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An analysis with electricity consumption data
and satellite images

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Abstract

This research analyzes the most attractive municipalities in Bolivia, that is, those capable of attracting (and retaining) more population, using new methodological approaches, specifically, using large databases of electricity consumption (Big Data) and powerful satellite images. The central analysis identifies the most attractive municipalities in the country and describes them using certain of their essential characteristics (their population, their geographical position, their political status, and their transport infrastructure). The main hypothesis of the research maintains that the greater concurrence of these variables (essential characteristics) is positively related to the degree of attractiveness of the municipalities.

Keywords: Bolivia, Migration, Attractive Municipalities, Big Data.

JEL classification codes: O15, O18.

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1. Introduction

The analysis of the most attractive municipalities in Bolivia, those capable of attracting (and retaining) more population within the country, is justified in the search for a better understanding of internal population dynamics. Dynamics that, many times, have been analyzed following only the main migratory trends or the simple presentation of the Net Migration Rates (NMR); without explaining more current phenomena, such as the formation of metropolitan areas, the complex dynamics of border municipalities, or the organization of certain special attractive regions (understood as groups of particularly successful municipalities). In this sense, this research seeks to understand - more completely - these phenomena based on new methodological approaches, specifically using large databases of electricity consumption and powerful satellite images (Big Data).

The identification of the most attractive municipalities in the country is contrasted with certain of their essential characteristics, specifically, their size (the most populated), geographical position (border or inland municipalities), political condition (departmental capitals) and, no less important, their provision of transport infrastructure (roads and railways); understanding that all these variables can be determinants for economic growth and development (World Bank, 2009; Henderson, 2001; Black and Henderson, 1999; Geddes, 1996; Evans and Rauch, 1999; Aschauer, 1989; Munnell, 1992; Calderón and Servén, 2004, 2011, 2014). Within this framework, the main hypothesis of the research sustains that the greater concurrence of these variables (essential characteristics) positively correlates with the degree of attractiveness of the municipalities in Bolivia. However, it is possible that they are not the only important variables and that, instead, they behave only as necessary (and not sufficient) conditions to achieve certain development and attractiveness (alternative hypothesis).

The first part of the research studies the distribution of the population of Bolivia, especially observing its concentration, that is to say, the most populated municipalities (cities and metropolitan areas), some of its geographical and political characteristics, and the main migratory dynamics that led to its constitution. It also analyzes transportation infrastructure (roads and trains) and how it determines international connections, specifically the country's main border points. In the second part, the main characteristics of the databases are presented, specifically, electricity consumption data and nighttime satellite images. Subsequently, the construction of the Attractiveness Index (AI) is presented, characterizing its variables and its potential scope. The third part presents the main results, which combines the analysis of the data obtained with AI and some potential explanations associated with the essential characteristics of the municipalities; seeking on the one hand, to characterize the municipalities classified as attractive by grouping them into potentially explanatory

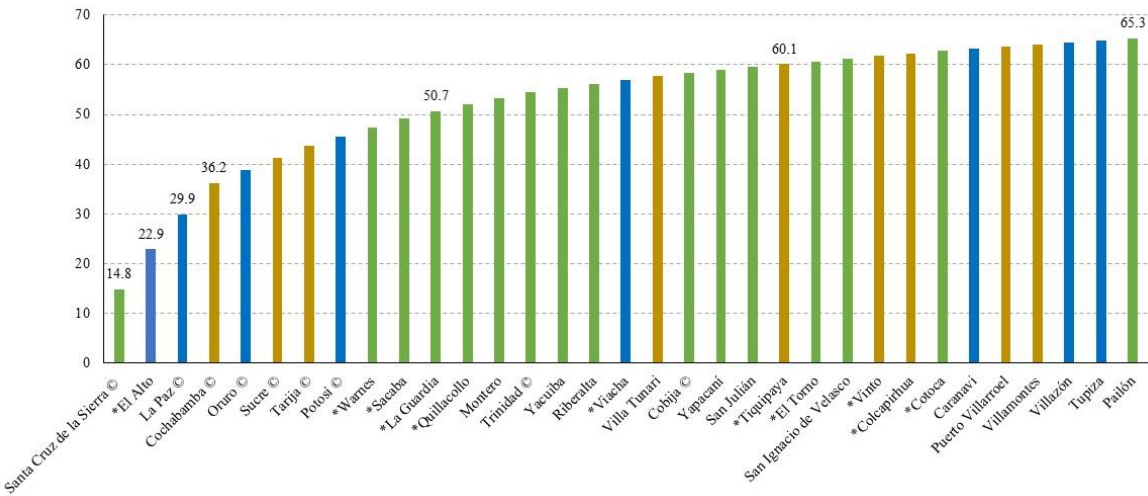
analytical sets and, on the other hand, to contrast the main hypothesis. Finally, the last section discusses conclusions and proposes certain public policy guidelines to enhance the most positive dynamics identified by the research.

2. The population of Bolivia: distribution and connections

The distribution of the population in Bolivia

Bolivia has an estimated population of around 12 million inhabitants (2020), distributed very irregularly over 1,098,581 Km². This distribution makes it one of the countries with the lowest population density in the world (with only 11 people per square kilometer)¹ and the second least densely populated in the Americas, behind only Canada. Additionally, the Bolivian population is highly concentrated in a few municipalities with the largest cities.

