Chapter 3

Regional freight transport modeling: considerations from South America

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Highlights

- Efficient integration of Latin American countries in the global supply chains.
- Development of freight transport models required "to think" on regional supply chain level.
- Evaluations of modeling need to inform effective long-term infrastructure decisions.

1. Introduction

South America is a region of enormous economic and social disparities. South American countries range from populations of 200 million (Brazil) to 3.5 million (Uruguay) and surface of 8.5 (Brazil) to 0.17 million km^2 (Suriname). The size of the markets and the level of development are various too. Although there are some members of the G20 and Organisation for Economic Co-operation and Development, there are others who have a gross domestic product (GDP) per capita of less than US $4000.

Nevertheless, there are several similarities in their economic structures, mainly given by the importance of the extraction of raw materials and low added value manufacturing. This production structure is export oriented, mainly to more developed countries, while importing industrialized goods.

The import and export flows influenced the development of transport networks in the region. The objective of the network was to develop the

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infrastructure to facilitate the flow of exports to ports, rather than to develop a network for integrating regional economies and societies, as part of its colonial legacy.

There is a strong dependency on road transport all over South America for the internal movement of goods. The main railway systems are those of Argentina and Brazil, although their modal share is relatively low. Regarding the intraregional trade, the largest share corresponds to sea trade (64% in volume and 46% in value), and a significant share is moved by road (30% by volume and 39% in value). There is some marginal transport by air, being of just 0.17% in volume (but 6.5% in value; Wilmsmeier & Spengler, 2015).

The appearance of global supply chain (GSC) and regional supply chain (RSC) reinforces the opportunity to take advantage of these regional flows to generate added value throughout the entire region. GSC reinforces the notion that competition is no longer between countries but between supply chains. Understanding and adopting the notions of GSC and RSC help to understand the new dynamics of the regional flows and how the transport systems can evolve.

Some actions can stimulate the GSC and RSC development in the region. Reduction of trade barriers among members, transport systems improvement, and regulatory cooperation and compatibility can be effective in doing so (Blyde, 2014). The results could help the generation and consolidation of RSC and participation in GSC.

Regional integration also plays a big role in the implementation of GSC and RSC in South America. Economic blocks such as Mercosur or the Pacific Alliance have proven to increase the trade among its members but have not changed the export profiles of the countries and the participation of intraregional trade (Desiderá Neto & Teixeira, 2012). Efforts to increase compatibility between regulations, foreign trade procedures, and logistical efficiency of international trade have been made in the last decades. Nevertheless, the experience in integration is still rather new.

More ambitious structures of regional integration have also been realized, such as the Union of South American Nations (UNASUR), which consists of all South American independent nations. (Currently, most structures of the UNASUR are not active. However, it is still a good example of regional integration initiatives.) Under this organization, several sectorial councils have been established with the participation of the ministries of the participants' nations. The most relevant action for transport infrastructure is the South American Council of Infrastructure and Planning (COSIPLAN), created in 2009. In 2011, the Initiative for Regional Integration of Infrastructure in South America (IIRSA) was created to support COSIPLAN with infrastructure development for boosting regional connectivity. The areas involved are transport, energy, and telecommunication.

However, since the integration processes is recent, many national interests tend to prevail over the regional ones. The internal transport policies of each country can collide with the global optimum of the region. This is especially true for "middle" regions (i.e., regions with passing flows from other countries).

To address, justify, and prioritize infrastructure investment, different transport models have to be implemented. Every model has its scope, objectives, strengths, and weaknesses, so it is logical that some adaptation has to be done to analyze different policies.

They vary across several aggregation levels, territorial coverage, data requirements, and institutional coordination needs. Areas can range from complex multinational corridors to localized country-level network revitalization. The objective of this chapter is to describe the models needed to address policy and infrastructure development in the context of regional integration in South America, discussing the various levels of aggregation and data needed. To do so, the framework proposed by de Jong et al. (2016) adapted to developing countries in Chapter 2 and with the overall description of models by de D Ortúzar and Willumnsen (2011), the main characteristics of the models are described. The models will be characterized with respect to its level of aggregation, data needs, and objectives and analyzed its compatibility with the objectives of the model.

The chapter will continue with Section 3.2, addressing different integration axes, choosing one of them for the modeling description, and exposing the general modeling requirements. Section 3.3 will address the particular example of infrastructure works between two countries with the binational tunnels under the Andes Mountains, and Section 3.4 will discuss the case of rail open access policy in Argentina to illustrate the difference between regional- and country-level policies. Finally, Section 3.5 will show the conclusions.

2. Regional development axis

As a consequence of the greater coordination among the different agents in the supply chain to reduce overall transport and transaction costs, the GSC and RSC emerge. It is evident that the elimination of tariffs will promote trade among the countries involved. Particularly in RSC, benefits are more significant because goods tend to cross the borders more than once. Moreover, regulatory and policy compatibility among countries in South America are fundamental for a better integration and for making the region more attractive. Both factors support the generation of new participants of the RSC by generating a more consistent regulatory framework (Blyde, 2014).

Infrastructure provision and adequacy plays an important role in the efficiency and attraction of GSC and RSC. In many cases, having a regional scope allows to identify priorities that can help the whole of South America to be more attractive. Without this regional perspective, the negotiation process between multiple countries becomes more difficult. In some cases, infrastructure improvements located in only one country have a positive impact on the whole region.

