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Brazilian Southern Borderland Strategic Circuits: a Network Approach

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ABSTRACT

This paper focuses on the role that borderland twin cities play on the hierarchy of transnational urban systems. It aims at analysing MERCOSUL road network measures of integration, synergy and centrality in order to display the correlations between the borderline twin cities functional specialization and the probability of transnational and cross-border flows. Methods are based on Space Syntax theories that provide descriptions of networks' structure properties at different geographical scales. The analysed road network spreads from São Paulo (Brazil) –the main South American industrial centre– to La Plata (Argentina) and Pacific seaports (Chile), comprising of five national territories: Brazil, Uruguay, Argentina, Paraguay and Chile. The analysis provides evidences that Paso de Los Libres/AR-Uruguaiana/BR twin cities hierarchical accessibility and centrality patterns in the regional structure correlate to their functional specialization as logistic hubs. We argue that these twin cities are strategic nodes controlling cargo flows within MERCOSUL due to their central position within the circulation network.

KEYWORDS

Borderline twin cities, MERCOSUL roads network, Cargo flows, Space syntax

RÉSUMÉ

Cet article porte sur le rôle des villes jumelées frontalières dans la hiérarchie du système urbain transnational, compris étant que résultat de l'interaction des propriétés morphologiques des réseaux local et régional. L'objectif est d'analyser quantitativement la probabilité de flux dans le réseau routier du MERCOSUR afin de saisir les corrélations entre la spécialisation fonctionnelle des villes jumelées situées à la frontière entre le Brésil et l'Argentine et leur position hiérarchique dans le réseau. Les méthodes sont basées sur la théorie de la syntaxe spatiale qui permet des descriptions multi-échelles de la zone d'étude, celle-ci étant délimitée au nord par la ville de São Paulo (Brésil) et au sud par la ville de La Plata (Argentine), en comprenant les territoires du Brésil, Uruguay, Argentine, Paraguay et Chili. L'analyse des villes jumelées Paso de los Libres/AR-Uruguaiana/BR signale une relation solide entre la position hiérarchique de ces villes dans le réseau routier et leur spécialisation fonctionnelle à cause de leur position stratégique de contrôle de flux de marchandises dans le MERCOSUR.

MOTS CLÉS

Villes jumelées frontalières, réseau routier du MERCOSUR, flux de marchandises, syntaxe spatiale.

1. INTRODUCING THE RESEARCH PROBLEM

International borderline regions are prioritised in transnational integration projects, although their role in controlling cross-border flows still arise concerns in Latin America. This article discusses the strategic role international borderline twin cities play in MERCOSUL urban network structure, focusing on Uruguaiana/BR-Paso de los Libres/AR case, a busy cargo cross border gateway.

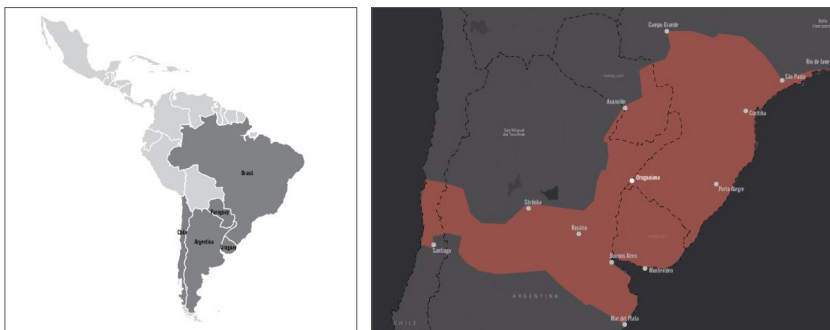
The hypothesis is that their hierarchical position in the regional circulation network differentiates the borderland region between Brazil, Uruguay and Argentina into subareas. Their heterogeneity is granted by the functional specialization of twin cities due to main flows characteristics that emerge from the interaction between local and MERCOSUL contexts, transport modals and merchandise flows towards global, local and regional markets, that in turn relate to spatial integration patterns, informing movement potentials and route choice probability.

MERCOSUL road networks properties are described with space syntax methods in which cities are nodal components of the network topological structure at global scale, allowing the measurement of their relative accessibility and centrality of each node. The modelling provides quantitative evidence to perform a hierarchical ranking towards potential movement and flows probability within the circulation system. The article displays preliminary evidences consisting of partial findings within the current research project "South American Transborder processes: Territorial Dynamics, Regional Development, Integration and Defense in Brazilian Southern and Northern borderland"¹.

2. CONTEXT: BRAZIL SOUTHERN BORDERLINE AND CASE STUDY

Brazil, Argentina, Uruguay and Paraguay borderland region characterise the configuration of the South American territorial divide due to its geographical, economic, political and strategic importance for the interactions between, firstly Spanish and Portuguese colonies, later, the emergent national states (Maxwell, 2012). The current territorial divide emerges from 19th century struggles over the La Plata Basin control, which testifies the imbricate relations between its geographical position, regional economic system, political disputes over territory and worldwide markets targeted by national states economies.

