key Words: congestion pricing, distributional concerns, Beijing

JEL Classification Numbers: H23

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1. Introduction

Transportation experts strongly recommend congestion pricing for reducing traffic congestion, and experiences in London, Singapore and Stockholm have demonstrated the efficacy of congestion pricing (e.g., Leape 2006; Olszewski and Xie 2005; Börjesson et al. 2012). By reducing automobile use, congestion pricing can also generate environmental benefits (e.g., Anas and Lindsey 2011). Despite these benefits, however, only a few cities in developed countries, and no cities in developing countries, have adopted this policy. In contrast, driving restrictions, under which certain vehicles cannot be used at certain times, have been implemented in a considerable number of cities in several developing countries (Wang et al. 2014). Cities adopt driving restrictions, instead of congestion pricing, largely because rationing is considered more equitable and thus more politically acceptable (Rouwendal and Verhoef, 2006; de Grange and Troncoso, 2011). Indeed, Karlström and Franklin (2009, 283) write that equity effects have long been recognized as the “Achilles Heel” of congestion pricing, “because the rich or otherwise privileged are likely to be more able to cope with the toll than the poor or those who are otherwise disadvantaged, either by paying the toll or by adjusting behavior.” The existing studies of the equity effects of congestion pricing have focused on cities in developed countries. See Eliasson and Mattsson (2006, section 2) for a summary of the literature.

Largely because of equity concerns, the Beijing municipal government has also been using rationing policies, including driving restrictions (Wang et al. 2014) and vehicle purchase restrictions (Yang et al. 2014), instead of congestion pricing. However, a congestion pricing scheme in Beijing may not be regressive in practice. In fact, because private car owners in China are relatively wealthy, Cao (2011) finds that taxing motor fuels in China is quite progressive. In this paper, we analyze the potential equity effects of congestion pricing by characterizing the Beijing residents who will be directly affected by a possible congestion pricing scheme.

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The extraordinarily high air pollution levels that often occur in Beijing and many other Chinese cities have recently prompted the Beijing municipal government to reconsider the possibility of using congestion pricing to reduce driving (Beijing Municipal Government 2013). In particular, the Beijing government is considering the following scheme. The charging zone will be within what is known as the 3rd Ring Road (or 3rd Ring), Beijing's set of concentric roads around the city center. Vehicles driving in this zone at any time are charged 8 Renminbi (RMB; roughly, \$1.25) each time they enter. Private and government- or company-owned automobiles, shuttles, and taxis will all be charged, but buses will be exempt. Residents living within the third ring are eligible for a 90 percent discount.

To investigate the distributional effects of this congestion charge scheme, we characterize the economic and social characteristics of the individuals who will be directly affected by the congestion pricing scheme. We also study the percentage of motorized travel that would be directly affected by the congestion pricing scheme. Our analysis focuses on commuting and school trips because such trips are not discretionary (i.e., individuals have no choice but to make such trips) and because our data are more suitable for identifying individuals who are making such trips. Consistent with our focus on the characteristics of the directly affected individuals, Eliasson and Mattsson (2006) conclude that, in the case of Stockholm, the two most important factors for determining the equity effects of congestion pricing are who are directly affected by the charge and how revenues are used.