By the year 2000, the need for a greater physical integration among South American countries started to develop. Discussions on how to achieve this integration and how to overcome logistical and infrastructure bottlenecks can be traced back to the first meeting of South American presidents in Brasilia. With the presence of the 12 independent countries in South America (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, and Uruguay) and with the support of some international credit agencies, a process of integration started within the UNASUR. As a result, the IIRSA was created within the COSIPLAN with the objective to "impulse the integration and modernization of the physical infrastructure under a regional conception of the South American space" (Ministerio de Relações Exteriores do Brasil, 2000). The IIRSA–COSIPLAN had the following courses of action:

- Develop territorial participation methodologies, with the purpose of deepening and enriching the process of sustainable planning of the integration infrastructure, maximizing the benefits of the works, and reducing undesired outcomes.
- Engage in sectorial processes, with the objective of identifying regulatory and institutional barriers that prevent the development and infrastructure use in the region and to propose actions to overcome this. In all cases, coordinated actions among multiple countries are needed to get over the obstacles and promote the efficient use of infrastructure for the physical integration.
- Develop axis of integration, defined as multinational areas where natural, human, productive areas, and commercial flows concentrate.

2.1 Union of South American Nations development axes

South America has several production regions in different countries. Some of them are connected by the generation of RSC and the complementarity of raw material production and posterior manufacturing.

UNASUR and IIRSA identified nine regions that share production, territorial, and population links, denominated as integration axis. Overall, they include approximately 98% of the total surface of South America and roughly all their inhabitants. For each axis, there are several infrastructure plans oriented to boost regional integration. None of the axes cover an exclusive area of influence, as several regions overlap.

Of the nine regions, we will use three axes as examples to demonstrate some overall issues in the conception of the axes and common characteristics: the Amazonian axis, the Paraná–Paraguay waterway, and the Mercosur–Chile axis.

The Amazonian axis, being the largest of all, has a surface of 8 million km^2, corresponding to approximately 45% of the total surface of South America (but only 20% of the regional GDP; IIRSA, 2016a). It contains the whole Amazonian rainforest, the Amazonian river basin, Northeast Brazil, and the Pacific shore located adjacent to the east of the rainforest. Fig. 3.1A shows the conformation of the axis.

The biggest obstacle for integration is geographical. The presence of the rainforest and the Andes Mountains is a barrier to the movement and integration of goods along this axis. The production and consumption areas are located in the borders of the axis, close to the more populated urban centers in the coastlines of both oceans. Supply chains of the axis are divided into two different and independent zones with little integration or territorial coherence, forcing infrastructure plans not to be complimentary. Additional challenges of conserving biodiversity and forestall areas are present.

The Paraná–Paraguay waterway organizes itself around the subsidiaries that end in the Rio de la Plata River to flow into the Atlantic Ocean. It uses

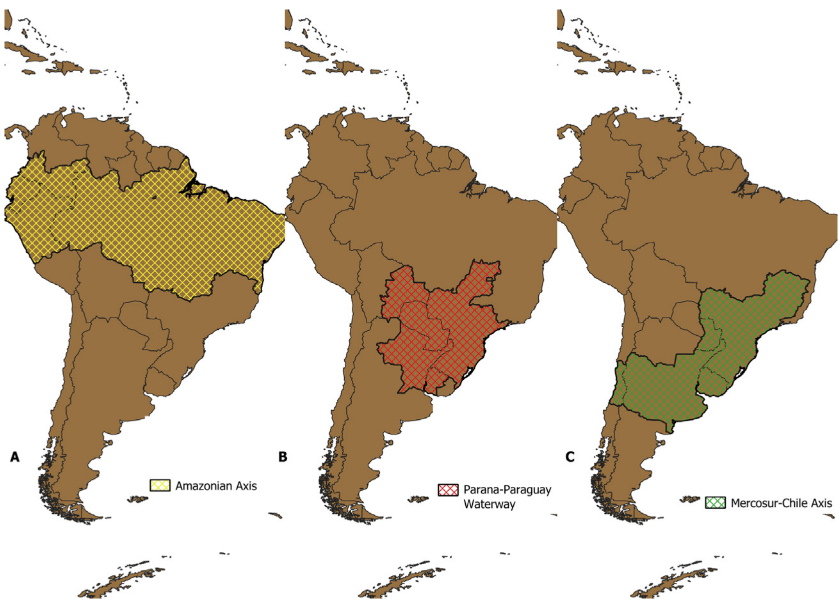

FIGURE 3.1 (A) Amazonian axis. (B) Paraná–Paraguay waterway. (C) Mercosur–Chile axis.

the Paraná–Paraguay River as vertebral column that gives cohesion to the axis. Surface wise, it covers all of Paraguay, Southeast Bolivia, West of Uruguay, Southeast Brazil, and Northeast Argentina (IIRSA, 2016b). Fig. 3.1B shows the structure of the axis.

The waterway is more than 3,000 km long. It is mainly used to carry agricultural products to be transhipped in the deep water terminals down the Paraná River. Only 20% of the barges used for this purpose return with a full load (IIRSA, 2016b). Although it has the potential to capture part of the Western Sao Paulo state, the richest state in Brazil, this is unlikely because of the proximity to Brazil's big maritime ports.

Infrastructure development of this axis is mainly oriented to improve navigability in the waterway. This would have the effect to reduce the overall cost of the barges, to improve the level of service, and to increase fluvial market share.

The Paraná–Paraguay waterway axis, in contrast to the Amazonian one, has a strong territorial and production cohesion. The waterway is already used to some extent and has several RSC already functioning, such as Paraguayan soy being crushed in Rosario (Argentina).

