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Spatial patterns of landside trade impedance in containerized South American exports

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ABSTRACT

The paper addresses claims implicating higher domestic transportation costs as a significant barrier to Latin America's trade and economic integration - and the region's inadequate transportation infrastructure as the primary cause. The relative "trade space" for U.S.-bound containerized shipments is delineated via reverse spatial interaction modeling. Reconfiguration and reverse calibration of the doubly constrained spatial interaction model is used to derive functional distances between origins and ports of export, as a means of estimating a Trade Impedance Quotient (TIQ) for trade flows at the scale of the continent. Global and local statistics of spatial autocorrelation are then used to analyze the spatial pattern of trade impedance. With this approach, the analysis of containerized flows establishes the existence, extent, location, and spatial distribution of discrepancies in South American landside trade impedance. A large share of trade flows have trade impedance that is disproportionate to distance. Trade impedance at origins is spatially clustered for the total dataset and randomly distributed for commodity segments, and randomly distributed at destinations. Potential focus areas for high trade impedance are identified.

1. Introduction

Latin America encompasses a spectrum of economic realities, both in terms of seemingly contradictory aspects of its economic performance as a world region, and also among its diverse national economies and their varied relationships with global trading partners. Considering Latin America's status as a developing region with great unfulfilled economic potential, economists note particular areas of concern for the region's economic integration, growth, and long-term stability. A persistent concern is the region's high transportation costs. It is increasingly clear that for the most pressing economic issues of the region – economic development and inequality – change cannot be effectuated without first reducing higher transport costs within the region (Fay and Morrison, 2007); (Mesquita Moreira et al., 2013).

The Inter-American Development Bank (IDB) notes several characteristics of transport costs that make them unique trade barriers: their high variability over time; their differing unit costs based upon weight (Hummels, 2001; Inter-American Development Bank (IDB), 2010; Mesquita Moreira et al., 2013), value, and perishability; and the fact that highly complex policy actions are required to affect change in transportation costs, due to the varied nature of their influences. These influences include volume and composition of trade flows, degree of competition between and within modes, and the varying quality of national (and sub-national) infrastructure (Limão and Venables, 2000; Clark et al., 2004; Mesquita Moreira et al., 2009; Inter-American Development Bank (IDB), 2010; Behrens, 2011; Mesquita Moreira et al., 2013; Chang and Tovar, 2014).

Inherent in many of these costs is regional export composition, which has built the region's "beaten paths" Mesquita Moreira et al., 2013). Additionally, in specific reference to the region, the IDB lists three reasons for higher transport costs in Latin America: lack of modal competition, urban congestion, and most especially, poor road quality and condition (Inter-American Development Bank (IDB), 2010). Trade costs stemming from customs delays are also noted regarding this region (Mesquita Moreira et al., 2009; World Bank, 2009; Inter-American Development Bank (IDB), 2010).

Regional economic development analysts claim that these disproportionate transport costs are primarily related to the region's inadequate transportation infrastructure (Mia et al., 2007). Yet in addition to the fact that infrastructure investment stands among the most costly solutions in any world region, history demonstrates that economic policy, processes, and regulation within Latin America pose significant challenges for financing and implementing infrastructure improvements (Green, 2003; Fay and Morrison, 2007). Thus it is dire that any

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suggested infrastructure improvements be targeted for maximum effectiveness in reducing transport costs. While the efficiency of Latin American transportation infrastructure is widely criticized as a trade barrier, the criticism is vague in that it has not been subjected to the types of multi-scalar trade and transportation analyses necessary to fully investigate impeding factors for Latin American trade.

Progress has recently been made in acknowledging this (Mesquita Moreira et al., 2013, 2009). The more recent study (Mesquita Moreira et al., 2013) was based on customs transactions in various years. An estimation of transport cost was constructed from variable cost and time factors, weight, and value, taking into account altitude and adjusted for road type along a least-cost network route from municipality to customs. This was then compared to the distribution of known exports. As in the present research, the focus is on the landside portion of the export journey. In Mesquita Moreira et al. (2013), transport cost and exports are nearly reciprocal; generally, high transport costs are occurring in areas further from main ports, which stems from the strong dependence on distance used in constructing transport cost. However, prior to recommending policy enhancements to facilitate Latin American trade growth and economic integration, evidence must be on hand regarding trade and transport costs. A premise of the present research is that trade impeding factors - which span the gamut of trade, national policy, and economic/sectoral issues, as well as those more directly associated with transportation – are best evidenced by the trade flows themselves. As trade flows reveal not just transportation-related costs, but all such costs, these are summarized here as generalized transaction cost or trade impedance (Kockelman and Ruiz-Juri, 2004; Navajas et al., 2010). Thus, while the approaches in Mesquita Moreira et al., 2013, 2009 espouse a traditional absolute space perspective, with the data and transport cost-constructions noted above, our view is that of a relative and relational space that is revealed by actual flows and trade interactions, which allows us to detect local departures from general cost-to-distance trends.