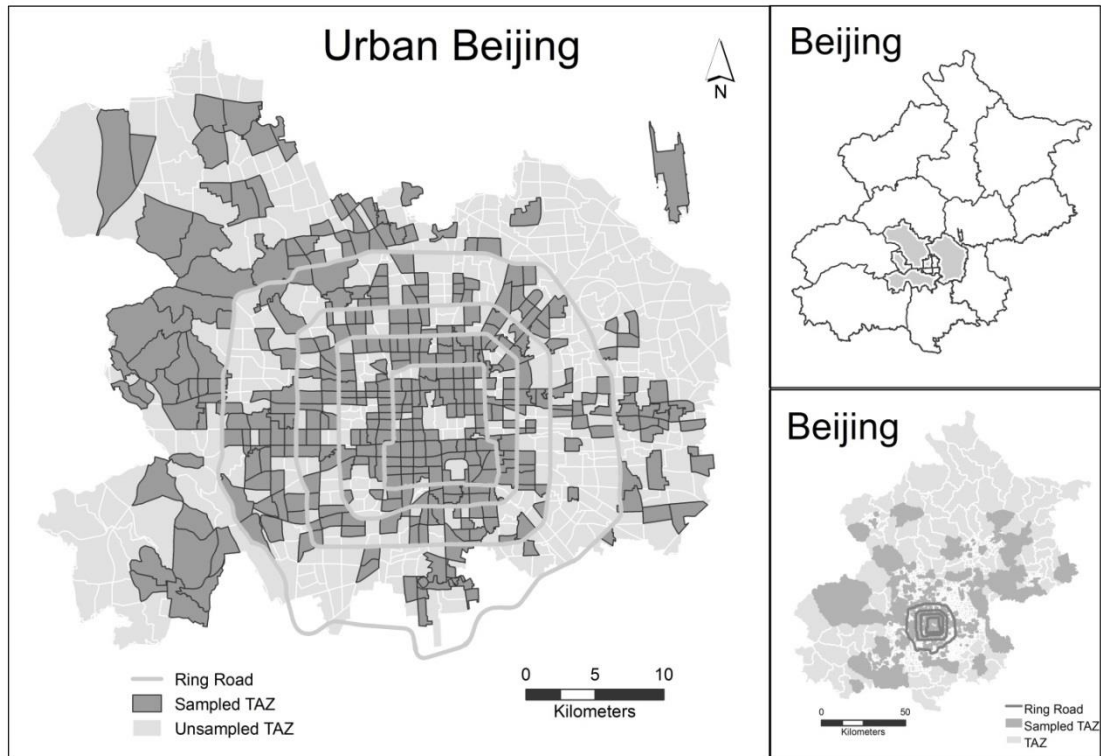
Using household survey data from 2010, we find that only about 3 percent of Beijing commuters live outside and work inside the 3rd Ring Road and drive to work, who will be directly affected by the congestion pricing scheme. More important, the directly affected individuals are wealthier than two comparison groups of individuals: those who live outside and work inside the 3rd Ring Road but do not drive to work, and the full sample of employed individuals in Beijing (excluding the directly affected individuals). The directly affected individuals tend to live in households that have higher annual income and larger living space per household member and are more likely to own their homes, and these directly affected individuals are better educated and more likely to be male. We find similar results for school trips as for work trips. We also find that regardless of where they live in Beijing, compared with individuals who are employed but do not drive to work, individuals who drive to work have higher household income, live in larger residence, are better educated, and are more likely to be male. Thus, our evidence suggests that congestion pricing in Beijing will affect the rich or the privileged more and that the equity effects of a congestion pricing scheme in Beijing is different from its equity effects in a developed country where low-income individuals often drive to work.

2. Data

Our analysis is based on the 2010 Beijing Household Travel Survey conducted by the Beijing Transportation Research Center (BTRC), an agency of the Beijing municipal government. BTRC has conducted annual household travel surveys for a number of years, and the Beijing municipal government uses these surveys to understand Beijing residents' travel behavior and to form transportation policies. Academic researchers have also used the survey data to analyze transportation in Beijing (e.g., Wang et al. 2014).

We focus on the 2010 survey because of its large sample size. The 2010 survey adopts a multistage sampling strategy with the target of a one percent sampling rate. The BTRC randomly selects 642 traffic analysis zones (TAZs) out of 1,911 in the entire city of Beijing. TAZs are geocoded areas defined by the BTRC for traffic analysis. Each of the administrative districts in Beijing has 16 to 238 TAZs, based on the size of the area and the population of the district. TAZs are smaller in districts with larger population densities. The average size of a TAZ is about 1.5 square kilometers. The area of a TAZ ranges from 0.21 to 16 square kilometers in the inner eight districts, on which the sampling focuses. On average, about 75 households in each TAZ are randomly selected for in-person interviews to collect data on trips taken during a designated 24-hour period (the household's travel day). Figure 1 shows the sampled and unsampled TAZs in Beijing. As can be seen in this figure, the surveyed TAZs are distributed evenly within each ring road.

The survey gathers the following: (1) information about each segment of a trip taken by each member of a household during the household's travel day, including travel purpose (e.g., going to work), travel mode (e.g., automobile), time when the travel began and ended, and the TAZ codes of the origin and the destination; (2) household information, including the TAZ code of the residence, vehicle ownership, household income, whether renting or owning the housing, and if owning, the size and building type of the housing; and (3) household member information, including gender, age, occupation, whether possessing a driver's license, whether employed, and if employed, the TAZ code of the workplace.

Figure 1. Traffic Analysis Zones in Beijing

3. Findings

We focus on the directly affected commuters because they have to either pay the congestion charge or switch to other modes of transport, at least in the short run. We consider whether the directly affected commuters tend be individuals with low income or low wealth. To provide context for this analysis, we first estimate the fraction of trips that will be directly affected by the congestion charge.

3.1. A Small Share of Beijing Residents Would be Directly Affected

The full sample includes 140,395 trips¹ made by 88,457 individuals from 43,793 households.² Of the full sample of trips, 43.19 percent, or 60,634, are motorized trips. Of these motorized trips, only 7.9 percent, or 4,789, involve driving (or taking a taxi) into the 3rd Ring

¹ These do not include the return leg of a round-trip. The purpose of the return leg is often missing in the survey.