The last axis to be described is the Mercosur–Chile (IIRSA, 2016c). The integration axis covers the main production regions of Argentina, Brazil, Chile, Paraguay, and Uruguay. It consists of the center of Argentina and Chile, Eastern Paraguay, the whole of Uruguay, and South Brazil, as shown in Fig. 3.1.

The Brazilian region contributes to 67% of the axis GDP, followed by Argentina with 21%. The main transport systems are the ones in the Paraná waterway (overlapping with the Paraná–Paraguay waterway axis) and the main road and rail corridors of the Mercosur. Sixty-two percent of the roads are asphalted, and 87% of the railways are operative in the region. Rail transport is exclusively for intranational transport because of the lack of gauge compatibility between the different rail networks.

Some of the RSC present in the axis are the aluminum recycling that starts in Chile and goes to Argentina and Brazil for processing. It is then sold to industries in Rosario, Buenos Aires, Cordoba (Argentina), Montevideo (Uruguay), Rio Grande do Sul, and Sao Paulo (Brazil). Copper is another example of raw material extracted in Chile and then transported to Argentina and Uruguay for manufacturing. Although these are parts of a supply chain, it does not mean that they are fully integrated. These flows are mainly unidirectional and hold little difference with regular exporting of raw materials (IIRSA, 2011). For RSC to exist, further processing and industrialization should be included with the movement of intermediate goods.

The three axes shown earlier have different characteristics that act as an example of the types of axes present in IIRSA–COSIPLAN. The Amazonian axis is big surface wise, has relatively low GDP, and shows little economic and geographical cohesion. The Paraná–Paraguay waterway axis is smaller with a definite economic area and similarity of industries.

The Mercosur−Chile axis is the most important in terms of GDP. It has significant trade flows across it, yet it somehow lacks some territorial cohesion because of the influence of origins and destinations on both oceanic shores. It also holds several challenges that are also present in other axes, such as lack of institutional coordination between countries, lack of data standardization, and little transport policy cooperation. Because of the importance of the axis and the transferability of its problems to other regions, the Mercosur−Chile axis is used for discussion.

As it is the biggest axis in terms of economic size, it also concentrates on several important transport infrastructure projects. Of the ones with greater impact are the intermodal terminals, gauge compatibility, railway revitalization, improvement, and building of binational tunnels between Argentina and Chile.

Binational tunnels are normally framed as part of bi-oceanic corridors between the Atlantic and the Pacific ports, meaning that, for example, production generated near the Atlantic shore would go through a Chilean port to reach Asia or west United States. Considering that the Chilean ports have a similar distance to Asian ports, the tunnels are more likely to work as a facilitator of trade within the axis rather than a corridor. This is especially valid for some provinces in Argentina.

The rail infrastructure projects tend to be in Argentina because of its central location in the axis and the large existing network. However, there are several interests deposited on these projects. Chile and Brazil may have a special interest in developing gauge compatibility because of the passing flows, whereas Argentina might focus on railway vitalization because of its greater impact on local logistics costs.

2.2 Modeling framework

The models needed for analyzing the integration issue illustrated by the three axes explained earlier should target a long-term macrointeraction among the economies. The models should be created to support decision-making for integrating the regions and prioritizing key infrastructure. The main characteristics of the models are described with the framework proposed by Jong et al. (2016) and adapted to the developing countries context in Chapter 2 and with the overall description of models from the study by de D Ortúzar and Willumnsen (2011).

It is likely that the institutional aspects of the models are the most difficult to overcome. By definition, the integration of a region involves the coordination of multiple countries. Consequently, an already big issue within one country becomes a bigger challenge. Responsibilities within a country can be divided into multiple areas, and they might not have a direct mirror in others. For example, some nations have a unique ministry that concentrates infrastructure development, whereas others have those responsibilities split among multiple ministries.

The result is a tougher flow of information between countries, limiting the synchronization of policies. Moreover, each country has their own regulatory framework, which is unlikely to be common because they address country-specific issues.

Stakeholders among countries differ too. Each country has different industrial profiles with different relative power among them. As a result, the countries may reflect conflicting interests to some policies, and coordination among them is difficult.

The confidence of the models may be affected by the multinational nature of the integration. Economic and political cycles are unlikely to be harmonized, deriving into the possibility of policy and investment shifts between countries during the time scope of the models. For example, Argentina, Brazil, and Chile have 4-year presidential mandates that start in different years, and Uruguay has 5-year terms.

2.3 Specifications

2.3.1 Level of aggregation

The level of aggregation of a model determines the level of detail that it has. An aggregated model can have a big coverage in time and geography. As it brings together multiple effects, it tends to average out anomalies, making it stable for long-term models, where a lot of uncertainty is involved. Aggregated models capture the broad relationships between macrovariables and allow simpler forecasting.

More disaggregated modeling requires more details between the interactions among agents. It gives more information to the analyst at a higher cost of collecting data, modeling efforts, and more detailed interactions. When projecting future scenarios, the variables have a higher level of uncertainty and can bring bigger errors to the model.

For example, an aggregated model that relies on international commerce, GDP, population growth, and minimum cost paths will not be suitable for analyzing modal change or the interaction of RSC in the region. A model that takes into account logistics costs, production location, and modal choice behavior could achieve this, for instance, but it would not be able to forecast the increase of trade and freight movements in the long term. Although the latter is a much richer model, forecasting logistic costs over time are difficult, and the assumptions of the effect of new infrastructure are weaker. In addition, it probably assumes that the behavioral model is still valid over time, what it may be a difficult thing to assume in a 20-year model with unknown technological innovations. For the aggregated model, there are more established tools to forecast those variables, making it more comparable and compatible for long-term models.