Graph 1: Cumulative percentage (%) of the Bolivian population by municipality (2020)



Note: © Departmental capitals, *Municipalities limited to one of the three main metropolitan areas. The blue municipalities are from the highlands (western Andean), the orange from the valleys and the green ones from the lowlands and Amazonia (east). Source: Andersen *et al.* (2020). <https://atlas.sdsnbolivia.org/#/>.

The so-called "central axis" - from west to east - is made up of the municipalities of La Paz, Cochabamba and Santa Cruz de la Sierra, which, taking into account their metropolitan areas², contain 47.5% of the national population. These metropolitan areas exhibit some of the best development rates in the country (Andersen *et al.*, 2020) and concentrate a

¹ [https://datos.bancomundial.org/indicador/EN.POP.DNST?locations=BO&most recent value desc=false](https://datos.bancomundial.org/indicador/EN.POP.DNST?locations=BO&most%20recent%20value%20desc=false)
²The metropolitan areas contain the following municipalities: 1) Metropolitan area of La Paz: Nuestra Señora de La Paz, El Alto, Viacha, Achocalla, Palca, Laja, Pucarani and Mecapaca; 2) Cochabamba metropolitan area: Cochabamba, Colcapirhua, Quillacollo, Sacaba, Sipe Sipe, Tiquipaya and Vinto; and 3) Santa Cruz metropolitan area: Santa Cruz de la Sierra, La Guardia, Warnes, Cotoca, El Torno and Porongo.

significant portion of the national economic activity, as indicated by the main studies that associate urban growth with economic development (World Bank, 2009; Henderson, 2001; Black and Henderson, 1999). Metropolitan areas have received important attention in recent decades in Bolivia due to their fast growth and associated challenges (Blanes, 2006; Cabrera and Escobar, 2021), as well as their multiple potentialities and opportunities (Andersen, 2002; UNDP, 2016).

Beyond the three metropolitan areas, the departmental capitals also stand out (see Graph 1), which due to their political condition (following Geddes, 1996; Evans and Rauch, 1999) have certain public services (departmental governments, Courts, etc.) and generate economic activity and population concentration (Just, 2022). On the other hand, some emerging intermediate cities are also relevant (UNDP, 2016; UDAPE, 2018), associated with their geographical position, status as a border point or other important characteristics (as will be seen later). In any case, Graph 1 illustrates that the 33 largest municipalities in the country (out of a total of 339), contain 65.3% of the Bolivian population, revealing the already mentioned high concentration of the Bolivian population.

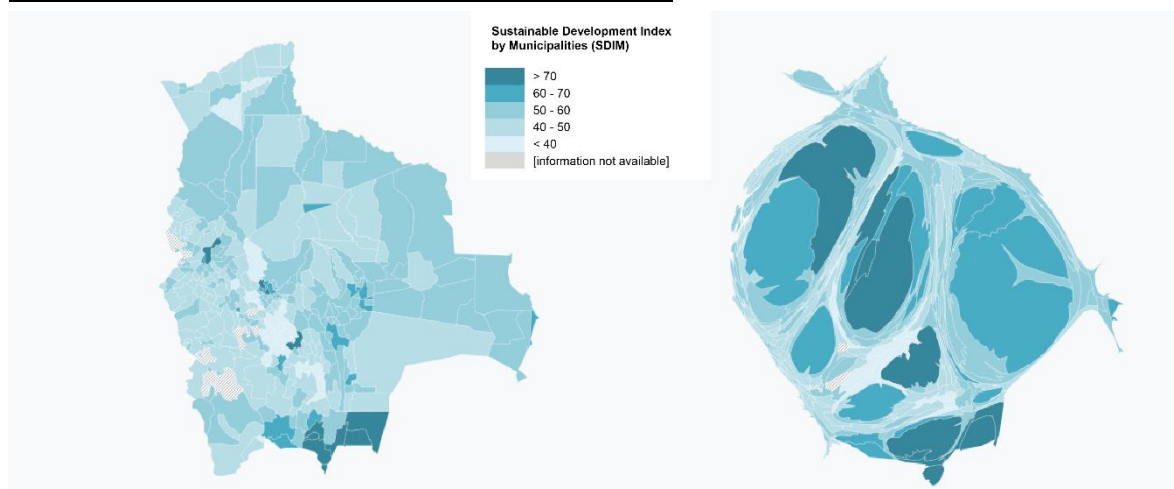
This distribution of the Bolivian population responds to two major internal migration trends. The first and oldest, the migratory trend from rural areas to urban areas (see Andersen, 2002; Gray Molina and Yáñez, 2009; UDAPE, 2018), which is clearly related to the best levels of well-being (public services, employment, education, etc.) that certain cities offer (Andersen et al., 2020), along with the problems of job creation and degradation of agricultural land that many small municipalities suffer (Balderrama et al., 2011). Data from 2012 already showed that 67.5% of the population lived in urban areas (INE, 2012), outlining a clear trend towards rural depopulation that does not seem to have stopped³.

In addition, there is a migratory trend from west to east (from the highlands and valleys to the lowlands), which has transformed and balanced the population of Bolivia (historically settled in the western highlands). According to estimates, by 2020, 37.7% of the Bolivian population would settle in the highlands, 27.9% in the valleys and 34.4% in the lowlands⁴. With a clear advantage in favor of the eastern municipalities that, with Santa Cruz de la Sierra at the head, mostly have positive Net Migration Rates (NMR) (Soliz, 2017; UDAPE, 2018). In this sense, it is reasonable to expect that the Bolivian population will increasingly settle in urban environments and with a greater preference towards the east of the country.