Figure 1. MERCOSUL road network boundaries (Fauri, 2015)



1 The project is coordinated by Aldomar Rückert (UFRGS) and supported by the Brazilian Federal Research Funding CAPES (PRO-DEFENSE/2013).

Brazilian borderland zone with Argentina and Uruguay comprises almost half of Rio Grande do Sul State area where half of its population is dispersed through a sparse urban network comprising small to medium-size cities. Numerous international borderline twin cities that are strategic nodes for globalised trading networks, attest for cross-border interactions intensity and resilience. Our case, the twin cities of Paso de Los Libres/AR has 45,803 inhabitants (INDEC, 2010) and Uruguaiiana/BR has 125,435 inhabitants (IBGE, 2010) and are connected by an international bridge across the Uruguay river. Uruguaiiana is classified as a sub-regional centre with restricted influence over its surroundings (IBGE, 2008). Our hypothesis is that its role as the main MERCOSUL logistic hub linking Brazilian production centers to Middle and Far Eastern markets relates to its centrality towards flows probability within the road network, that drives its functional specialization (Braga, 2013).

3. METHODS, MODELING TOOLS & RESEARCH TARGETS

In order to verify the hypothesis, Space Syntax methods (Al-Sayed *et al.*, 2014: 11) were applied regarding movement potentials and flows probability as generic functions of roads spaces. The road network is based on satellite images decomposed into a one dimensional graph, where axial lines represent the longest straight possible paths within a circulation structure. Modelling is performed on the resulting graph with Depthmap². The iconography structures accessibility in a colour range based on quantitative measurement, where hot colours are the most integrated spaces. The axial integration measure describes relative asymmetry globally or within a restricted topological radius (R3,5, etc.) captured by depthness (number of turns) from one point to all others.

Morphological properties are described, measured and analysed towards:

- a. *closeness centrality* (nodes's adjacency or relative accessibility) that equals to integration measure to infer origin-destination movement potentials within networks (Al-Sayed *et al.*, 2013);
- b. *betweenness centrality* (bridge effect on flows probability) computes a node's frequency in every possible path used to reach other nodes in the network, displaying the shortest paths from all origins to all destinations and forecasting vehicular movement (Hanna *et al.*, 2013);
- c. *route choice* displays our case hierarchical position towards cross-border and trans-national flows probability (Hillier *et al.*, 2007);
- d. *synergy* (correlation between global and local integration) measures the robustness of multiscale flows probability informing the emergency of alternative regional divides according to the twin cities' functional specialization. The hierarchical position on MERCOSUL roads network allows a spatial explanation of our case role as the main MERCOSUL cargo gateway (Al-Sayed *et al.*, 2013).

4. MOVEMENT AND FLOWS PROBABILITY THROUGH INTERNATIONAL BORDERLINES

Global Integration analysis highlights the paths with higher accessibility on the road network (figure 2), comprising the Uruguay river basin where Uruguaiiana/BR-Paso de Los Libres/AR is the higher origin-destination movement potential gateway. It displays

spatial evidence of historic territorial disputes for control over this strategic node and the paths with higher integration measures that have been The Paraguay War epicenter in the 19th century.

Local Integration (R20) depicts the urban network integration core limits (figure 3) comprising of its main seaports (Montevideo/UY and Buenos Aires/AR) and other borderline gateways such as Foz do Iguaçu/BR-Iguazu/AR and Ciudad del Este/PA-Salto/UY-AR), all of them holding intensive MERCOSUL cross-border interactions. Spreading from Salto, it encompasses the most part of Uruguay/Brazil borderland attesting its porosity, intensive interchanges and conurbation processes that enhances the urban network importance in structuring and controlling cross-border flows. The measure is also effective in explaining tourists' movement from Buenos Aires to the Brazilian/Uruguayan Atlantic coasts: Uruguai/BR is the potential main gateway between Argentina and Brazil, and Salto/UY for regional touristic flows. *Local Integration* spreads weakly to Colonia de Sacramento/UY, once a Portuguese enclave in Spanish Colonial Territories and to Santa Fé, Rosário, Mendoza and Córdoba/AR, leading to the Andes cross-border paths to Chile, through which intensive cargo flows originated in São Paulo, Buenos Aires and other production centres reach Pacific seaports.

Route choice (figure 4) displays the highest flows probability along the paths connecting São Paulo/BR to Mendoza/AR through Uruguai/BR and São Borja/BR, where the Brazil-Argentina roads systems connect. Santa Fé/AR is the main crossroad linking Buenos Aires to the borderland with Brazil and Paraguay. The segments with highest flows probability converge to strategic nodes where river crossings are possible. The locational choices of international cooperation infrastructure projects channel transnational and cross-border flows through easily controlled and surveilled nodes (bridges), achieving the regional economic integration aimed by MERCOSUL. Interchanges between the twin cities of Uruguai/BR-Paso de los Libres/AR are driven by their distinctive centrality towards cargo flows probability within the regional circulation network, what attests for this node resilience as an international cargo and logistic hub.