² The survey covered 116,142 individuals from 46,900 households. Some individuals did not make any trips in the designated 24 hours.

Road and thus will be directly affected by the congestion charge. Of these directly affected trips, 32.41 percent, or 1,552, are work trips;³ 3.49 percent, or 167, are business trips; 3.11 percent, or 149, are school trips; and the other 61 percent, or 2,921, are discretionary, including trips to shopping locations, restaurants, gyms, parks, banks, hospitals, and to visit friends or relatives.

To provide further context for our focus on commuters, we estimate the percentage of employed individuals who will be directly affected by the congestion charge. Of the 41,078 employed individuals in our sample,⁴ only 3.1 percent, or 1,275, live outside but drive to work within the 3rd Ring. Since 6.4 percent of these 1,275 individuals have access to government- or company-owned cars, and many of them can avoid the congestion charge, the proportion of employed individuals who will be directly affected by the congestion pricing scheme is very small, at 2.9 percent of the total sample. In our sample, 4,362 individuals, or 10.6 percent of the employed population, live outside and work inside the 3rd Ring but do not drive to work. That is, a total of 5,637 individuals live outside but work inside the 3rd Ring, and 22.6 percent of these individuals drive (or take a taxi) to work.

For comparison, 8,029 individuals in our sample, or 19.5 percent, live and work within the 3rd Ring; 23,360 individuals, or 56.9 percent, live and work outside the 3rd Ring; and 5,637 individuals, or 13.7 percent, live inside but work outside the 3rd Ring. This last group needs to pay 10 percent of the congestion charge when they drive home from work.

3.2. Directly Affected Commuters Tend to Be Wealthy

We compare the characteristics of the directly affected commuters with those of two comparison groups of individuals: (1) those who live outside and work within the 3rd Ring but do not drive to work; and (2) the full sample of employed individuals minus the directly affected group. The congestion charge does not directly affect, but could indirectly affect, the behavior of individuals in these comparison groups. For example, if the congestion charge reduces congestion, the lower time cost of driving could induce some individuals in the comparison groups to drive. Analyzing such responses, however, is outside the scope of the paper.

³ Our classification of trips is based on the answers to the following question: What is the purpose of your trip? “Working” and “business trips” are two options listed in the survey answers. It is possible that some survey subjects may have chosen the answer of “working” for both commuting and business trips.

⁴ The survey covers 49,758 employed individuals. Some of the individuals did not make work trips on the survey day.

Compared with either of the two comparison groups of individuals, as shown in Table 1, the directly affected individuals, on average, have higher household income and larger living space, are more likely to own their residence, are better educated, and are more likely to be male. The directly affected individuals, on average, are about one year older than those who live outside and work within the 3rd Ring but do not drive to work, and they are about one year younger than the full sample of employed individuals (excluding the directly affected individuals).

Table 1. Comparing the Directly Affected Individuals with Two Other Groups

	1	2	3	4	5
	Directly affected group (group 1)	Individuals who enter the 3rd Ring to work but do not drive (group 2)	p-value of comparing group 1 and group 2	Full sample of employed other than the directly affected group (group 3)	p-value of comparing group 1 and group 3
Number of observations	1,275	4,362		39,803	
Year of birth	1973.30	1974.76	0.000	1972.10	0.000
Male	0.63	0.50	0.000	0.54	0.000
Head	0.43	0.40	0.071	0.43	0.959
Education (0–8)	6.19	5.89	0.000	5.45	0.000
Number of autos	1.07	0.29	0.000	0.40	0.000
Proportion having access to a government/company car	0.06	0.01	0.000	0.02	0.000
Household income (1–7)	2.16	1.70	0.000	1.62	0.000
Housing size (square meters)	91.29	74.99	0.000	78.23	0.000
Housing size per household member (square meters)	37.01	30.29	0.000	31.00	0.000
Proportion of homeowners	0.79	0.66	0.000	0.66	0.000
Commute distance (kilometers)	12.15	12.53	0.145	7.04	0.000
Bus stop density at home TAZ	44.04	47.88	0.001	48.45	0.000
Bus station density at work TAZ	68.35	68.02	0.797	49.47	0.000

Note: The density of bus stops in a TAZ is defined as the number of bus stops in the TAZ divided by the size of the TAZ in square kilometers. The categorical education variable ranges from 0 to 8, and the categorical household income variable ranges from 1 to 7.