³ 54% of Bolivian municipalities have negative Net Migration Rates (NMR), almost all are rural municipalities and the vast majority are in the west of the country (93% between highlands and valleys) (UDAPE, 2018).

⁴ <https://www.ine.gob.bo/index.php/publicaciones/estimaciones-y-proyecciones-de-poblacion-de-bolivia-departamentos-y-municipios-revision-2020/>

Graph 2: Sustainable Development Index by Municipalities (SDIM) in Bolivia (2020): Political Map (left) and Population Density Cartogram (right)



Source: Andersen *et al.* (2020). <https://atlas.sdsnbolivia.org/#/>.

The scenario described above can be observed when comparing the Sustainable Development Goals at the municipal level, measured through the Sustainable Development Index by Municipalities (SDIM) (Andersen *et al.*, 2020). In the left part of Graph 2, it can be seen how the SDIM reaches its highest values in the largest cities (La Paz, Cochabamba, and Santa Cruz de la Sierra), in the departmental capitals (Sucre, Potosí, Tarija, Oruro) and in some municipalities in the south of the country (direct beneficiaries of hydrocarbon rents). What explains, in short, the right part of the graph, a cartogram deformed by the size of the population, which shows us how a few municipalities, territorially small, are the most important at the national level, due to the amount of population that lives in them.

Connections in Bolivia: transportation infrastructure and borders

Transportation infrastructure is a determining variable for economic growth, productivity and even social inequality in all countries (Aschauer, 1989; Munnell, 1992; Calderón and Servén, 2004, 2011, 2014) and the Bolivian case is no exception (Agramont and Flores, 2019). In Bolivia, the construction of this type of infrastructure has determined, in many ways, the

economic dynamism and population growth of its municipalities; either through the construction of railway lines (typically associated with the export of raw materials) or automobile roads (usually more oriented towards connecting internal markets). Without a doubt, a municipality with a road and rail connection has a much greater probability of generating sustainable development and being potentially more attractive to the population than one without these infrastructures. However, the construction of transportation networks in Bolivia has marked by high costs, slow progress, and incomplete projects. Certain structural characteristics of the country, such as its especially rugged topography, landlocked condition, very low population density, and its correspondingly low level of economic development, have not contributed to achieving a minimum transportation network that guarantees a good national or international connection (De Marchi *et al.*, 2018; Agramont and Peres-Cajías, 2016).

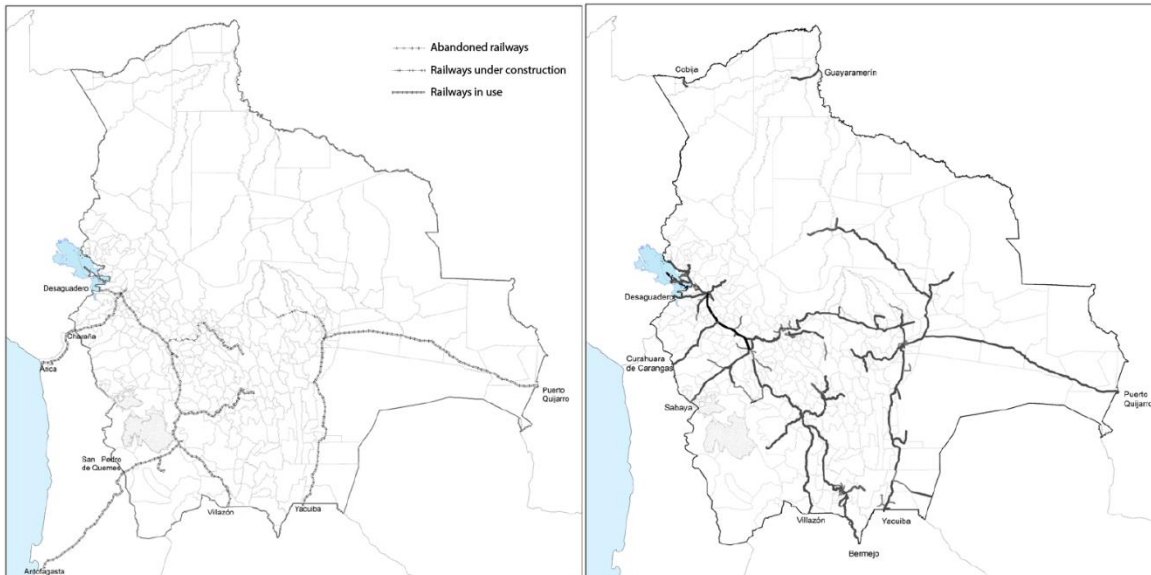
Regarding railways, Bolivia has two railway networks not connected to each other (see Graph 3, left side). The first and oldest is the western Andean network that, which spans 2274 km and extends through the departments of La Paz, Oruro, Potosí, Cochabamba and Chuquisaca. It was built since the end of the 19th century with the main purpose of exporting minerals (silver, tin, zinc and lead) and importing goods (machinery, food and fuel), through the Chilean ports on the Pacific Ocean (Contreras, 2003).

