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Brazil's rail freight transport: Efficiency analysis using two-stage DEA and cluster-driven public policies

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ABSTRACT

This paper uses Data Envelopment Analysis to assess the efficiency of Brazilian rail concessionaires between 2010 and 2014, when new competitive regulations were introduced. In a second stage, a Bootstrap Truncated Regression was used to test the significance of exogenous variables on concessionaire performance: main type of cargo, track gauge, railway operation type (shared infrastructure or monopoly), in order to address an important gap in the literature. Secondary data came from the National Land Transport Agency (ANTT). The findings have significance for broad-gauge track commodities transport, while shared-infrastructure operations had no significance on efficiency, despite regulator incentives. Well directed regulations must encourage concessionaires to increase efficiency, particularly through incentives for agricultural and mineral commodities carried on the broad-gauge track characteristic of North and Center-West Brazil. Public policies designed to boost cluster efficiency are presented, addressing options such as upsizing, downsizing and resizing inputs, restructuring, best management practices and infrastructure upgrades.

1. Introduction

Due to the continent-sized dimensions of Brazil, cargo transport plays a leading role in lowering transportation costs. It is vital for servicing economic boundaries, increasing the competitiveness of companies and enhancing the well-being of the population through more affordable access to materials (industrial inputs) and goods. However, the cargo transport matrix is unevenly structured in Brazil, with the road mode accounting for some 67% and railways accounting for around only 18% [1]. There are several reasons behind this situation going back many years, which outside the scope of this paper. It is important to stress only that the road mode has higher total costs per unit carried than rail, for long-distance transport of goods [1], which is typical in Brazil. Brazil's cargo transport matrix structure holds the entire nation hostage to higher environmental and transport costs than countries with better balanced cargo transport matrixes [2]. It is, thus, a matter of strategic importance for Brazil to achieve an even balance for its transport mode matrix from the standpoint of the competitiveness of its companies and of the transport industry as a whole, lowering their overall CO2 emissions [3]. It will be important to make good use of potential reductions in outlays on logistics (freight fees, inventory, cargo handling costs and overhead) resulting from more intensive use of alternative means of transport with greater cargo unit capacity (railways and waterways) to service new economic frontiers in the Center-West, North and Northeast Regions, as well as areas with more mature economies.

For the transport infrastructure to function efficiently, its operations must be efficient in terms of sector-specific benchmarks. Thus, when presenting the topic of this survey – the cargo-carrying efficiency of Brazilian rail concessionaires – one must address the development of the Brazilian economy. For comparative measurements of concessionaire efficiency, a commonly used technique was used, which is Data Envelopment Analysis (DEA) [4–6]. The model allows comparative assessments to be made of a set of Decision-Making Units (DMUs), to see which of them are on the efficiency boundary of the production possibility set and thus benchmarks for other inefficient DMUs. From a methodological standpoint, this paper contributes in the second stage with an analysis using Bootstrap Truncated Regression (see Methodology) of the significance of contextual variables in DMU performance. The selected variables are 'predominant cargo' (agricultural

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commodities, mineral commodities or assorted cargo), track gauge (broad or metric) and 'type of operation' (shared infrastructure or monopoly). This paper seeks to shed light on the conditions that would boost the efficiency of Brazilian rail transport by evaluating, among other aspects, whether the regulatory incentives designed to boost competition offered by the ANTT after 2011 (see on Brazilian Rail Freight Context) — particularly shared track use — have been significant for DMU efficiency, which is the main gap in the literature. Proposed public policies focused on groups of concessionaires (clusters) with similar performances are presented.

The reminder of this paper is organized as follows. Initially, in Section 2, the Brazilian Rail Freight Context is presented. Section 3 shows a review of the literature on railway efficiency, indicating the gap in the literature. Section 4 describes the methodology used to analyze the data. Section 5 comprises a detailed description of the database and our findings, including the significance levels of the selected contextual variables on DMU efficiency. Additionally, rail concessionaires are clustered by performance, a proposal is made for public policies (item 5.4) and outliers are discussed (item 5.5). Section 6 concludes the discussion and presents the constraints of the survey and suggestions for future projects focused on the development of Brazil's rail freight sector.

2. Brazilian Rail Freight Context

Although Brazil's rail freight network is around 29,000 km long [7], it is used unevenly because while some segments carry heavy traffic every day, others are underutilized, if at all. Twelve concessionaires operate this network under a concession model that is controlled by the private sector from standpoint of the capital ownership. A minority share of capital is owned by the public sector (in America Latina Logística S.A., merged with Rumo Logistics S.A. in 2015, 8%; Vale, 5%; and VLI, holding that controls FCA and FNS, 16%), though this does not affect capital control. This private sector control was firmed up through the concession award process for rail transport systems in Brazil between 1996 and 1999 [8].