The directly affected individuals, on average, have the same commuting distance as those who live outside and work inside the 3rd Ring but do not drive to work. However, the directly affected individuals live in TAZs with a lower density of bus stops, where the density of bus stops in a TAZ is defined as the number of bus stops in the TAZ divided by the size of the TAZ

in square kilometers. A possible explanation for this result is that the directly affected individuals, who have higher income and are better educated, choose to live in larger residences that are located farther from public transportation.

Figure 2. Household Income Distribution of the Employed

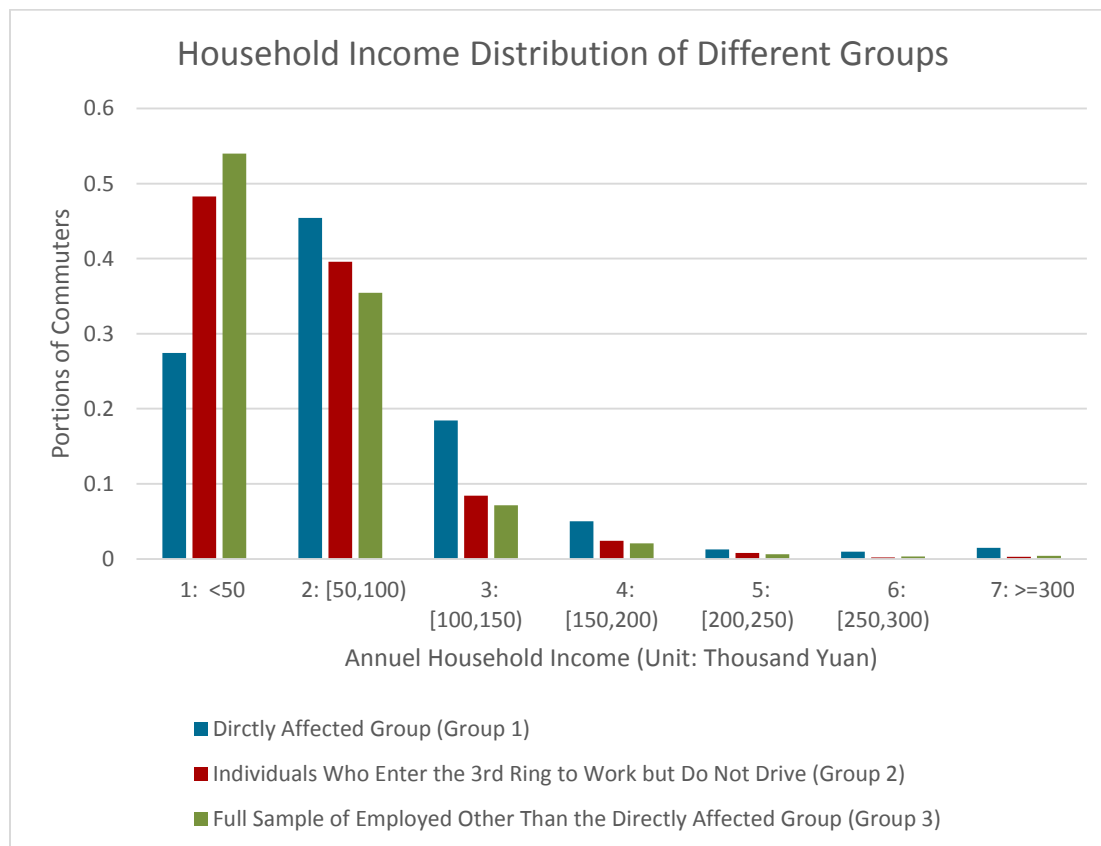


Figure 2 compares the income distribution of the households in which the directly affected individuals and the two comparison groups of individuals live. It illustrates that 53.98 percent of the full sample, other than the directly affected individuals, and 48.28 percent of those who live outside and work inside the 3rd Ring but do not drive to work have an annual household income of less than 50,000 RMB. In contrast, only 27.45 percent of directly affected individuals have income of less than 50,000 RMB. Furthermore, the share of directly affected individuals who have an annual household income of more than 100,000 RMB is more than twice the share of such individuals in the two comparison groups. These observations are further evidence that the directly affected individuals have much higher income than the two comparison groups of individuals.