In this network, the Arica (Chile)-La Paz railway⁵ and the Antofagasta (Chile)-Uyuni railway (further south) stand out, as the two main Bolivian connection routes to the Pacific ports⁶. The connection between both railways passes through important municipalities such as Oruro, Viacha or Patacamaya. The western Andean network has several branches (typically short) that connect some mines with the main lines that end in ports; These branches have functioned as long as the mining operations that justified their construction have (for example, the San Cristóbal-Río Grande branch is fully operational, associated with the San Cristóbal mine; on the other hand, the Pulacayo-Uyuni branch stopped operating when the Pulacayo mine stopped extracting mineral). Likewise, the western network was also structured to connect important inland cities (Sucre, Cochabamba, and Potosí) and some agricultural towns in the upper Cochabamba valley (Punata, Tarata, Cliza and Aiquile). Finally, the connection via Tupiza to Villazón (border with Argentina) is also very important. This network had historical importance for transport people, but it lost it as other means of transportation (road and air) were developed, but it still retains its relevance in the transportation of goods (minerals stand out).

⁵ This train ran intermittently throughout its history for various reasons, it is currently out of operation.

⁶ There was also a branch to the lake port of Guaqui, on Titicaca Lake, which was used to trade and transport passengers via Peru. This section is no longer operated, it used to reach the city of La Paz.

Graph 3: Railway network (left) and road network (right) of Bolivia (2018)



Source: own elaboration based on data from Ferroviaria Oriental S.A. (<https://www.fo.com.bo/>), Ferroviaria Andina S.A. (<https://ferroviaria-andina.com.bo/>), GeoBolivia (<https://geo.gob.bo/>) and the Bolivian Road Administrator (<https://transitibilidad.abc.gob.bo/>).

On the other hand, the eastern railway network with 1,424 km (departments of Santa Cruz, Chuquisaca, and Tarija) connects the lowlands of the country with Brazil and Argentina; but more importantly, it connects the country with the Paraguay-Paraná waterway, the De la Plata River and, ultimately, with the ports of the Atlantic Ocean. This network was designed mainly for the export of agricultural products (Limpas, 2009), and currently it is used for the export of soybeans and their derivatives, among others. The network has two important branches, Santa Cruz-Puerto Quijarro (border with Brazil) and Santa Cruz-Yacuiba (border with Argentina). Likewise, it extends north from Santa Cruz to Montero, and a new section is under construction that will pass through Yapacaní to Entre Ríos (Bulo Bulo, specifically).

It is regrettable that the two Bolivian railway networks (western and eastern) are not connected to each other, which limits the country's role as a continental and bi-oceanic integrating axis, restricting the volume of trade and keeping national markets dependent on road connections (De Marchi *et al.*, 2018). Additionally, although it is true that many important railway branches are no longer operational (Oruro-Cochabamba, for example), or have significantly reduced their functionality (Viacha-Guaqui), the old layout of the railway lines later determined the design of many of the modern roads that pass through municipalities that already had a certain commercial importance, making some old railway

stations maintain their relevance but associated with the highways (Viacha, Patacamaya or Oruro).

With reference to the road network, in 2015 Bolivia had 10,593 km of paved roads and another 30,383 km of gravel roads (Contreras, 2017). The historical process of building roads in the country had the main purpose of connecting isolated populations to ensure that their production - usually agricultural - reached the markets of the largest cities. Likewise, it was fundamental for the promotion of internal migration from the highlands (not very fertile) to the lowlands of the eastern departments. In this sense, the La Paz-Cochabamba-Santa Cruz highway is the main Bolivian road infrastructure, connecting the largest cities; Likewise, it is the most used internal trade route, and explains the migratory processes and the emergence of metropolitan areas.

The road network is older than the railway network and was built by expanding the colonial paths (Contreras, 2017) that connected the main towns, almost all of them in the west. Later, roads also connected the country with its neighbors (Peru, Chile, Argentina, Paraguay, and Brazil) and competed with the railway network in the transport of goods and people (successfully in both cases, but to a greater extent in the transport of people). The road network is more extensive than the railway network, much deeper in its internal expansion and is the only land way to reach the northeastern departments of Beni and Pando, the least populated⁷. The paved international connections that integrate the fundamental road network (RVF) with neighboring countries and with the main commercial ports used by the country are very important; highlighting the Tambo Quemado-Arica (Chile) road, which leads to the main commercial port for Bolivian use (Agramont and Flores, 2019); although the roads to Peru, via Desaguadero, are also important; towards Argentina, via Villazón and Yacuiba; towards Paraguay, via Palo Marcado (municipality of Villamontes) and towards Brazil, via Puerto Suárez.

2. Data and the Attractiveness Index (AI)

The electricity consumption data

The electricity consumption data (kWh/month) correspond to the records of residential and commercial meters in Bolivia (duly anonymized), with monthly frequency between the years 2012 and 2016, consolidated in a database with 116 million observations (Andersen *et al.*, 2019). The database has information for 327 of the 339 municipalities in the country, both for the integrated system (92% of connections) and for isolated systems (8% of connections outside the network) (Hinestroza-Olascuaga *et al.*, 2021); giving us a complete image of the

