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The rising demand for subway after private driving restriction: Evidence from Beijing's housing market

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ABSTRACT

This paper studies to what extent subway demand increased after the Beijing city government imposed restrictions on private driving in October, 2008. Utilizing a pseudo-repeat sale approach in a short sample period that includes 6 months before and after this exogenous shock, we mitigate the omitted variables problem, a common limitation in existing subway capitalization studies. We estimate the incremental effect of subway capitalization, and infer a 1.8 to 2.7 percentage point increase in people's willingness to pay for subway proximity, which is roughly 36% to 60% of the initial price premium for subway proximity. This increase is mainly due to the change in transportation mode following the driving restriction policy. We also find that the increase in demand for subway proximity exhibits significant spatial heterogeneity. Locations where subway travel time can better match that of car travel experience relatively higher housing price appreciation. Moreover, we find evidence that the increase in subway premium persists over time. Our estimation provides a basis for a sound cost–benefit analysis regarding how much and where the government should increase the supply of subway services after imposing restrictions on private driving.

1. Introduction

China has experienced massive urbanization over the past three decades. The annual average urbanization rate increase is about 1 to 1.5 percentage points, which means that roughly 15 million people migrate into cities every year. Furthermore, as Baum-Snow and Turner (2014) point out, there has been a significant trend for population centralization into the city proper. While urbanization brings the benefits of agglomeration economies, Chinese cities are simultaneously experiencing growth pains.

Beijing, as the nation's capital, and where the population in the city proper has increased from 7.4 million to 18.8 million from 1990 to 2010, is representative of them all. Traffic congestion, air pollution and sky-rocketing housing prices are the urban problems faced daily by every city resident. According to the data from the Beijing Transportation Research Center, between 2005 and 2010, the number of private cars grew from 1.34 million to 3.57 million, a rate three times that of the population growth rate for the same period. Meanwhile, the percentage of car riders for all passenger travel increased from 23.2% to 35.2%.

Alarmed by the deteriorating urban traffic situation and air quality, the city government has imposed a series of policies to promote public transportation and restrict private transportation. On the supply side, as is typical of many big cities all over the world, Beijing's city government has made significant investments in building its subway and light rail system (collectively referred to as subway hereafter). The 2008 Beijing Olympic Games gave an important boost to the construction of the new subway lines. By May 2014, in the city proper of Beijing, the total length of subway lines in use was 527 km, consisting of 18 lines and 279 stations, ranked the second in the world in terms of the total length. Average daily passenger volume exceeds 10 million, making the Beijing subway the busiest subway in the world.

On the demand side, while a number of policies have been introduced, two policies in particular have the greatest degree of command-and-control: the private car driving restriction (CDR) and, more recently, the rationing of new private car purchasing using lottery. These have also had the most direct impact on residents' choices about transportation mode. Beginning from Oct. 11th, 2008, Beijing has implemented a "one-day-per-week" policy that requires that all private cars not be driven for one non-holiday weekday; this policy is implemented according to the last digit of each license plate. This schedule is set by the city's transportation bureau and rotates every three months so that it's not always the same day of the week.

For a mega city like Beijing, the city government's intention seems to be discouraging private transportation and encouraging public transportation. Taking subway is quite cheap with subway fares only 2 RMB per trip. The Beijing government subsidizes the subway enormously, and even after the fare increase in late 2014, the city treasury will continue to subsidize 50% of operating costs. Further, subway construction costs

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have risen sharply, reaching 1.1 billion RMB per kilometer now. It is thus important to conduct a sound cost benefit analysis before determining where and by how much subway services should be supplied. Our study sheds light on this, aiming to answer the following touch-the-core question: how much will restrictions on private transportation increase subway demand?

This paper estimates the additional willingness to pay for subway proximity due to driving restrictions on private cars. We use individual transaction data in Beijing's resale housing market for the period of 2006–2010 from "*WoAiWoJia*" ("I love my family"), one of the largest real estate brokers in Beijing. The car driving restriction policy took effect in Oct. 2008, in the middle of our sample period. Note that the car purchase restriction policy began in January 2011, which is after our sample period. Thus our study is only able to examine the effect of car driving restrictions due to data availability.[1]

Our pseudo-repeat sale approach focuses on a short period of time before and after the imposition of the CDR policy during which there were no other shocks to Beijing's transportation system. This policy provides an exogenous shock that can help us infer the increase in households' willingness to pay for subway proximity. If we assume low elasticity of housing supply around subway stations during this short period of time, any increase in subway demand will be capitalized into housing prices. By comparing the housing price change near subway stations before and after this CDR policy, to the change at locations farther from subway stations, we can infer the extra willingness to pay for subway proximity due to CDR. We find a significant rise in the willingness to pay. Specifically, the price premium for subway proximity increased by 1.8 or 2.7 percentage points for housing units within 2 km or 3 km of a subway station after CDR was introduced.