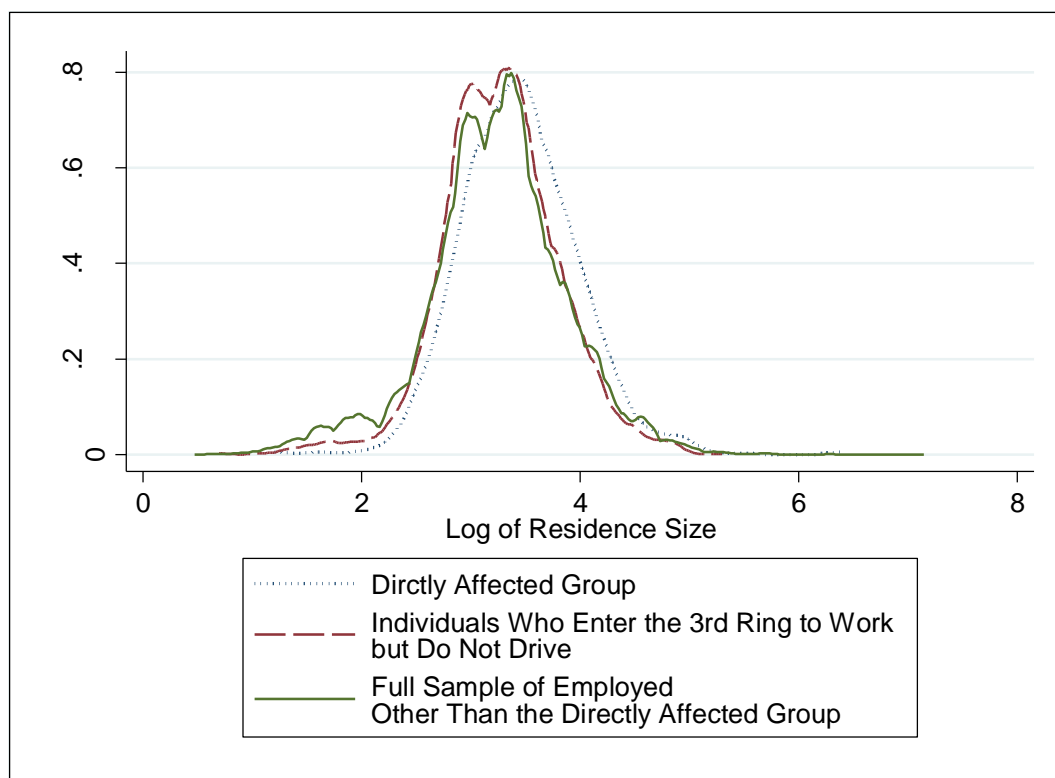
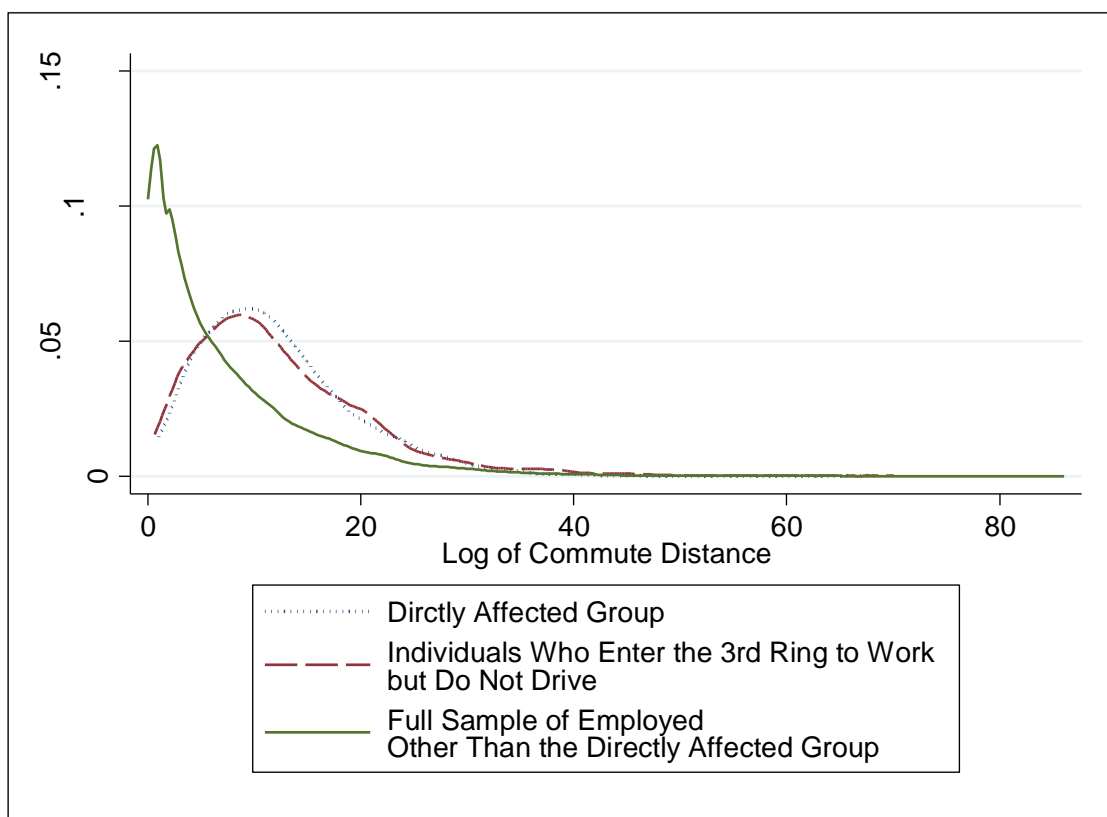
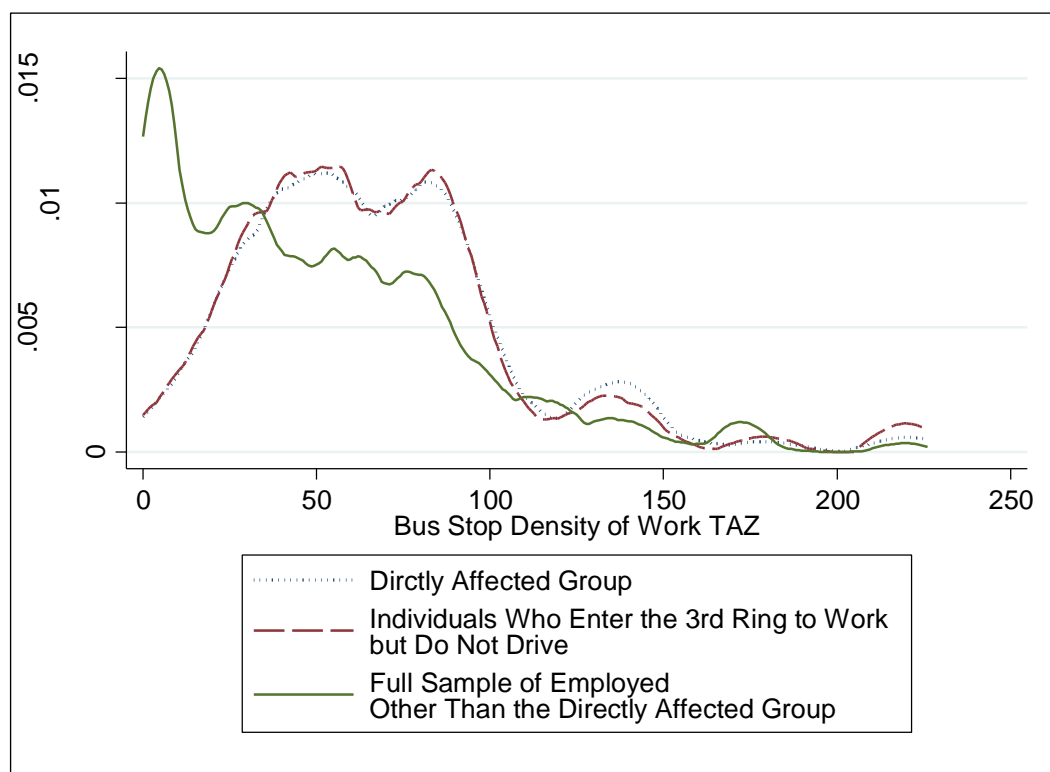