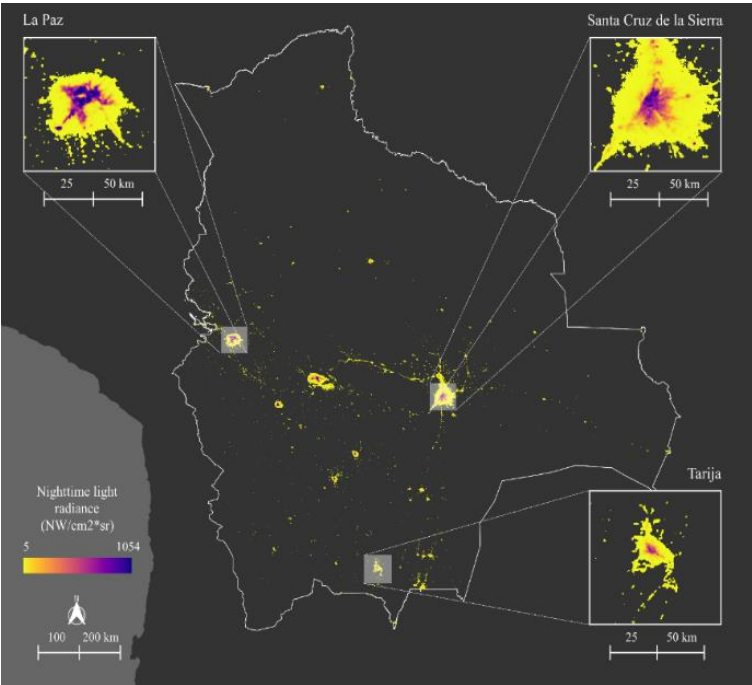
⁷ Unfortunately, the departments of Beni and Pando do not have paved roads that link their main municipalities (Guayaramerín, Riberalta or Cobija) with the national road network.

country due to the high coverage of the electrical service in 2020 (93.7%, according to official estimates (Bolivia, 2021)). These data give us valuable information about the magnitude of electricity consumption at the municipal level, about its different categories (residential, commercial, etc.) and its evolution over time.

Night satellite images

Satellite images measure the nighttime luminosity (NTL)⁸ of most urban centers in Bolivia, aggregated to the territories corresponding to each municipality (Garbasevski *et al.*, 2023), with annual observations (2012-2016) provided by the Black Marble project of the National Aeronautics and Space Administration (NASA) (Román *et al.*, 2018). In Graph 4 we can see the NTL of some of the main cities in the country, where La Paz, Santa Cruz de la Sierra, and Tarija are highlighted. In addition, it is possible to identify the main departmental capital cities and, with a bit more difficulty, some towns along the main road connections (for example, the La Paz-Santa Cruz highway can be delineated). Likewise, the map also reflects the low population density of the country and its serious integration problems, showing few relevant population centers, usually isolated from each other.

Graph 4: Distribution of nighttime luminosity (NTL), using satellite images of Bolivia (2016)



Source: Garbasevski *et al.* (2023) y Román *et al.* (2018).

⁸ The specific measurement of the intensity of nighttime light radiation is (NW/cm2*sr), for more details see Román *et al.*, 2018.

Attractiveness Index

The Attractiveness Index (AI) is built from the normalization of five relevant variables to approach the phenomenon of internal migration and the capacity of municipalities to attract population (all of them reflect data on electricity consumption and night luminosity). Specifically, the first variable (θ_1) is the average (2013-2016) of the annual variation in the number of residential electricity meters, understanding that municipalities that attract population increase their number of household meters (with positive consumption).

Secondly, (θ_2), is the average (2013-2016) of the annual variation in residential electricity consumption, in this case focusing on energy demand, also as an indicator of economic dynamism; It is reasonable to think that municipalities with increases in household consumption are attracting more population. Third and fourth (θ_3 and θ_4), we repeat the two previous variables, but for the case of businesses, that is, the average (2013-2016) of the annual variation in the number of electric meters of the businesses and the annual variation in business electricity consumption. Finally, for (θ_5) we take the average (2013-2016) of the annual variation of nighttime luminosity, the lights that turn on at night seen in satellite images from NASA data, specifically from the Black Marble project (Román et al., 2018). With all this data, it is possible to build the normalized Attractiveness Index (AI):

$$IA = \left\{ \sum_i^n (\theta_i - \theta_{i(\min)}) / (\theta_{i(\max)} - \theta_{i(\min)}) \right\} / n$$

and order the Bolivian municipalities from the most attractive to the least.

3. Results

As our interest is to understand the dynamics around the most attractive municipalities, we focus our analysis on the 10% of the municipalities with the highest values according to the Attractiveness Index (AI), that is, the 34 most attractive municipalities, summarized in the Table 1. In addition, Table 1 shows us some of its essential characteristics, specifically, if it is a municipality belonging to one of the three main metropolitan areas (Metro); if it is Departmental Capital; if it is a border municipality; if it has a paved road connection to the fundamental road network; and, finally, if it has a rail connection.

Table 1: Most attractive municipalities (Top 10%): AI and characteristics

<i>Municipality</i>	<i>AI</i>	<i>Metro</i>	<i>Departmental Capital</i>	<i>Border</i>	<i>Paved road</i>	<i>Railway</i>
Santa Cruz de la Sierra	0.93	X	X		X	X
El Alto	0.71	X			X	X
Cochabamba	0.60	X	X		X	X
La Paz	0.51	X	X		X	X
Quillacollo	0.42	X			X	X
Oruro	0.40		X		X	X
Sucre	0.40		X		X	X
Uyuni	0.39				X	X
Sacaba	0.35	X			X	X
Tarija	0.34		X		X	
Guayaramerín	0.33			X		
Viacha	0.32	X			X	X
Warnes	0.32	X			X	X
Cobija	0.32		X	X		
Tupiza	0.32			X	X	X
Punata	0.31				X	X
La Guardia	0.31	X			X	X
Cotoca	0.30	X			X	X
Colcapirhua	0.30	X			X	X
Yacuiba	0.30			X	X	X
Camargo	0.30				X	
Montero	0.30	X ¹			X	X
Coripata	0.29					
Caranavi	0.28				X	
Trinidad	0.28		X		X	
Palos Blancos	0.28				X ²	
Sipe Sipe	0.28	X			X	X
Tiquipaya	0.28	X			X	X
Las Carreras	0.28				X	
Villa Tunari	0.28				X	
Puerto Villarroel	0.28				X	
La Asunta	0.28					
Atocha	0.27					X
Riberalta	0.27				X	

Note: ¹ Montero is not officially part of the Santa Cruz metropolitan area, however, its proximity makes it so in practice.; ²road under construction. Source: Own elaboration based on data from Andersen *et al.* (2019) and Román *et al.* (2018).