The UNASUR axes were created to identify infrastructure priorities to boost regional integration. Although some interventions are trivial in terms of money and payback time, such as port access improvements, there are other interventions that are more complex and made to last longer. For example, tunnels are not projected for obsolescence, and the economic appraisal spans a period of over 30 years. The minor interventions can rely on smaller regions and more disaggregate modeling, but the larger ones should aim for long-term interactions among the regions.

However, it is not always a straightforward rule. Rail investments have long project duration (concessions can be of over 15 years) and might need to disaggregate behavioral modeling to justify investments. Understanding which parameters affect the modal choice to correctly reflect the rail's level of service is crucial for forecasting transport volumes correctly.

Regional integration is a matter of analyzing the interactions of several countries and regions. The level of aggregation of the analysis is an important matter to be analyzed. In general, freight transport regions need a certain degree of production and consumption homogeneity. Preferably, there should not be big differences in product volumes, and it is desirable to follow political disaggregation (e.g., provinces) to potentiate data compatibility.

The size (and quantity) of the transport regions also depends on the level of aggregation of the model. In general, the more aggregated the model, the bigger the regions will be. There is a trade-off between the size and detail of the network and the effort needed to collect data. For example, the zoning for the OD in Argentina (Benassi, 2015) consists of 123 zones, whereas the zoning used by the Brazilian National Development Bank (BNDES, 2008) uses 21 zones to represent the whole of South America.

Another aggregation consideration is the product types. Products grouping that responds to similar transport requirements helps to simplify the analysis and data collection. In addition, product groups, if disaggregated enough, can help to gain insights on complementarity/competitions of RSC.

2.3.2 Behavioral approach

Another element to take into account is the behavioral process of the model. Some approaches are more deterministic, and some are probabilistic. An example for the first case is all or nothing allocations to the shortest/cheapest route. These models are poor in the behavioral approach but help to understand potential cargo to be transported by a corridor.

A probabilistic approach takes into account the uncertain nature of choices and allows more than one route to be used. Depending on the data used for the estimation, it can have a behavioral background or just capture correlations between variables to reflect market shares. On the one hand, having a behavioral background is a more stable and causal relationships among the parameters and welfare measurements [e.g., value of time (VoT)] that can be used for cost−benefit analysis. On the other hand, they are much more data intensive and requires the data to be disaggregated per choice maker.

In general, it can be said that the models needed to address issues at an international level are aggregated ones. When multiple regions and expensive infrastructure are analyzed, the extent of the influence is of several years and thus involving large time frames into the models. This makes that the models overlook some local peculiarities and interactions.

2.4 Data

Some aggregated data on the zones are relatively easy to find or estimate. As most of the zones are an aggregation of provinces or nations, macroeconomic data (such as GDP and production volumes) are usually made available by the governments. However, some compatibility work should be needed because of differences in methodologies, especially between countries. Depending on product aggregation, comparable product types can be obtained independently from the country specification.

Although data on international trade are easy to find, it is more difficult to establish the origins and destinations. International commerce is well documented and publicly available, but information on where it is produced and consumed is not usually available, without detailed knowledge of the study area.

When incorporating modal change dimensions, as it would be the case for rail revitalization, information on the modal split is needed. Data availability for mode choice behavior historically has been a problem for mode choice in freight (Tavasszy and de Jong, 2013). In general, only aggregated data (generally at a regional level) are available of modal split at a regional level, limiting the size of the dataset for estimation. Moreover, accurate data on travel times, cost, and level of service are rarely found. Gathering revealed preference (RP) or stated preference (SP) data for behavioral models are also complex because of the large territorial coverage of the models, besides the usual problems of high collection costs, low response rate, and difficulty in identifying and contacting the respondents.

3. Regional-level models: binational tunnels

Binational tunnels under the Andes Mountains between Argentina and Chile is framed as a way of generating bi-oceanic flows, which are generated near one shore and exported through the other. These kind of infrastructure works have been in several infrastructure plans, boosted mainly by provincial authorities. The most common example the case is of Argentinian commodities generated in Buenos Aires or Cordoba with Shanghai or other Asian port as destination. This section discusses freight modeling issues over bi-oceanic corridors, first by analyzing the logic of those corridors over the example of binational tunnels and then illustrating the modeling needed to analyze its viability.

3.1 Context

For several reasons, the concept of improving access to Pacific ports is confused with the possibility of creating bi-oceanic corridors. This underlies the assumption that products originated near one ocean could be drawn to the other because they have a more direct export route. However, this may not always hold. The assumption is broken when considering the magnitude of maritime distances. As Fig. 3.2 shows, the distance covered by maritime routes between Valparaiso (main Chilean port) is larger than from Buenos Aires if the destination is Southeast Asia (from Hong Kong to the south).

Another source of error comes from not considering the relative importance of the inland leg of the travel. For the case of any product generated in the province of Cordoba (the main inland production center, relatively close to Chile), such as soy, with destination, Shanghai would have to cover a shorter distance than if exported through Rosario (20206 km vs. 21607 km). However, when costs are compared, it would be more than 1.6 times more expensive. Fig. 3.3 illustrates the example.

Although these estimations can be improved by considering the generalized cost of transport (e.g., through the VoT measurements), these rough calculations help to delimit the problems and influence of infrastructure investment, besides limiting the scope and efforts in modeling. The preliminary results from the valuations can rule out areas that, out of basic economic sense, would not be influenced by the tunnel. For example, there are some areas, such as the provinces that border the Andes Mountains that may see an increase in exporting opportunities with the binational tunnels, but it will not attract many products from eastern Argentinean provinces because of the fact that Atlantic ports have rather competitive shipment costs.