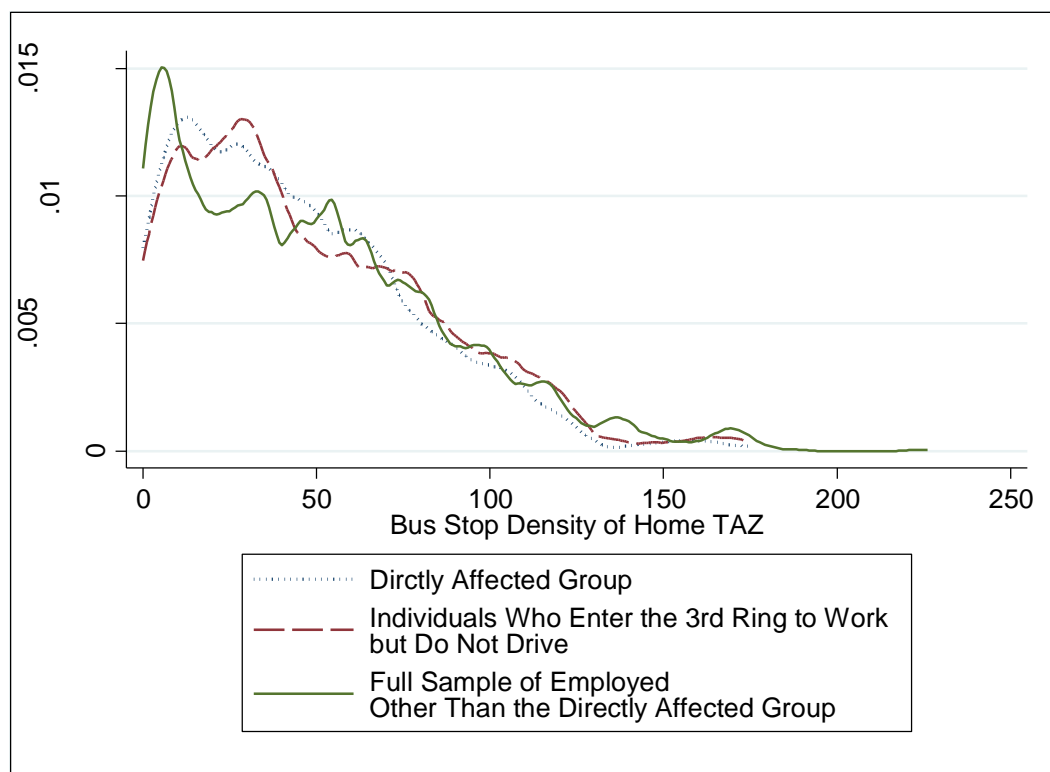
Figure 3. Residence Size Distributions of Three Groups of Individuals