Metropolitan areas

The three main metropolitan areas are the most attractive groups of municipalities in the country. The notable predominance of Santa Cruz de la Sierra (AI=0.93) stands out, followed by El Alto (0.71), Cochabamba (0.6) and La Paz (0.51), all well above the national average (0.25). This prevalence of the three main metropolitan areas is evidently explained by the fact that they are the most populated urban centers in the country and, consequently, the places that offer the greatest probability of finding a job. As already noted, the three metropolitan areas also constitute the so-called central axis from west to east, which has a paved highway connection (the most important for the country's foreign trade) (see Graph 5 and 6); This situation also increases and facilitates the migration of the population between the three areas, making their municipalities the most attractive and dynamic in Bolivia. Likewise, we must not forget the connections with the two railway networks of the west and the east that, although unconnected, are fundamental for foreign trade and economic growth (for example, the important train to Puerto Quijarro for the agro-industrial production of Santa Cruz).

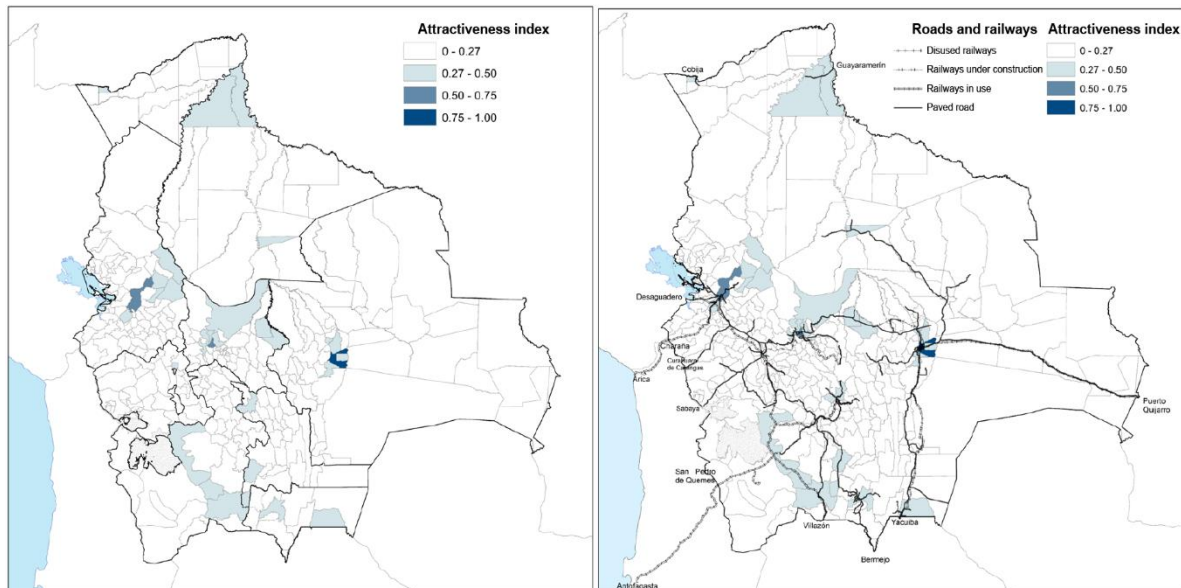
Many medium or small municipalities that belong to metropolitan areas are also attractive to the Bolivian population. In the metropolitan area of Cochabamba, Quillacollo (AI=0.42), Sacaba (0.35), Colcapirhua (0.30), Tiquipaya (0.28) and Sipe Sipe (0.28) stand out⁹. In the metropolitan area of Santa Cruz, Warnes (0.32), La Guardia (0.31) and Cotoca (0.30). And in the metropolitan area of La Paz, only Viacha (0.32) (the rest was possibly eclipsed by the attractiveness of El Alto (0.71)). Furthermore, although they do not appear among the 10% of the most attractive municipalities in the country (Table 1), almost all metropolitan municipalities occupy positions marginally above the national average: in the metropolitan area of La Paz, Achocalla (0.26), Palca (0.25), Laja (0.26), Pucarani (0.26) and Mecapaca (0.26); in the metropolitan area of Cochabamba, Vinto (0.27) and in the metropolitan area of Santa Cruz, El Torno (0.26) and Porongo (0.27). The municipality of Montero also stands out (0.30), although it does not formally belong to the metropolitan area of Santa Cruz, in practice and due to its proximity, it does.

The analysis shows that metropolitan areas attract a large amount of population, but with disparate results. In the case of La Paz, El Alto stands out greatly and leaves municipalities like Palca or Pucarani far behind. On the other hand, in the metropolitan area of Cochabamba, almost all its municipalities show notable results (within the 10% most attractive). Finally, the case of Santa Cruz, with exceptional dynamism, shows that its metropolitan influence even exceeds its own formal jurisdiction, as in the case of Montero.

⁹ The municipality of Punata also stands out, although it is located near the metropolitan area of Cochabamba (47 km), it does not belong to or border it.

