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Anticipation and post-construction impact of a metro extension on residential values: The case of Laval (Canada), 1995–2013

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A B S T R A C T

The application of hedonic pricing models has a long history in estimating the externalities associated with urban infrastructure, such as public transportation. However, results accuracy crucially depends on methodological and empirical considerations such as: i) presence of spatial latent component (spatial autocorrelation); ii) temporal breaks related to different periods over which the infrastructure is built; and iii) heterogeneity of the effect along the line and stations. This paper aims to assess the impact of Montréal's metro extension to the suburb city of Laval (announced in 1998 and started operating in 2007). A spatial difference-in-difference (SDID) estimator based on a repeated sales approach is used to isolate the impact of the proximity to the new infrastructure on single-family house prices depending on the implementation phases and the stations. The results suggest that among the three new infrastructures, only one shows a positive impact of proximity after the first operation of the transit service. The study results tend to relativize the sometimes high expectations in terms of economic impacts of such a project, at least for residential properties.

1. Introduction

Derived from Ricardo and von Thünen's seminal work, the Alonso (1964) model allows explaining the urban price gradient as a function of the distance to a central business area (McMillen, 2006). In its first version of the paper, the bid-rent location curves explicitly introduce the importance of transportation cost has a factor that shape land prices. Transportation cost implicitly includes the possibility that urban infrastructures, such as public transport, can shape land and real estate prices. This has also been recognized previously through the work of Wingo (1961). A reduction in transportation costs through the development of new public transport infrastructure should, consequently, be translated into land and property values (Kim and Lahr, 2014). Thus, location rent can be isolated using proximity to mass transit lines or stations, depending on the type of public transportation. Yet, it must be admitted that the assessment of the expected impacts by planners and policymakers remains a complex task (Higgins and Kanaroglou, 2016). Despite abundant literature on the topic, varying results are observed between studies (Debrezion et al., 2007) ranging from negative to positive effects (Kim and Lahr, 2014).

The latent spatial components of the price determination process (Lancaster, 1966; Rosen, 1974) invalidate standard regression assumptions of independence (Anselin and Griffith, 1988; Legendre, 1993) and, by extension, conclusions drawn by empirical applications. From a methodological perspective, it is well recognized that real estate values are location dependent, which can result in spatial autocorrelation among residuals of pricing equations (Can, 1992; Dubin, 1998). Spatial autocorrelation is a central concept in empirical spatial research (Getis, 2008) and is defined as the coincidence between measures depending on location (Anselin and Bera, 1998; Lesage and Pace, 2009). It may be associated with the omission of significant spatial variables (Mcmillen, 2010) or with spatial dependence processes structuring a data generating process (Le Gallo, 2002).

Other methodological challenges emerge when trying to isolate the effect of accessibility to a mass transit (MT) system on real estate values. The impact may be heterogeneous and varies over time according to the implementation phases of the development of new MT lines, but also among the stations serving the line. For a major MT development project, the development and construction of infrastructures can be broken down into distinct implementation phases (announcement, construction, operation) during which the impacts on real estate values can fluctuate according to anticipation effects of the market. Stated otherwise, the impact measured during the planning periods can well be different from the final impact according to possible

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speculation or anticipation effects (Mcdonald and Osuji, 1995; Mcmillen and Mcdonald, 2004; Agostini and Palmucci, 2008; Atkinson-Palombo, 2010). While a global assessment of the effect is often realized for the whole transportation system once in operation, station effects are also likely to generate localized premium distinctions (Hess and Almeida, 2007) due to station characteristics, services quality or landscaping and urban development choices.

The paper aims to assess the impact of the extension of Montreal's subway on the (suburban) island of Laval (on the north side) using 5422 repeated (pairs of) transactions collected between 1995 and 2013. Repeated-sales approach (Bailey et al., 1963; Case and Shiller, 1987) is used and matched with a spatial difference-in-difference model (SDID) (Dubé et al., 2014) to deal with possible spatial omitted variables and control for spatial spillovers over transaction prices. For comparison purposes, two model specifications are estimated. The first assesses the premium associated with each project implementation phase from a global perspective (all stations combined) while the second breaks down this periodic effect for each new station. Additional statistical tests for homogeneity and cumulative significance effect over the implementation phases are performed. Moreover, the impact is not homogenous along the transport line and implementation periods, with only positive significant effect being estimated for one of the three stations observed after the first operation.

The paper is divided into five sections. The first section is dedicated to literature review presenting previous empirical studies and paying special attention to the variation of study results depending on the project implementation phases and contextual factors. The second section covers the proposed modeling approach. The third section presents the data used to estimate the model, while the fourth section presents the estimation results. The last section covers a discussion and a conclusion closes the paper.

