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## From rivers to roads: Spatial mismatch and inequality of opportunity in urban labor markets of a megacity<sup>☆</sup>

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### 1. Introduction

Location decisions of firms and workers shape the spatial distribution of economic activity between and within cities. On one hand, the interaction between cities is widely investigated in the literature of regional and urban economics, which tries to assess the extent to which urban scale affects the local concentration of different skills, sectors, etc., apart from defining each city's role in the regional system. On the other hand, within-city dynamics and internal heterogeneity is the focus of urban labor economic theory, simultaneously analyzing the interaction of land/housing markets with the labor market (Zenou, 2009).

Furthermore, the spatial scale of analysis shapes the choice of tools and measures to investigate specific issues. For instance, agglomeration economies are usually assessed by aggregated measures such as total population or density. However, this type of analysis does not provide a complete understanding of the intra-urban distribution of agglomeration economies effects (Melo & Graham, 2009). An alternative approach requires the estimation of market potential measures over labor market indicators, with distance decaying effects varying over space. In a way, accessibility to jobs embeds the concept of market potential and a higher chance of interactions and matching in the job market. Thus,

agglomeration economies may have heterogeneous effects within cities, affecting location decisions of workers and firms.

In this paper, we look at how economic agents benefit from such interactions within a specific urban labor market area. Any equilibrium in the labor market will be directly related to the housing market. Therefore, wages and housing prices will alternatively be the interest variables, being jointly affected by, among other characteristics, the accessibility to jobs in the city.

We use the São Paulo Metropolitan Region (SPMR), the main economic and financial center of Brazil, as our case study. SPMR is the fourth largest urban agglomeration of the world, and the largest urban agglomeration in the country, with about 10% of the national population and 19% of Brazilian GDP. The city of São Paulo is the core of the metropolitan area and accounts for 5.9% of the country's population and 12% of its GDP. In 2007, the reference year of our main database, SPMR housed 19.5 million individuals, while the population of the city of São Paulo (MSP) reached 10.9 million inhabitants. The SPMR population density in the same year amounted to 2,458 inhabitants per km<sup>2</sup> (in an area of 7,947 km<sup>2</sup>), while in the MSP it was of 17,155 km<sup>2</sup> (in an area of 1,523 km<sup>2</sup>).

Furthermore, the rate of car ownership in SPMR was of 184 cars per 1,000 inhabitants in 2007, similar to the rate observed in 1997 (according to Origin-Destination surveys), with 3.6 million private cars in total. From the 38.1 million daily trips that happened in the SPMR in 2007, motorized vehicles were responsible for 66.0% of them. Finally, private cars did 31.7% of the trips from home to work. As we will discuss, the spatial mismatch between residential locations and jobs can be particularly relevant for poorer individuals, who rely more heavily on public transportation.

In what follows, we explore the relationship between commuting time, accessibility to jobs and urban prices in the context of urban markets in a megacity in the developing world. We start by lining up the theoretical framework that permeates the empirical analysis. The key point is the simultaneous determination of land use and urban prices in the context of the family of spatial general equilibrium urban models we consider. That brings challenges for dealing with simultaneity bias in the empirical estimation of urban wages (and housing prices) models. Our goal is to measure how individual wages are affected by the potential access

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to job opportunities. We develop an accessibility index that accounts for production externalities by weighing the travel time of each location to the various job locations in SPMR, in a rich geographical setting. The simultaneity bias in this case may arise as both residents and firms' locations are determined at the same time. Thus, wages paid in a specific part of the city will depend on local supply and demand for jobs, which, in their turn, will also affect wages. Wages may also influence the number of jobs openings through their impact on production costs faced by firms. Therefore, accessibility to jobs, which is the explanatory variable of interest in our analysis, depends on some of the factors that affect wages and may also be indirectly affected by wages. Then, a positive shock to individual wages may change the number of job openings, so that the measurement of the causal relationship from accessibility to wages will require that we isolate variations in local job openings that can be reasonably assumed to be exogenous to potential shocks on wages. We address this issue by relying on an instrumental variables estimation that uses the river shore access to the city's founding location as instrument for accessibility to jobs.

The paper adds to the debate on spatial sustainability in large human settlements in developing economies (Fan, Allen, & Sun, 2014; Lau & Chiu, 2004). Policy choices in the past may impose strong costs to spatial sustainability in the present. In the case of São Paulo, current patterns of accessibility to jobs, imposed by physical infrastructure constraints, were heavily influenced by the development of the urban road network. Geography helped to define the design of such network that, together with a historical strategy that privileged motorized vehicle, reinforced the observed patterns of inequality of opportunity in the labor market.