In any case, it seems that metropolitan dynamics are a kind of competition process between metropolitan municipalities to attract the population that congregates around large cities, where proximity is always beneficial but not enough to stand out.

Graph 5: Map of the most attractive municipalities and transportation infrastructure in Bolivia



Source: Own elaboration based on data from Andersen *et al.* (2019), Román *et al.* (2018), Ferroviaria Oriental S.A. (<https://www.fo.com.bo/>), Ferroviaria Andina S.A. (<https://ferroviaria-andina.com.bo/>), GeoBolivia (<https://geo.gob.bo/>) and the Bolivian Road Administrator (<https://transitibilidad.abc.gob.bo/>).

Departmental capitals

Secondly, we have almost all the departmental capitals, that is, Sucre, Oruro, Tarija, Trinidad and Cobija (in addition to La Paz, Cochabamba, and Santa Cruz, already explained). It is possible that the significance of these municipalities as attractive destinations is explained both by their greater provision of private services based on their population (commerce, education, health, etc.), and by a greater presence of the State (police, courts, and public services)¹⁰. Both phenomena have an impact on greater labor demand (administrative, university or healthcare positions), which ultimately replicates the dynamics of large cities, although on a smaller scale.

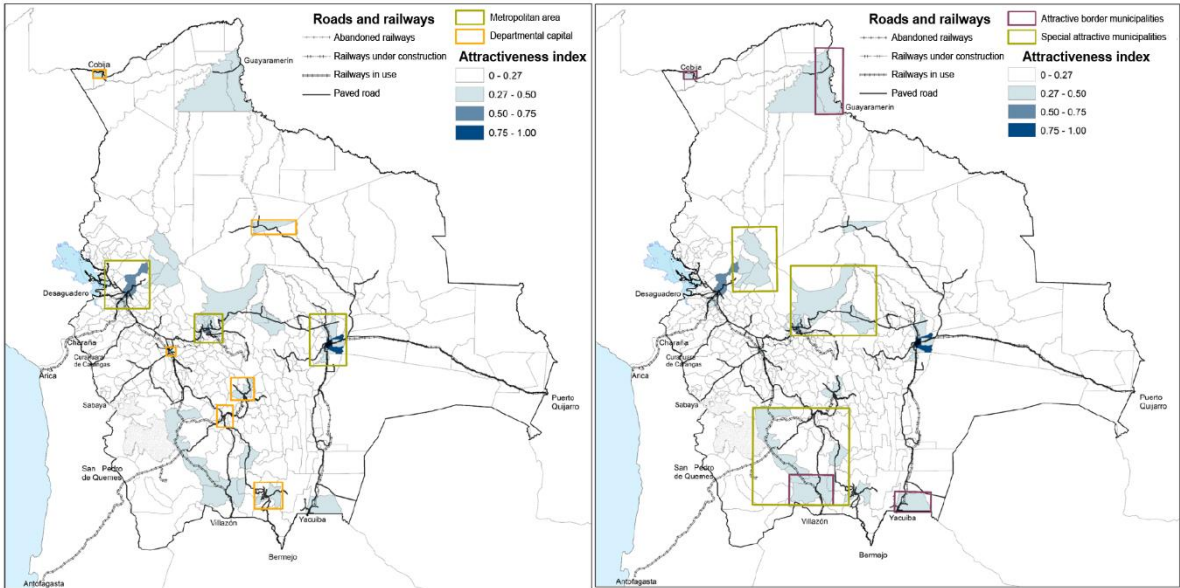
Likewise, it is reasonable to think that a part of the population, which migrates from the countryside to the city, prefers the closest municipality that offers greater possibilities,

¹⁰ This concept is fully related to the one proposed by Just (2022), which indicates the existence in Bolivia of a fragmented State that only achieves a certain intensity where it can provide some public services and showing a certain presence.

thus minimizing its migration costs, and this seems to coincide with the departmental capitals.

We must not forget that almost all departmental capitals are duly connected to the fundamental road network (see Graph 6) through a paved road, which increases their attractiveness (with the only exception of Cobija in the Department of Pando)¹¹. Finally, it is striking that Potosí (capital) does not appear among the most attractive municipalities in the country and occupies a lagging position (AI = 0.25), just above the national average. This may be due to its proximity to Sucre (150 km), a quite attractive municipality (AI = 0.4), with a better weather, and which was traditionally preferred by some Potosinos as a place of residence; In addition, it may also be related to the strength of Uyuni, which is the most attractive municipality in the department of Potosí and one of the best in the country.

Graph 6: Map of the most attractive municipalities in Bolivia: metropolitan areas, departmental capitals (left side), border and special municipalities (right side)



Source: Own elaboration based on data from Andersen et. al (2019), Román et al. (2018), Ferroviaria Oriental S.A. (<https://www.fo.com.bo/>), Ferroviaria Andina S.A. (<https://ferroviaria-andina.com.bo/>), GeoBolivia (<https://geo.gob.bo/>) and the Bolivian Road Administrator (<https://transitibilidad.abc.gob.bo/>).

Border municipalities

¹¹ Tarija and Cobija do not have a railway connection, see Graph 6.

The municipalities of Guayaramerín and Cobija (border with Brazil), Yacuiba and Tupiza (border with Argentina), also stand out as important attractive municipalities¹² (see Graph 6). This is explained by the positive economic dynamics that border cities have with the large economies of Brazil and Argentina. The population that lives in these municipalities traditionally benefits from the public services of border countries (education in Argentina or health in Brazil), in addition, they have many opportunities for trade (legal or smuggling) and employment.