Furthermore, we differentiate locations by their degree of substitution between private transportation and subway transportation in terms of travel time. Due to the uneven development of urban space, road system and subway system, locations differ in the degree of substitution. We use the "*GAODE*" online navigation map[2] to obtain the travel times for each residential complex to CBD by subway and by private car, respectively. We calculate the change in a private car driver's travel time before and after the driving restriction policy (assuming he/she will use the subway on the days when driving is restricted) to construct the subway-private car substitution index. Our results indicate that the willingness to pay for subway proximity increases more in locations where subway is a better substitute for driving in terms of travel time.

There is an extensive literature on the property value capitalization of urban rail transit investment, and it relies heavily on data from the US and other industrialized countries. This literature is primarily empirical, relating property value to distance from rail station (see Duncan, 2011, and Bartholomew and Ewing, 2011). The vast majority of such studies have found positive price premiums for properties closer to rail transit stations. Cervero et al. (2004), reviewing studies completed since 1993, found that homes within a quarter to half mile of rail stations are 6.4 to 45% more expensive than otherwise similar homes farther away. In a meta-analysis of 57 studies, Debrezion et al. (2007) conclude that proximity to a transit station is worth 2.4% of home value for every 250 m closer to the station. However, some studies have shown insignificant effects of capitalization (e.g., Gatzlaff and Smith, 1993; Ryan, 2005), and some have even found negative effects (e.g. Nelson, 1992), primarily attributed to nuisances (e.g. noise and congestion) brought by nearby transit facilities (especially bus and at-grade rail).

The dominant approach used to infer the value people place on urban rail transit, among other local (dis)amenities, is the hedonic (implicit) price method pioneered by Rosen (1974), which has subsequently provided the theoretical basis for developing revealed preference estimates of the value people put on local public goods and externalities. The majority of such revealed preference estimates, however, are based on a direct comparison of different properties. However, there is methodological weakness to this cross-sectional analysis (see Imbens and Wooldridge, 2009). The provision of public goods across locations may be endogenously determined. This is likely to induce correlation between local access to public goods and unobserved housing characteristics and neighborhood attributes, causing an endogeneity problem for the ordinary linear squares (OLS) estimation of the capitalization effect. A recent wave of empirical research has sought to mitigate this endogeneity issue caused by omitted variables. The leading strategy uses temporal variations in data (including multi-year panel and before–after comparison) to identify how exogenous shocks to public goods are capitalized into property values. Recent examples include those studies focusing on aggregate market impacts (Gatzlaff and Smith, 1993; Baum-Snow and Kahn, 2000) and those studies that analyze the effects on individual properties (e.g. McMillen and McDonald, 2004; Gibbons and Machin, 2005; Dubé et al., 2013). In general, these studies still find positive capitalization of rail transit in home value, although the magnitudes of effects seem to be on the small side of the overall literature on rail transit capitalization reviewed by Cervero et al. (2004) and Debrezion et al. (2007).

However, many of the existing panel studies using property-level data rely on before–after comparison of property sales. The usual scarcity of sales of any given residential property means most, if not all, before–after analyses based on housing sales are still cross-sectional in nature, as few repeat sales are observed. Some estimates using true longitudinal sale records of homes (e.g., McMillen and McDonald, 2004) may be critiqued as based on a non-representative sample of housing units that are particularly subject to frequent changes of ownership.

Our paper is also related to several recent papers that study the impact of Beijing's restrictions on private driving. However, those papers have different focuses. For example, Sun et al. (2014) find little effect of driving restrictions on air quality. However, Brian Viardand and Fu (2011) find that Beijing's API (Air Pollution Index) fell by 8% following implementation of the one-day-per-week driving restriction. Actually, a debate exists regarding whether car driving restrictions have a long-term effect on road congestion and air pollution. Some argue that since people can buy a second car to overcome this restriction, the driving restriction will have only a short-term effect. In this paper we also attempt to explore whether the CDR policy has an effect on subway premium that persists over time. We find evidence showing that the increase in the subway premium persists over time during our sample period (that is, for the period that extends to 2 years after the imposition of CDR). And there is an overshooting in the housing price near subway stations during the first few months right after the policy took effect.

Our paper contributes to the literature in three ways: first, we focus on the *change* in the willingness to pay for subway proximity after an exogenous demand shock, while many existing studies focus on supply shocks. We estimate the increment in the value of public good caused by substituting public transportation for private transportation, and this may have important policy implications for mega cities, like Beijing, in the developing world where private car ownership is already 35%.

It is noteworthy how we interpret our estimated increment in subway premium. For each location proximate to a subway station, such increase is brought about by residents who own cars and must change their transportation mode as a result of the policy shock. However, the percentage of this type of residents may increase after the policy since locations near subways will become more attractive to those who own cars and must make some change to their transportation habits. Due to data limitations, our empirical analysis cannot control for such a sorting effect. We argue that in our short sample period (six months before to six months after the policy was implemented), the sorting effect may be limited. We present some indirect evidence for this later in the empirical section. Thus the increased subway premium may be

[1] The car purchase restriction policy was announced all in a sudden without any advanced notice. Therefore, there was no expectation effect in housing prices before January 2011.

[2] http://www.amap.com/.