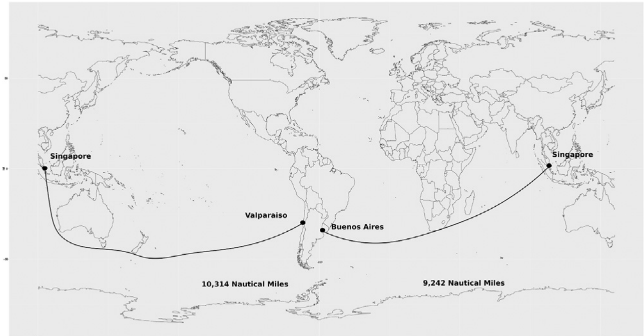

FIGURE 3.2 Relative distance to South-East Asia ports.

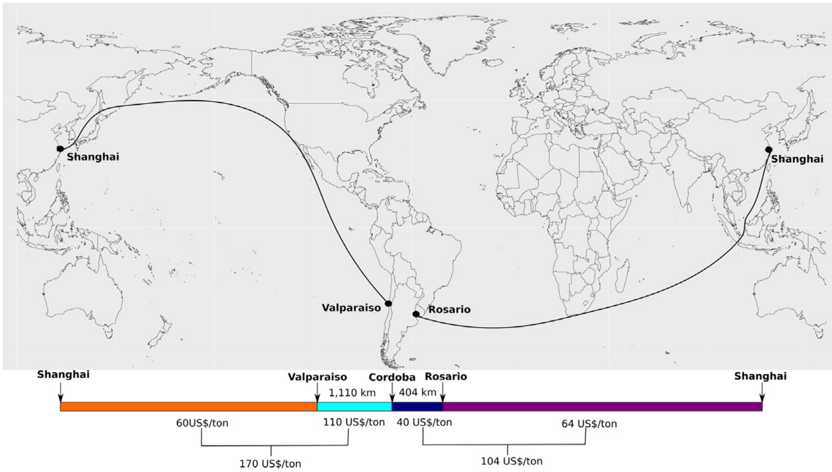

FIGURE 3.3 Relative cost of sending soy to Shanghai from Cordoba.

3.2 Modeling framework

A model able to quantify the impact of a tunnel between Argentina and Chile is necessary to assess the infrastructure needed. Currently, the most used crossing point under the Andes Mountains is Cristo Redentor, near Mendoza City and Santiago de Chile. By connecting the capital of Chile and the most important industrial city in western Argentina, it receives and concentrates important flow of materials. Moreover, in winter because of the low temperatures, it is sometimes closed, incurring costly delays. This motivates the analysis for improving Cristo Redentor or creating new binational tunnels.

Such an analysis helps to reduce the regional coverage of the tunnel's influence. Having a tighter geographical focus reduces the effort involved in modeling. The regions to be covered consist of western and midwestern Argentina for newly drawn cargo and different regions of Chile and Brazil for existing freight flows. Chile and Brazil would be stakeholders because of the inclusion of passing flows (trade flows between these two countries), but it is unlikely that the tunnel would generate bi-oceanic flows.

3.3 Specifications

Spatially, the model has to be relatively aggregated. It has to reflect higher level of detail at the regions closer to the tunnels and higher level of aggregation at the regions further away, such as Brazil or coastal Argentina. In addition, its findings should be sufficient at least to evaluate the traffic for the first 20 or 30 years of the tunnel, so the level of time aggregation can be rather high.

As the flows follow international trade patterns, the overall trends of commerce are well tracked, and the expansion of the figures should be rather easy to adapt to this situation. The main difficulty in this case is to know the origin and destination, what can be done using local export, or production information. When analyzing the flows through Atlantic ports and that can be drawn toward Chilean ports, additional information on the final destination is needed.

The flows through the tunnels can be estimated by modeling the route choice. Because of the aggregation level of the model, a simple allocation with minimal cost analysis can be of good use because it allows the modeler to estimate the possible origins and destinations that are more likely to be drawn by each tunnel. An example of this approach in the context of international freight is presented for analyzing on binational corridors made in Brazil (BNDES, 2008). Although new initiatives have been proposed, such as the tunnel of Agua Negra, no detailed flow study has been found, besides the ones that fall under the issues detailed in Section 3.1 (COSIPLAN, 2017).

3.4 Data

The main type of data needed to calibrate the aggregated model for the binational tunnels is related to international commerce. In general, it is a stable and consolidated dataset created at official level. The challenge is to correctly decompose these international flow data into origins and destinations. Some common regressors for estimating international trade are population size, GDP, and past exports.

Some product flows in RSC are intermediate goods movements. For these products, official forecasts for the consumption of the final products of the supply chain can be used. With additional information on the inputs needed to get the final good (normally found in input−output tables), a successful estimation of intermediate goods can be made.

On the allocation side, the alternative networks have to be determined, over the costs (current and projected) and times. VoT measurements are useful to estimate the generalized costs, which can provide a better estimation than cost alone. However, these values are difficult to find in a Latin American context, so in case of unavailability, the VoT of developed countries can be used. There are still few VoT works in developing country context, so it is difficult to assess if any considerable bias is introduced by using it.