Figure 3 shows the estimated kernel density functions of log residence size. The distribution of the directly affected individuals generally lies to the right of the distributions of the two comparison groups of individuals. The figure indicates that the cross-group differences in mean residence size, which Table 1 reports, are not driven by outliers. Figure 4 shows that the full distribution of commute distance, not only the average, of the directly affected individuals is very similar to that of those who live outside and work inside the 3rd Ring but do not drive to work. Even though the directly affected individuals, on average, live in TAZs with a lower density of bus stops, Figure 5 shows that the distribution of bus stop density for the home TAZs of the directly affected individuals is not dramatically different from that for the home TAZs of those who live outside and work inside the 3rd Ring but do not drive to work.

Figure 4. Commute Distance Distribution of the Employed

Note: Of the employed population, 15.7 percent, or 6,463 trips, have zero commute distance, because they live and work in the same TAZ.

Figure 5. Bus Stop Density Distribution of the Employed

3.3. Few School Trips Will Be Affected

A total of 6,702 individuals in our sample are of school age, which is defined as between 7 and 20 years old. Of these individuals, only 2 percent, or 135, live outside the 3rd Ring but take a car or taxi to go to a school inside the 3rd Ring. About 6 percent of these individuals live in households having access to a government or company car. Table 2 compares these directly affected students with two comparison groups: those students who live outside and go to a school inside the 3rd Ring but do not take a car or taxi to school, and the full sample of students other than those directly affected. Compared with either group, the directly affected students live in households that have higher income and larger living space per household member and are more likely to be homeowners. The directly affected students do have longer school trips and live in areas with lower density of bus stops.

3.4. Robustness Check

We have assumed that the congestion pricing scheme covers the area within Beijing's 3rd Ring Road, and we have consequently defined the directly affected individuals as those who live outside the 3rd Ring Road but drive to work inside the 3rd Ring Road. Our primary findings are not sensitive to potential variations of the congestion pricing scheme. Table 3 compares the individuals who drive to work with those who are employed but do not drive to work, regardless of where they live in Beijing. Individuals who drive to work have higher household income, live in larger residence, are better educated, and are more likely to be male.

Table 2. Comparing School Trips

	1	2	3	4	5
	Directly affected group (group 1)	Individuals who enter the 3rd Ring to school but do not drive (group 2)	p-value of comparing group 1 and group 2	Full sample of school age other than the directly affected group (group 3)	p-value of comparing group 1 and group 3
Number of observations	135	347		6,565	
Year of birth	1997.51	1996.12	0.0001	1997.99	0.1324
Number of autos	1.13	0.36	0.000	0.45	0.000
Proportion having access to a government/company car	0.06	0.02	0.014	0.02	0.001
Household income (1–7)	2.09	1.44	0.000	1.52	0.000
Housing size (square meters)	89.12	76.34	0.001	78.87	0.012
Housing size per household member (square meters)	27.80	24.32	0.004	25.06	0.033
Proportion of home owner	0.80	0.69	0.017	0.71	0.024
School trip distance (kilometers)	8.52	6.95	0.004	2.69	0.000
Bus stop density at home TAZ	43.54	52.16	0.010	49.73	0.071
Bus station density at school TAZ	59.41	62.97	0.295	53.10	0.071

Note: The density of bus stops in a TAZ is defined as the number of bus stops in the TAZ divided by the size of the TAZ in square kilometers.