## 2. Theoretical background

We use as the conceptual framework a spatial general equilibrium model of land use with endogenous job locations in a circular city. The model we draw on was developed in Lucas and Rossi-Hansberg (2002) – henceforth, LRH – and represents a generalization of the work by Fujita and Ogawa (1982).<sup>1</sup> The model was further extended in Rossi-Hansberg (2004) to look at efficiency properties of land allocation in the context of the same conceptual framework.<sup>2</sup> The theory determines the distribution of business and residential land together with employment and residential densities at all locations in the city, as well as urban prices (i.e. wages and land rents). Given the general equilibrium nature of the theory, one should be aware of the potential simultaneity bias in the empirical estimation of wage equations based on accessibility measures.

In this framework, productivity is higher the higher is employment in neighboring locations. Following Lucas (2001), the specification of the model considers such external effect of employment to decline exponentially with distance. This arbitrary form of production externalities will prove to be very useful for our empirical work.

Despite the admittedly very stylized nature of the model, it can be used as a conceptual framework to understand the interaction of

<sup>1</sup> Zenou (2009) provides a modern synthesis of urban labor economic theory, which consolidates research that explicitly model both the land/housing market (where both the location of workers and the price of land/housing market are endogenous) and the labor market (where both wages and unemployment are endogenous).

<sup>2</sup> The model in Rossi-Hansberg (2004) characterizes the optimal distribution of urban land. It is shown that the analysis of optimal urban structure can be used to design optimal policies to improve the efficiency of equilibrium allocations in the same setup.

forces that are important in determining urban structure. As such, it provides the structural background to obtain quantitative implications in more detailed empirical studies.

The take-home results from LRH that are relevant for our empirical strategy are:

1. The model simultaneously determines the location of jobs and workers, as well as wages and land rents.
2. In equilibrium, wages within the city increase with employment density.
3. In equilibrium, land rents within the city also increase with density of workers.
4. As a consequence of (1)–(3), accessibility to jobs is also simultaneously determined, for any given commuting cost function.

We will depart from reduced-form intra-urban price equations based on accessibility to capture production externalities in the form proposed in LHR. Many studies have already considered accessibility as a key variable in models for housing prices and land rents. Duranton and Puga (2015) have surveyed a well-established urban economics literature that provides evidence that accessibility determines land and housing prices in different locations. However, a far less numerous literature provides evidence of accessibility determining intra-urban wages.

In the case of land and housing prices models, Duranton and Puga (2015, p. 471) points out that the patterns of accessibility are also affected by the location choices of firms and workers, which are determined by prices. Hence, the land use problem is in essence a hard equilibrium problem with many feedbacks. The authors also recognize that the literature first solved it by restricting accessibility to be solely about access to jobs and by treating the location of these jobs as exogenous within a simple geography and with frictionless markets. In cities where the majority of jobs are well outside the urban core, it is also empirically problematic to equate accessibility to jobs (or even general accessibility) to the distance to the city center. In other words, better work is needed to reduce uncertainty.

Focusing on the labor market outcomes, we present the research methodology discussing the strategy to get rid of the usual identification hypothesis that restricts job locations to the central business district (CBD). Our strategy allows dealing with the simultaneous nature of business and housing locations, and urban prices determination in a richer geographical setting. Before proceeding to that, we look at some stylized facts concerning the spatial structure of our study region.

## 3. The internal structure of the SPMR – some stylized facts

From a stylized perspective, a Muth-Mills-Alonso urban model, having as the CBD the extended center of the city of Sao Paulo (Haddad, Hewings, Porsse, Van Leeuwen, & Vieira, 2015), may loosely approach the internal organization of the SPMR. Even though the broadly-defined CBD concentrates a great part of the jobs, a considerable level of employment decentralization is perceived in the region (Fig. 1). Households are spread across the territory, mainly located in the surroundings of the center, with population density decay in the boundaries of the territory of the metropolis (Fig. 2).

According to the 2010 population census, the city of São Paulo – the core of the SPMR – received daily an inflow of almost one million commuters, representing 15.4% of workers in the city. The great majority of commuters' flows were from peripheral regions in São Paulo and other municipalities to the metropolitan business centers in the central and western zones of São Paulo city.

Low-income residents are overwhelmingly overrepresented in

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