3.5 Limitations

One major challenge is coordination between authorities of different countries. The multiplicity of objectives, interests, and enforcement capability from national and provincial participants from Argentina and Chile are the most tangible barriers. National and provincial participants from Argentina and Chile with different interests are the most tangible barriers. Chile and Western Argentinean provinces might have a stronger interest in developing binational tunnels initiatives than the rest of Argentina because of the reduced costs of the existent commercial flows. Another issue are the long-term negotiations that are susceptible to changes in governments. Chile and Argentina have elections at different years, and each change of government tends to slow down the process and restart the negotiations.

In addition, there are many additional infrastructure plans in Argentina and Chile that can influence the flow of goods. For example, transport infrastructure and policies in Argentina have a direct influence on the destination choices of cargo generated in Argentina. The following Section 3.4 presents an example of such policies in detail with the example for the rail modeling in Argentina.

4. Country-level modeling: railway system in Argentina

Argentina, besides being one of the most important economic areas in the Mercosur–Chile axis, acts as a middle region for flows between Brazil/Uruguay and Chile. Consequently, some inefficiencies of the Argentinian transport network are replicated into these flows. Although the former countries have a strong interest in improving infrastructure to reduce logistic costs, Argentina gives more importance to local functioning of the railway network rather than optimizing for passing flows. This section discusses the historical and current reasons for Argentina to adopt a rail open access system and the models needed to assess this policy.

4.1 Context

Argentina's modal share is, as in the rest of Latin America, dominated by road transport. Of all the goods transported, only 5% go by rail (ITF-UNSAM, 2012). In the case of agricultural products, it raises to 14%, measured in transported tonnes. This has led to a relatively high cost of transport in every sector of the economy compared with other countries of the same dimension as Argentina. Some authors (ITF-UNSAM, 2012; Schwartz et al., 2009) claim that this is caused by the relatively short distances connecting exporting/manufacturing areas. In distances under 300 km, truck tends to be more competitive because of the relatively high impact of the road leg of the trip (transporting from the harvest fields to the railway plant). However, there is some evidence that with a higher level of service (frequency, capillarity, and reliability), rail can gain market share even in short distances (Tapia et al., 2019).

The rail network is mainly port oriented because it was built with the objective of moving agricultural production for export. The national network has not been centrally planned, so in the overall network, there are three different gauges, depending on the geographical characteristics of the terrain, which decreases the interoperability of the network (Raposo, 2014).

After reaching its largest extension of 44,000 km in the fifties, the functioning railway network length started to fall until it reached a minimum in the 1990s, when it was privatized. After the privatization, rail recovered volume, but not network length. Nowadays, the network consists of 25,500 km of railway, of which approximately 18,300 km are operative. In the year 2018, nearly 19 million tons were transported at an average distance of 485 km (9000 tons-km).

The network was divided into six rail lines to be outsourced. Between 1991 and 1993, five of them were successfully transferred to the private operators for 30 years. Among the obligations of the private parties were to pay a fee for the infrastructure use and rolling stock and to invest in the modernization and improvement of the network. Fig. 3.4 shows the current operating network.

In the beginning, the volume transported grew, as the level of service improved but at a slower pace than expected. This shows flaws in the demand estimation models of the tender, making the concessionaries to fail in complying fully with their obligations. Besides the loss in operating lines, there is a severe degradation. The opportunistic behavior was also allowed because of deficiencies and late applications of the regulatory framework for the privatization (Raposo, 2014). The situation led to a renegotiation that eliminated the fee and gave greater flexibility in the investment requirements. However, this did not happen in every case, as two of the concessions have been revoked and are currently operated by a public company because of the high level of deterioration of the infrastructure.

After the Argentinian crisis of 2002, when all the economic activity suffered, the volumes carried by the railroad recovered, but at a slower pace than the total amount transported, causing the rail market share to decrease even further. This has been more noticeable in the agricultural sector, which historically was an important niche in the Argentinian rail market.

Besides the uncertainty of the regulatory framework, the economic crisis and the optimistic demand forecasts are the major causes of the current state of the market share of the railway. The acquisition of railway lines by companies to transport their own products is another factor to be taken into consideration (ITF-UNSAM, 2012). Although they are obligated by contract to accept the third-party cargo, this does not always work. Two examples are worth mentioning in this matter. The first one is about the network South of Buenos Aires, of Ferrosur, which is currently operated by the same economic group that owns a quarry in the region. Therefore the main product transported is minerals at the expense of agricultural products, which is also present in the district. Consequently, the grain volumes transported by rail are marginal, so the links that were not important for quarry did not get enough

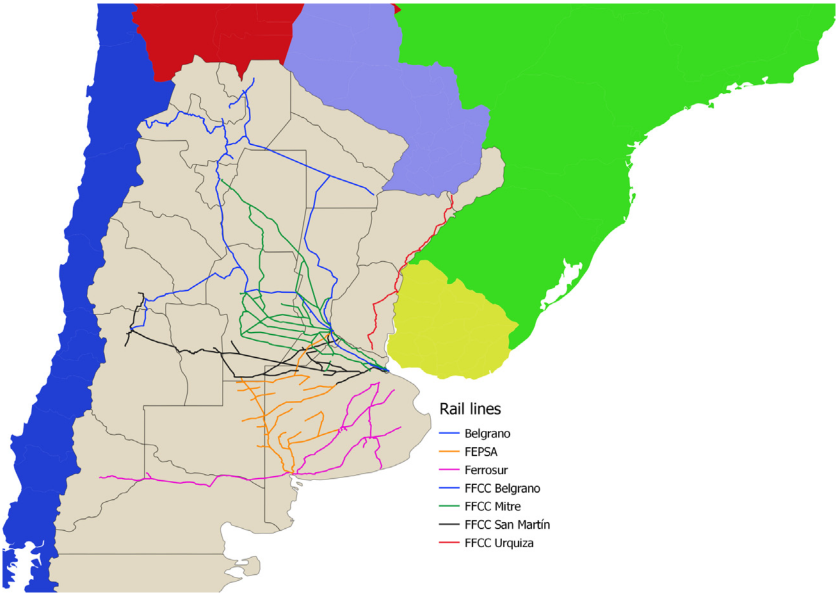

FIGURE 3.4 Rail network in Argentina.

investment to continue to operate, and the rolling stock priority was not allocated to this product.