2. Literature review

The bid-rent theory, first introduced by (Alonso, 1964; Mills, 1969; Muth, 1969), suggests that land prices are a decreasing function of distance to the center (or central business district - CBD). According to the complex structure of actual cities, theory needs to be considered according to realities such as urban sprawl and polycentric forms (Heikkila et al., 1989). In this context, the development of the transportation infrastructures contributes to supplant the notion of physical proximity to the benefit of accessibility and modifies the distribution of socio-economic profiles across urban space (Glaeser et al., 2008). According to Burgess (2008), an increased mobility acts as a catalyst of change in a city and land values are "one of the most sensitive indexes of mobility" (idem: 344) explaining the consideration for hedonic pricing modeling using property values to isolate the impact of mobility through proxies such as distance to mass transit system and infrastructure. As such, high expectations are associated with mass transit systems in terms of urban and economic developments (Dittmar and Ohland, 2004; Hess and Lombardi, 2004; Landis et al., 1994; Calthorpe, 1993). Since the early work of Dewees (1976) and Bajic (1983), our capacity to predict the impact of those development policies is still limited (Handy, 2005) and the extensive literature reflects great results variability due to spatial and temporal considerations.

Regarding spatial consideration, each station is different and can produce a distinctive impact (Hess and Almeida, 2007). In fact, from an urban development perspective, each station can be perceived as a singular infrastructure with service, structural and landscaping particularities. The premium measured may not be homogenous over the whole transportation system's line and may vary due to station characteristics effects. One source of station-related result variation could be associated with the complementarity between transportation modes (Voith, 1993; So et al., 1997; Ryan, 2005), and other transportation modes may even impact the premium due to substitution effects (Ryan, 1999; Baum-Snow et al., 2005).

As exposed by Bowes and Ihlanfeldt (2001) the presence of parking facilities positively affects the sales prices. By studying Hamburg's transit system, Brandt and Maennig (2012) state that subterranean stations significantly increase the impact on condominium prices. The location of the station has also been noted as a factor influencing the premium. According to Cervero (2006) and Mulley and Tsai (2016), the most important premium is for residential and commercial values near downtown stations, with the impact varying among the MT system, with the higher effect related to commuter rail services (Debrezion et al., 2007). Of course, the effect may not be linear over space (Chen et al., 1997), but follow an inverse U-shape. Empirical works noted that the effect of proximity may be lowered by negative externality predominance such as noise, pollution or criminality (Bajic, 1983; Diaz and Mclean, 1999; Bowes and Ihlanfeldt, 2001).

An additional challenge related to evaluating the impact of such infrastructures relies on the fact that the development of a new MT system takes a considerable amount of time and money to be built. Agostini and Palmucci (2008) suggested that the impact can be decomposed into three distinct phases: announcement period; construction period; and operation period. The announcement period refers to the moment the project is publicized. During this period a speculation effect may be observed indicating a first market response (anticipation) to an MT system development.

The second phase, the construction period, marks the realization of the project. At that time the location of the future stations is concretely observed by the public, where the anticipation effect can be exacerbated. McMillen and McDonald (2004) considered the Chicago transit system and pointed out that house prices were affected even before the stations were built but after the project plans were known. Bae et al. (2003) also identified anticipation effects for the construction of a subway line in Seoul. Knaap et al. (2001) and Atkinson-Palombo (2010) identified capitalisation benefits from the time the project was publicly known. Studying Santiago's metro system, Agostini and Palmucci (2008) have noted that the average apartment price rises after the project has been announced, and that there is smaller, but positive and significant, impact after the identification of the station location. On the opposite side, Yan et al. (2012) did not observe any anticipation effect of the project proximity on home prices before the rail system began operation in Charlotte (North Carolina).

After the MT comes into operation, the maturity of the service is another plausible source of impact variation. While a number of studies note a positive impact of fully developed light rail systems on real estate values (Cervero and Duncan, 2002; Weinstein et al., 2002), Gatzlaff and Smith (1993) did not find any relationship for a semi-developed rail system. Mohammad et al. (2013) illustrate those conclusions by citing the example of the *Metropolitan Atlanta Rapid Transit rail system* (MARTA) whose impact was first studied 10 years after its initial operation by Nelson and McCleskey (1989). The authors only found a minimal effect while, a few years later Bowes and Ihlanfeldt (2001) identified positive and negative effects depending on the location. On the opposite side, Cervero and Landis (1997) assessed the impact of the *Bay Area Rapid Transit* (BART) system during its first 20 years of operation. The results for the fully developed service are consistent with those previously obtained after the first operation (Dyett et al., 1979).

Considering spatial and temporal dimensions, the decomposition and isolation of a proximity effect of a new transportation station per project implementation phase and station implies devising an appropriate econometric model.

3. Methodology and research strategy

Hedonic theory and price function is one of the most used methodologies to break down the value of a complex good into its characteristics' implicit prices (Rosen, 1974). The approach is based on revealed preferences: actual sale price reflects an equilibrium reached where both agents (buyer and seller) agree on a given amount (pay and