As to concessionaire performance, how is this impacted by the regulatory environment? More than half of the concessionaires haul mainly agricultural commodities and ores [7,9]. The predominant track gauge is metric (58% of the DMUs) and 25% of the DMUs in the sample operate shared infrastructure with other operators. The concessionaires are clustered mainly in South and Southeast Brazil (58%). Furthermore, most (74%) of the cargo carried on the system is considered tied to the rail sector (i.e., not subject to economic competition from other means of transport). Mineral commodities are particularly important (iron ore, other ores and coal) [9]. Transportation of agricultural commodities (soybeans, soy bran and maize), although typically carried by rail, is open to competition from other haulage options, especially the road mode with its economic and environmental externalities.

The key regulatory framework consists of provisions set forth in the concession agreements, supplemented by resolutions published by the National Land Transport Agency (ANTT) [4,6–9]. Some operating indicators present growth rates higher than those of the Brazilian economy for the period [9]. Important indicators include transport output in useful tons x kilometers (TKU), investments (in Brazilian reais), reduced rate of accidents (number of accidents recorded by number of trains and kilometers travelled) and cargo shipped in useful tons (TU). However, from 2011 onwards, the regulatory framework for the Brazilian rail sector was gradually altered in an attempt to include provisions for competition in the network, in order to provide users with greater benefits. Outstanding efforts include the removal of regulatory obstacles to facilitate the penetration of rail concessionaires into third-party networks, the setting of new contractual production (TKU) and safety targets and, subsequently, implementation of a methodology for calculating the rates to haul each type of cargo [10]. Resolutions promulgated by the ANTT in 2011 (Resolutions N° 3,694, 3695 and 3696/2011) [11–13] seek both to boost supplies for the concession system and encourage intra-mode competition; this can be achieved mainly through regulating mutual traffic and right-of-way operations and setting segment production targets for each concessionaire to allow third-party use of idle capacity.

The modifications to the regulatory framework fostered competition in the network while curtailing the monopolistic powers of the incumbents, culminating in Decree N° 8129, promulgated on October 23, 2013, which established the policy of free access to the federal rail sub-system, based on the European model [14–16]. Rail sector regulations made provision for separating the concessions for operating rail infrastructure and the rendering of rail transport services. Viewed as a whole, the regulations altered the organizational structure of rail operations from a monopoly regulated by segments to a contestable market with no barriers to entry, despite the existence of the economies of scale that are typical of natural monopolies and the multiplicity of services in the network.

The alterations being implemented suggest that the grantor authority was dissatisfied with the results of the administrative mechanisms put in place by the rail concessionaires. These included the exercise of monopolistic power in price management, control of supply quantities, and quality of service at a level often harmful to users. Although disputed by operators, these conditions were the principal reason for removing barriers to entry for new operators [10]. Concerns built up regarding whether the assessment of these matters was scientific and whether the selected remedy (regulatory actions) was the right choice for boosting the efficiency of Brazilian rail freight operations.

In this context, we present the main questions underpinning the proposal to generate expertise: How efficient are cargo-carrying rail concessionaires in Brazil? Which operators are on the efficiency frontier? What exogenous factors affect the efficiency of these companies? Do shared-infrastructure operations impact concessionaire efficiency? What public policies could be adopted to boost efficiency? This survey seeks to solve a practical problem for the Brazilian economy by delineating the conditions needed to boost rail freight efficiency and thereby enable lower transport costs in the supply chain of products being transported in Brazil. Table 1 presents the rail concessionaires that constitute the sample for this survey. In addition, the predominant cargo, rail network track gauges, regions serviced by each of the concessionaires and type of operation, whether shared infrastructure (with more than one operator) or monopoly (exclusive to a single operator) are listed. Concessionaires with shared operations addressed by this survey were ALL.P, which encompasses the operations of ALL.N, MRS and FCA; the EFC, which includes the operations of FNS; and FNS, which encompasses the operations of VALEC, handled by VLI on behalf of VALEC.

3. Literature review

Several surveys of analysis of transport system operating performance have been conducted using the non-parametric DEA model. Markovits-Somogyi [5] compiled 69 applications reported in the literature, finding that the methodology is widely used to assess companies in the transport sector through a wide variety of methodological nuances. The application of DEA has diversified to studies of airports (33%), ports (30%), public transport (15%) and railways (13%). Only five studies (7%), however, were conducted in South America, the majority being focused on Europe, Asia and North America. The inputs used were selected mainly from labor