



# The underground economy: Tracking the higher-order economic impacts of the São Paulo Subway System



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## ABSTRACT

Over one million workers commute daily to São Paulo City center, using different modes of transportation. The São Paulo subway network reaches 74.2 km of length and is involved in around 20% of the commuting trips by public transportation, enhancing mobility and productivity of workers. This paper uses an integrated framework to assess the higher-order economic impacts of the existing underground metro infrastructure. We consider links between mobility, accessibility and labor productivity in the context of a detailed metropolitan system embedded in the national economy. Simulation results from a spatial computable general equilibrium model integrated to a transportation model suggest positive economic impacts that go beyond the city limits. While 32% of the impacts accrue to the city of São Paulo, the remaining 68% benefit other municipalities in the metropolitan area (11%), in the State of São Paulo (12.0%) and in the rest of the country (45%).

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## 1. Introduction

In 1989 Aschauer asked the question: “Is public expenditure productive?” In the last several decades, a great deal of research has focused on the measurement of the impact of public investment including analyses that have attempted to identify the main channels through which public capital may affect growth: a direct productivity and cost effect of infrastructure, a complementarity effect on private capital, and possible crowding out effects on private investment (Agénor, 2012). In large metropolitan areas, the provision of public infrastructure (and increasingly its maintenance) has become a source of intense debate, especially in an era of declining fiscal resource and limited appetite on the part of the general public for increased taxes. Increasingly, cost–benefit analysis (CBA) is used as a tool by national and local policymakers to appraise and evaluate large infrastructure projects (Vickerman, 2000). However, although this tool suggests a simple comparison between costs and benefits, in reality this is not so simple (see Mackie and Preston, 1998).

Part of the problem comes from imperfections in measurement of the productivity enhancements that are derived from public infrastructure. In many cases, only partial equilibrium estimates have been made, discounting the full, economy-wide

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implications of the public investment. Increased productivity can result for example in higher incomes and increased household expenditures, but also in a decrease in demand for labor due to increased efficiency.

Furthermore, the benefits of any public transport system extend beyond productivity measurements. Additional dimensions would include impacts on health (environmental metrics),<sup>1</sup> accidents, mobility and income (in terms of equity) and household budgets (in terms of expenditures). The difficulty of taking these issues into account is not only related to quantification challenges, but also to decoding on their relative importance (Mackie and Preston, 1998).

In the context of the present paper, the focus is specifically on one aspect of the wide spectrum of costs and benefits, namely the direct and indirect economic effects of (individual) productivity gains to a metropolitan economy that can be ascribed to the existence of the subway system compared to one counterfactual – its removal (i.e. the impact on the metropolitan economy without a subway). By estimating the effect of different commuting times and accessibility of jobs on (individual) wage, a direct (monetized) effect of the proposed scenario can be derived as well as indirect effects due to for example changes in household demand, labor productivity, firm output, demand for labor, etc.

The methodology employed in the paper share some of the same conceptual characteristics as the Dietzenbacher and Los (1998) hypothetical extraction method in input–output systems where the economic impact of the removal of one or more sectors is evaluated.

Further, the impacts of time savings on productivity (in terms of wage) presented in this paper only include the effects on individual movements and do not account for the potentially significant effect on freight flows and costs within the metropolitan region. In addition, both the direct and indirect effects are partial and not related to for example (individual) transport cost savings.

In the next section, the region of focus is described, along with some pertinent characteristics about the economic structure, commuting patterns, the role of Sao Paulo's external trade and the nature and extent of public transit. Section 3 discusses the modeling strategy that is centered on a spatial general equilibrium model (SCGE); econometric estimates of some direct main changes in the transit system (e.g., the removal of the subway system) are then fed in the SCGE model to capture the system-wide impacts. Thereafter, Section 4 presents the empirical results from a counterfactual experiment in which the subway (underground) was assumed to have been removed. The results explore the differences in terms of workers' productivity, and in terms of value added (GRP/GDP) for the city and for other regions of the country. Section 5 discusses the SCGE simulations for the extraction scenario under a mixed short-run/long-run closure (endogenous capital stocks but fixed housing stocks and residential locations). The paper concludes with some summary remarks and the opportunities to extend the analysis.

## 2. The study region

The São Paulo Subway System (*Metro*) is the main rapid-transit system in the city of São Paulo and the largest in Brazil. It is also the second largest system in South America and the third largest in Latin America, behind the Mexico City Metro and the Santiago Metro. The Metro has a length of 74.3 km (46.2 miles), distributed into five underground lines with 64 stations. The subway system carries 4000000 passengers a day – even though it is far from covering the entire urban area in the city of São Paulo –, running only within the city limits. Although with a limited territorial cover, it plays an important role in passenger mobility in the São Paulo Metropolitan Region (SPMR), as the system is interlinked with the Sao Paulo Metropolitan Trains Company (CPTM) and with other modal transportation terminals in the city of São Paulo (Fig. 1).<sup>2</sup>

The SPMR, the main economic and financial center of Brazil, consists of 39 municipalities in an intense process of conurbation. It is the fourth largest urban agglomeration of the world, and the largest urban agglomeration in the country, with about 10% of the national population (around 20 million inhabitants), and responsible for 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 (Table 1).

From a stylized perspective, one can notice the existence of an extended central business district (CBD) associated with the spatial configuration of economic activities in the metropolitan area. The CBD concentrates the jobs, while households are located in the surroundings of the center, with population density decay in the boundaries of the territory of the metropolis.

According to the 2010 population census, the city of São Paulo received daily an inflow of almost 1 million commuters, representing 15.4% of workers in the city.<sup>3</sup> From the total number of commuters, 82.7% came from different municipalities within the metropolitan area. The Origin Destination (O–D) Survey for the SPMR reported, for 2007, commuting patterns based on 460 zones – aggregated into 47 regions in Fig. 2 (nine administrative zones of the city of São Paulo and the remaining 38 municipalities in SPMR). The main attracting centers of commuters were the central and western zones of São Paulo, which respectively received a total of 180000 and 300000 commuters from other municipalities. On the other hand, the main origin municipalities of commuters were Guarulhos (138000) and Osasco (105000). In relative terms the municipalities of Francisco Morato and Franco da Rocha stand for having half of their workers commuting to São Paulo.

<sup>1</sup> Silva et al. (2012) analyze the benefits of the São Paulo subway in terms of the air pollution in the city, analyzing both the health outcomes and the related economic burden.

<sup>2</sup> [www.metro.sp.gov.br](http://www.metro.sp.gov.br).

<sup>3</sup> Around 170 thousands of São Paulo residents commuted daily to other cities, especially in the SPMR.

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