The second integration worth mentioning is of the railroad Nuevo Central Argentino (NCA). NCA has a big presence in the heart of the agricultural production area, and it is owned by one of the biggest seed crushers of Argentina. Although some products of other companies are accepted, there is no incentive in pursuing additional cargo and thus sharing its competitive advantage. There are reports suggesting that inconvenient loading time windows and relatively high prices are offered to competitors.

In both cases, the organizations that took over the rail lines have a strong interest in moving their own material and optimize their logistics. This does not imply that they do not want or are not interested in transporting extra cargo, but given the low investment in rolling stock and infrastructure, they privilege their own products.

The lack of effective regulation has resulted in a lowered level of service, absence of incentives for looking for new clients, and outdated infrastructure and rolling stock, which can be considered a recurrent issue in developing countries. Vertical integration combined with the low acceptance of cargo from other companies is a mixture that has implications in modeling because it will break most assumptions about the availability of alternatives, especially for choice models. Not knowing beforehand who has the option of choosing rail can bring bias to the parameter estimates because the model will confound the effect of no availability with a nonpreference of the alternative. Additionally, there is an asymmetry on the service information available obtainable for modeling, such as fares and travel times. It is likely that companies that own rail lines have a different tariff than other shippers.

To promote the participation of more companies and to expand the rail market share, an open access policy is under evaluation. The idea is to separate the providers of the infrastructure from the operation as an attempt to increase the participation of several providers. This way, this separation would facilitate the appearance of new service providers and make it feasible for other companies to carry their own goods and to capture other smaller loads (ITF-UNSAM, 2012).

4.2 Modeling framework

To evaluate the effectiveness of an open access policy, an ad-hoc model should be used. The models currently under use in the Ministry of Transport of Argentina consist of detailed O-D matrices and some aggregated overall estimation for potential cargo to be transported by rail (Benassi, 2015). The model consists of several methods for obtaining and updating O-D matrices and for assuming a likelihood of being transported by rail depending on the product characteristics and distance of the travel. This likelihood of adopting rail are coefficients that determine the potential volume that the rail could attract. The main limitation is the lack of behavioral background involved in the definition of these coefficients, resulting in little responsiveness of demand toward changes in the network, such as improvements in reliability, frequency, and lower travel times.

Regarding the organization of the model, institutional aspects of it should be easier to overcome. Although the coordination of multiple authorities (such as the Ministry of Agriculture, the Ministry of Mining and Energy, the Ministry of Economy, and the Ministry of Production) and data from multiple sources is needed, the Ministry of Transport has the greatest responsibility in policymaking and enforcement of the open access. The Ministry of Transport has also under its influence (although with some independence) the control agencies.

4.3 Specifications

When evaluating infrastructure use, specifications not only for the demand but also for the supply models must be considered. The model should accommodate the mutual interactions of supply and demand characteristics to address the impact of policy scenarios, to understand current and future operators' incentives, and to assess the compliance with the objectives of the policy. Network use and open access regulation are some of the possible objectives of the model.

A model of this nature is complex because of the multiple interactions between demand and supply side. From the demand side, modal shift has to be studied in detail to assess the potential demand for the railway at different levels of service. This has to take into consideration potential pricing strategy reactions of the road services. The model should be suitable for forecasting of a behavioral nature.

From the supply side and to consider the feasibility to attract private interests or to evaluate public participation, supply side modeling should be incorporated. Cost models that consider different levels of service (with interaction with demand side modeling) are preferable to consider the trade-offs between cost and potential remuneration. Pricing strategies for infrastructure use could be simulated in this stage. These types of models that reflect interactions are also important to understand the incentives of the operators (how to maximize own profit) and if they are aligned with the objectives of the public sector policy (maximize social benefit). With the application and simulations of the model, several policies can be tested to make the public and private sectors' objectives to be compatible.

Cost−benefit analysis for public sector investment can also be included. Quantifying benefits that go beyond cost savings are important to analyze up to what extent the public sector is willing to invest money or subsidize rail using. Some of these benefits could be lower truck-related accidents, emission reduction, road congestion, and noise, among others (Havenga, 2015).

4.4 Data

Regarding data collection, the demand side is likely to be more difficult. If a behavioral framework is preferred, disaggregated data have to be obtained. To do so, there are mainly two sources: RP and SP. RP consists of actual choices made by shippers, whereas SP consists of declared choices in hypothetical scenarios.

RP is generally preferred because of the better representation of reality. However, there are some drawbacks, such as failing to accommodate new or unavailable alternatives and to obtain the actual parameters used by the choice maker. In chapter Y (the chapter on tax revenue data processing for modeling), a discussion on how to obtain RP data from nontraditional sources is made.