This is accomplished via a mathematical reversal of a gravity model of trade, a process that reveals distances as experienced during the shipping and trade process, and thus serves as a measure of generalized transaction costs or trade impedances. The modeling result of interest is expected distance (trade impedance), as explained in greater technical detail in Section 2.4. The first inquiry is intended to determine the existence and degree of trade impedance that is disproportionate to shipping distance, in order to address multiple claims that Latin American transportation costs are disproportionate to distance. It is these claims, along with the multiple sources of trade impediments in South America, which set the expectation that disproportionate trade impedance with respect to distance exists across the study region. This is first explored on the basis of all cargo shipments. In addition, as commodities differ based upon transportability (due to higher transport costs for heavy commodities (Hummels, 2001) and higher costs of insurance for higher-value goods (Hummels, 2009)), this study also compares the ratio of trade impedance (expected distance) to actual distance in terms of variability across six commodity categories.

As the institutional source of many recognized impedances to trade suggests that significant spatial autocorrelation would exist in trade impedance to actual distance ratio values across South America, we test whether these ratios are spatially random across South America. Whether or not an overall tendency toward spatial non-randomness exists, it is also beneficial for trade policy makers to adopt an approach that is spatially more focused, in order to identify local clusters of high or low trade impedance ratio values. A method such as this may assist in development of appropriate interventions for the reduction or elimination of impediments to trade and freight traffic.

This research is a crucial first exploration into the need for transportation infrastructure improvement for reduction of trade impedance in South America. On the premise that trade flows between locations across an economic space are organized according to a gravity modeling formulation, it follows a four-step approach, namely determining the existence, extent, location, and spatial distribution of trade impedance that is disproportionate to distance. Though it is widely held that the impedance experienced by freight shipments is disproportionate to the distance traveled in South America, the first step must be to determine whether trade impedance is indeed disproportionate - and, if so, with what magnitude. Additionally, the spatial distribution of trade impedance discrepancies must be investigated via analysis that provides "global" (or study-area wide) and local measures of its spatial pattern. The analysis is conducted on the domestic/landside portion of the shipment journey, from origin of production to port of export, for containerized cargo shipped by sea to the United States.

These first steps enable the study to be narrowed in terms of geographic framework and economic context, for the future focused analysis of sub-continental regions delineated by trade flow corridors. The existence of disproportionate trade impedance can begin to be specified by location of occurrence and association with potential trade impedance factors. Given the primary importance of the U.S. as a trading partner, this research is conducted in terms of U.S.-bound export shipments. The Latin American sub-region of South America is analyzed because it appears to be particularly poised to reap benefits from improved market access. Additionally, its trade impedance factors are demonstrated in the data to be quite different than those of Central America, Caribbean island nations, and Mexico.

The creative reconfiguration and unique application of a traditional spatial interaction model presented in this paper are applicable to many types of flow data, for exploring the association of a set of variables with disproportionate impedance. Thus, the methodology presented here is positioned as a useful tool for determining the existence, extent, location, spatial pattern, and association of disproportionate impedance evidenced in current and future flow data - such as that expected to be harvested from the Internet of Things (IoT).

2. Conceptual framework, methodology, and research questions

2.1. A conceptual approach in relative space

The vision advanced here demonstrates an analytical framework applicable not only to trade-transport interactions, but to many varied types of interactions involving flow data. It stands as an invitation to the relativist approach and an example of relative space methods.

As Thill (2011) forwarded in 2011, acceptance of only the isotropic plane, the "neutral container" (Jammer, 1969) into which we have long tacked events and interactions, is denial that these events and interactions in fact construct the space in which flows operate. Without the analytical tools to demonstrate this, our analyses are not representative of the space in which flows operate – in which semantic information is not separable from space, but comprises space (Thill, 2011).

The relative space analytical framework and quantitative method used here is an echo of the quantitative herald that Plane (1984) sounded some time ago. We are decades behind in hearing it. Prior to this, as Thill (2011) notes, scholars in the history and philosophy of science have combed through concepts of space in multiple disciplines. Geography cannot claim conceptual analogies with these disciplines. However, just as in the evolution of gravity models and their incorporation of practical depiction from physics, geography can borrow mathematical descriptions of systems, movement, or interactions which happen to be useful for different systems. Thill notes that since the 1960s, relativist mathematical models describing socioeconomic processes have been in use, noting Couclelis (1992). However, this line of thought and analysis has not yet permeated the mainstream of quantitative analysis.

Thus we can expand our understanding of the construction of space, adopting this practical task-list for relativist quantitative methods and their practical implementation which Thill (2011) forwarded a half-decade ago, including: the capture of both apparent and latent semantic information framing space(s), and measuring the dimensions of such;