However, being an important border municipality does not directly imply greater attractiveness. For example, municipalities bordering Peru, Chile or Paraguay do not appear on our list. This may be due to several factors, firstly, it seems that these municipalities are next to a neighboring town; for example, Cobija (Bolivia)-Brasileia (Brazil), Guayaramerín (Bolivia)-Guajará-Mirim (Brazil) or Yacuiba (Bolivia)-Salvador Mazza/Pocitos (Argentina); On the other hand, other important border points, such as Tambo Quemado (Curahuara de Carangas municipality), have not been developed, possibly because there is no border population in the neighboring country (Chile, in this case).

Secondly, it seems that being a border municipality offers development possibilities associated with access to foreign markets, which municipalities in the interior of the country do not have. In fact, some of these border municipalities have managed to be attractive even when they are not fully connected to the national market (Cobija and Guayaramerín, for example), which are more connected to the outside than to the inside of the country.

Groups of special attractive municipalities

This category of attractive municipalities is made up of three groups in three different regions (see Graph 6), but in all cases, they are groups of municipalities -close to each other- that are generating a type of attractive regions. Firstly, the group made up of the municipalities of Coripata, La Asunta, Caranavi and Palos Blancos stands out, located to the east of the Andes, in the jungle region of Los Yungas in the department of La Paz. This group of municipalities has a partial road connection, which reaches Caranavi and which is under construction in its section to Palos Blancos (there are no paved roads to La Asunta or to Coripata). Secondly, we have the group made up of the municipalities of Villa Tunari and Puerto Villaroel, in the tropical area of Chapare in the department of Cochabamba. This group benefits from the connection to the road network through a paved highway (between Cochabamba and Santa Cruz). Both groups explain their attractiveness by agricultural activities, among which the cultivation of coca leaves stands out, but also livestock (cows), fishing and forest wood;

¹² Some non-border municipalities, but very close to the border, also benefit from this feature. This is the case of Riberalta, very close to Guayaramerín. And, in some way, this is also the case of Tupiza, which, although territorially borders Argentina, benefits from a border crossing between Villazón and La Quiaca.

Unfortunately, illicit economic activities also stand out, specifically, drug trafficking and illegal gold mining.

Finally, it is possible to identify a third special group, formed by the municipalities of Uyuni, Atocha, Las Carreras and Camargo, in addition to Tupiza (already considered in the group of border municipalities). This group is located between the departments of Potosí, Chuquisaca, and Tarija, near the border with Argentina and has an important road infrastructure (the western railway network that ends at the Pacific Ocean and some important highways), although greater and better connections are lacking. The reasons that explain its attractiveness are multiple, firstly, the tourist importance of the Salar de Uyuni, the main tourist destination in the country with great potential; secondly, its proximity to large mining operations (San Cristóbal in the municipality of Colcha K, the largest mine in the country); thirdly, the already noted importance of Tupiza (and Villazón) as an international border; and, last but not least, the existence of significant wine production (wine and Singani) in the Cinti valley (Camargo, Las Carreras and others). This special group of municipalities is very interesting because it has a broad and diverse set of economic drivers that explain its attractiveness. Furthermore, the lithium mining reserves in Uyuni (and other nearby municipalities), along with other minerals equally necessary for an energy transition, outline a potentially prosperous future. Without a doubt, a remarkable combination in the national territory.

4. Conclusions

We can summarize some of the fundamental reasons that explain the success of attractive municipalities. Mainly the population (the metropolitan centers with the best job opportunities), the connection to a road or railway network (essential for domestic and foreign trade), the proximity to other countries (border municipalities), the existence of a certain state presence (services public) and, finally, some economic activities in growth or expansion. In the first instance, we cannot reject our main hypothesis since the greater concurrence of these essential characteristics seems to be positively related to the degree of attractiveness of the municipalities in Bolivia. However, the existence of some attractive municipalities that have these characteristics and, even so, fail to stand out, leads us to move closer to the alternative hypothesis; It seems that these essential characteristics behave more like necessary, but not sufficient, elements to achieve development and attractiveness. Furthermore, the identification of some municipalities that, without having essential characteristics, are attractive is also striking; This is the case of Cobija and its lack of road connections, or of Uyuni that competes with the large departmental capitals without being one.

It is important to propose public policies that promote the development of some of the most attractive municipalities in the country (as generators of growth and well-being). The absence of a road connection with the northeast of Beni (Riberalta and Guayaramerín) and with the capital of Pando (Cobija) is especially worrying; These municipalities are attractive to the population due to their proximity to Brazil, but it seems that their potential is frankly wasted by Bolivia. In the opposite sense, it is necessary to investigate the lack of attractiveness of some municipalities in the south of the country (direct beneficiaries of gas revenues), since they have very important development indicators and, however, they do not stand out as attractive for the population.

Likewise, it could be very reasonable to support those municipalities that base their attractiveness on a broad set of reasons (think of the special group of Uyuni, Atocha, Las Carreras, Camargo and Tupiza); since their combination of various economic activities (mining, tourism, agriculture, and commerce), their proximity to a border and a good road connection makes them potentially more sustainable over time. These types of positive synergies must be identified and supported by public policies.

Finally, the country's road and railway networks must be improved, seeking to transform Bolivia's geographical condition - landlocked but central in South America - into an element of national development. In this sense, the definitive connection of the two railway networks of the east and west must be achieved, and the road connections must be significantly improved.

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