SP can solve these issues by allowing the modeler to create the choice scenario. By also being able to show more than one choice task per respondent, data collection is easier. However, the hypothetical nature of the situations makes models estimated exclusively from these data unsuitable for forecasting. To overcome the weaknesses of both sources, models with combined RP and SP data can be estimated (Hensher, Rose, & Greene, 2008).

In addition, data on current and projected flows are needed too. For the Argentinian case, the Ministry of Transports estimates OD matrices for different products (Ministerio de Transporte de la Nacion Argentina, 2017b). This matrix is periodically updated, but it has a greater focus on flows created in Argentina, having an overall aggregated view of the road trade between Brazil and Chile. Although the Brazil—Chile flows might not be as significant as flows between Chile and Argentina, they can still cause the infrastructure to be under dimensioned.

For the supply side model, data on the network are needed. Road data are widely available in multiple formats, but rail data are outdated. Most sources do not consider the current operational status of the tracks. In that sense, the Ministry of Transport is making a significant effort to have reliable data on the network status. In addition, the ministry has also created rail cost models (COSFER) for the operation of the railroad that can be used in the model (Ministerio de Transporte de la Nacion Argentina, 2017a).

The COSFER has been a 2-year project that generated a cost model that depending on the terrain, operational speed, volume, and other operational variables, it estimates the operational, maintenance, and investment costs (if renovation of rail tracks is projected). The validation of the model has been done with interviews with the different rail operators.

5. Limitations

Regarding the confidence level of the model, some challenges arise with the trucks companies and unions power. They have shown in the past a high reaction to the introduction of the railway by adjusting prices and generating nonmarket barriers, such as blockage of rail loading plants. A difficult thing to consider in the models is the impact of social issues derived from the potential losses of jobs in the trucking sector. Argentina, as many other countries in South America, has a large number of families that depend on trucking incomes to survive, meaning that the loss of jobs in the sectors will have an important social resistance.

Other issues that can interfere with the applicability of the results of the model are the regulatory assumptions. The open access law was enacted in 2015, but it has been neither effectively regulated nor enforced. The final regulation of the open access could be the result of the model by generating and comparing the reaction of current rail operators and potential new ones in different scenarios. However, to capture these behavioral responses is a complex matter, even if the model explicitly models the responses.

Besides the already mentioned lack of access to data for infrastructure, level of service, network, and rail tariff, there is the issue on how to model rail availability in an area (i.e., who has the possibility to ship by rail). Behavioral models are particularly sensitive to this issue. If an attractive alternative is available and not chosen, its attributes will be interpreted as "undesired" in the modeling process. This could result in a bad model specification, wrong signs of the variables, or low significance of important variables. To solve this issue, assumptions on availability have to be made, with a potential bias on the model.

One dimension of the limitations of the model is how to quantify the impacts of the infrastructure improvements on the region, such as the generation of new volumes of trade generated. The models that are used focus on the transport system of Argentina only. Consequently, the results and applications of the model are confined to the country because of not only the assumptions needed for extrapolation and transferability of the projects but also the effects of the assumptions on other models.

For example, as the Argentinian network is heavily port oriented, it is more likely that those links receive a better overall level of service. Consequently, Atlantic's ports hinterland increases, reducing traffic across the Argentina–Chile border. The inverse is also true; some flows that would naturally have come to Atlantic ports (either by truck or rail) could be drawn toward Pacific with the construction of binational tunnels.

Besides the effect of the open access in ports hinterlands, the considerations of other countries in the policies are not necessarily taken into account. Chile and Brazil, for instance, have strong interest in developing infrastructure to reduce the costs of entering and moving within Argentina, which would involve better roads and intermodal terminals. This, although it does not contradict the open access policy, is not purely aligned with its objectives.

6. Conclusion

Regional integration in South America has not been a straightforward process. There are plenty of institutions with their own objectives and regional coverage. The focus case for integration in this chapter has been on the axes proposed by COSIPLAN-IRSA in the context of UNASUR. Although this may not be the main institution that drives this integration, the axes show the general ideas that the integration of the region have.

Three different axes have been described. The Amazonian axis covers a large territory with lack of production flow logic, something that Paraná–Paraguay waterway axis has. In the middle and as a representative of the axes that have some level of production flow logic and holds most of the integrational challenges, the Mercosur–Chile axis is presented.

Several transport projects are available to boost integration along this last axis, some of them at a regional level and other exclusively at a country level. Regardless of the territorial coverage, they share similar challenges, such as multinational interest, agencies and cooperation issues and interests, and problems in data generation and availability.

Some projects with regional-level impact can be tested with simple yet effective models to reduce and focus the scope. Binational tunnels between Argentina and Chile are examples of this. With simple relative distance analysis, the use of these tunnels to help ports on one ocean attract cargo closer to the other shore is rejected in most cases.

Nevertheless, high institutional challenges are expected because of the international nature of the intervention.

At the country level, Argentina's policy on rail transport is relevant because of the passing commodity flows it has. The intention to reregulate the rail market with an open access policy to increase its market share demands complex modeling. Behavioral modules with interaction with supply side modules may be considered to define and model concession and investment plans. Moreover, the development, implementation, and update of the model should not have many institutional issues, and there are several nonmodel-related challenges such as truck unions and current operators' interest. A challenge to be addressed from the regional point of view is the inclusion of other countries' interests in the definition of the rail policy.

Overall, the models needed to address policy issues at a regional level are difficult to develop and implement. For the simpler models that can be solved with aggregated and not so detailed modeling, there are multiple coordination challenges among the countries. Other models, such as national-level models, may have an easier coordination between stakeholders but have a more complex and detailed modeling.

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