Table 3. Comparing Individuals Who Drive to Work with Those Who Do Not Drive to Work

	1	2	3
	Individuals who drive to work	Individuals who do not drive to work	p-value
Number of Observations	8,115	32,963	
Male	0.67	0.51	0.0000
Education (0-8)	5.91	5.37	0.0000
Household income (1-7)	2.01	1.55	0.0000
Housing size	89.84	75.87	0.0000
Housing size per household member	34.76	30.31	0.0000
Proportion of home owners	0.77	0.64	0.0000

4. Conclusion

Our findings suggest that under the congestion pricing scheme that covers the areas within the 3rd Ring Road of Beijing, a very small proportion of commuters in Beijing will have to pay the full congestion charge. More important, these directly affected commuters typically have higher income and are wealthier than individuals in the two control groups; they have higher household incomes, live in larger residences, are better educated, and are more likely to be male, although income and wealth vary across individuals within the group of directly affected commuters. Our results suggest that the equity effects of a congestion pricing scheme is different from its equity effects in a developed country where low-income individuals often drive to work.

Other than the distributional concern, another often-mentioned concern with congestion pricing in Beijing is that a large proportion of motorized travels in Beijing may be done using government or company vehicles, and drivers of government or company vehicles are not responsive to congestion charges (Creutzig and He 2009). In the survey data set, only about 6 percent of the directly affected commuters have access to a government or company car, though it is possible that the survey underestimates the proportion of commuters who have access to a government or company car.

This paper has focused on the distributional effects of a Beijing congestion charge, but policymakers are also interested in the efficacy of the charge at reducing congestion. The congestion charge is more likely to affect the travel behavior of individuals making discretionary trips than those who are commuting. We observe that a large share of motorized trips across the 3rd Ring Road is discretionary. The large share of discretionary trips implies that a congestion charge could be effective at reducing congestion, but testing this hypothesis would require economic modeling of individuals' travel behavior, which is left for future research.

References

- Anas, A., and Lindsey R. (2011) 'Reducing Urban Road Transportation Externalities: Road Pricing in Theory and in Practice', *Review of Environmental Economics and Policy symposium on transportation and the environment*, pp. 1–23.
- Beijing Municipal Government (2013) 'Beijing Clean Air Action Plan 2013-2017', <http://zhengwu.beijing.gov.cn/ghxx/qtgh/t1324558.htm> (in Chinese).
- Börjesson, M., Eliasson, J., Hugosson, M.B., and Brundell-Freij, K. (2012) 'The Stockholm Congestion Charges—5 Years On. Effects, Acceptability and Lessons Learnt', *Transport Policy*, 20, pp. 1–12.
- Cao, J. (2011) 'Is Fuel Taxation Progressive or Regressive in China?', in Sterner T. (ed.) *Fuel Taxes and the Poor: The Distributional Effects of Gasoline Taxation and Their Implications for Climate Policy*, pp. 128-140. New York: RFF Press.
- Creutzig, F., and He, D. (2009) 'Climate Change Mitigation and Co-benefits of Feasible Transport Demand Policies in Beijing', *Transportation Research Part D:Transport and Environment*, 14(2), pp. 120–131.
- De Grange, L., and Troncoso, R. (2011) 'Impacts of Vehicle Restrictions on Urban Transport Flows: The Case of Santiago, Chile', *Transport Policy*, 18(6), pp. 862-869.
- Eliasson, J., and Mattsson, L. (2006) 'Equity Effects of Congestion Pricing: Quantitative Methodology and a Case Study for Stockholm', *Transportation Research Part A*, 40, pp. 602-620.
- Karlström, A., and Franklin, J. P. (2009) 'Behavioral Adjustments and Equity Effects of Congestion Pricing: Analysis of Morning Commutes During the Stockholm Trial', *Transportation Research Part A*, 43, pp. 283-296.
- Leape, J. (2006) 'The London Congestion Charge', *Journal of Economic Perspectives*, 20(4), pp. 157–176.
- Olszewski, P., Xie, L. (2005) 'Modeling the Effects of Road Pricing on Traffic in Singapore', *Transportation Research Part A*, 39, pp. 755–772.
- Rouwendaal, J., and Verhoef, E. (2006) 'Basic Economic Principles of Road Pricing: From Theory to Applications', *Transport Policy*, 13(2), pp. 106-114.

- Wang, L., Xu, J., and Qin, P. (2014) 'Will a Driving Restriction Policy Reduce Car Trips? The Case Study of Beijing, China', *Transportation Research Part A: Policy and Practice*, 67, pp. 279–290.
- Yang, J., Liu, Y., Qin, P., and Liu, A. A. (2014) 'A Review of Beijing's Vehicle Registration Lottery: Short-term Effects on Vehicle Growth and Fuel Consumption', *Energy Policy*, 75, pp. 157-166.