Figure 2. Global Integration (Braga and Fauri, 2015)

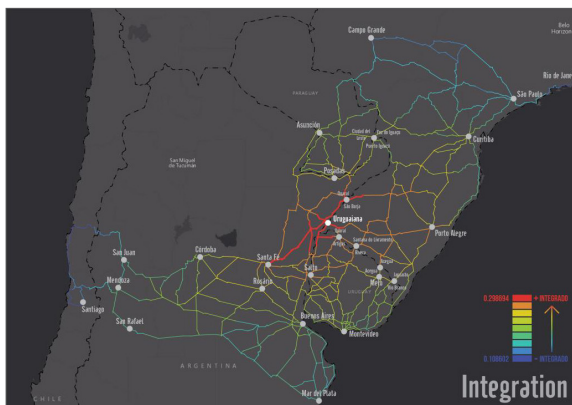


Figure 3 Local Integration R20 (Braga and Fauri, 2015)

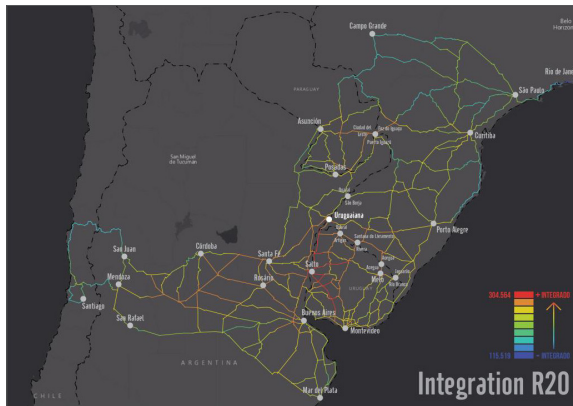
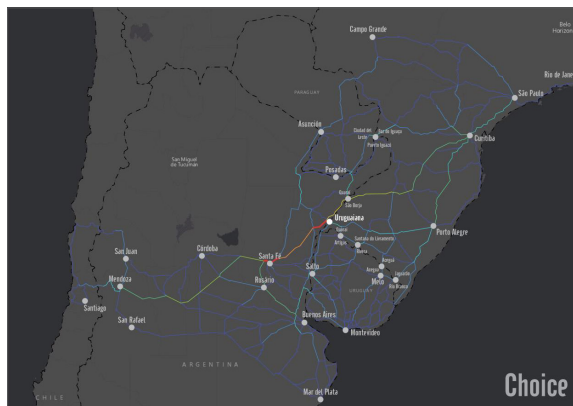


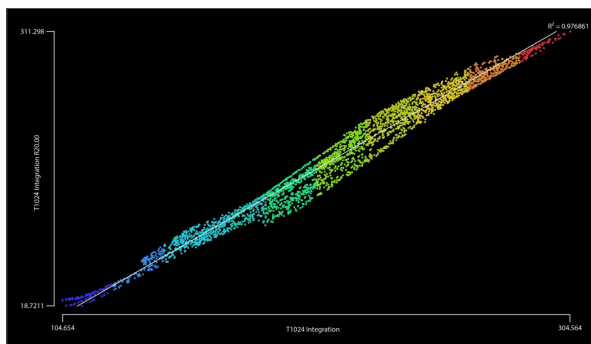
Figure 4. Route Choice System (Braga and Fauri, 2015)



5- ON FURTHER ANALYSIS: TOPOLOGICAL SCALE BOUNDED CROSS-BORDER REGIONS

The robust correlation between local and global integration measures (synergy) evidences the multiscale coherence between spatial integration patterns that reinforces the network hierarchy. Uruguiana/BR-Paso de los Libres/AR hierarchical position within the road network structure enables international cooperation investments and control strategies regarding cargo flows that characterize them as the main MERCOSUL logistic hub. Its functional specialization differentiates this case from others, where conurbation processes inform the prevalence of local cross-border flows and commuting. The ascending correlation attests for the emergency of an alternative regional divide enhancing a transnational logistic hub zone, driven by the economic integration between MERCOSUL national members (figure 5) and another one, in which microscale cross-border commerce induces the emergency of hybrid communities and cross-border market towns.

Figure 5. Synergy RN-R20 (Fauri, 2015)



In order to verify the acuteness of these preliminary findings, further research targets to widen multidimensional analysis, correlating twin cities functional specialization to qualitative data performed over an extended road network encompassing the whole of MERCOSUL territory, including local multivariable indexes such as GNP and import / export flows data to corroborate our general hypothesis.

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