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To Be or Not to Be: An Assessment of Latin American Airport Infrastructure and the Creation of An Airport Infrastructure Index

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TO BE OR NOT TO BE:
AN ASSESSMENT OF LATIN AMERICAN AIRPORT INFRASTRUCTURE AND THE CREATION OF AN AIRPORT INFRASTRUCTURE INDEX

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Table of Contents

List of Tables

Abstract

Latin American transport infrastructure underperforms the global standard across the board, and previous research indicates that deficient infrastructure deters economic and social development (Fay 2007). Using multiple research methods, this thesis explores how transport infrastructure relates to the economic global competitiveness of a nation.

More specifically, the quantitative research includes regression analyses with quantity of varying infrastructure types (airports, roadways, railways, and navigable waterways) and the creation of an airport infrastructure index. The index attempts to determine what dimensions of airport infrastructure truly reflect "good infrastructure" because Latin America has a relatively large quantity of airports. As infrastructure mechanisms are complex and nuanced, this thesis includes a review of foundational research concerning infrastructure and economic development along with a case study between Bolivia and Chile.

The research finds that *quantity* of infrastructure is not related to global competitiveness, yet certain aspects of airport infrastructure like *usage* and *efficiency* do correlate. Like previous research in this field, the findings are challenging to decipher because the effects of infrastructure extend far beyond economic measurements, and the economic measurements are affected by a multitude of factors, such as politics and cultural values.

Introduction

An economic analysis from the World Bank shows that Latin American hard infrastructure, i.e., the physical infrastructure of roads, bridges, tunnels, railways, ports, airports, and harbors, underperforms the global standard (Fay 2007). The same report deduces that this poor infrastructure hampers productivity, growth, and poverty reduction throughout the region, relying on notions that investment in hard infrastructure increases economic productivity and availability to services, clean water, sanitation, recreational activities, and medical attention (Aschauer 1989, Kessides 1993).

As expected, Latin American aviation infrastructure ranks poorly globally. Only Panama (9tth) ranks inside the top fifty nations in air transport efficiency in the 2019 Global Competitiveness Report (World Bank 2019). Using 2008 metrics, the Latin America and Caribbean (LAC) region accounted for seven percent of total passengers and five percent of total cargo while accounting for 8.4 percent of the global population (Serebrisky 2012). The World Bank's Logistics Performance Index (2014) shows that only twenty percent of respondents thought the airport infrastructure of the LAC region was "high" or "very high." Financial reports from the Banco de Desarollo de América Latina estimate that the region needs an investment of $53.2 billion by 2040 to close the airport demand-capacity gap.

Simultaneously, the region has a high number of airports. Of the top twenty countries with the most airports, paved or unpaved, nine are in the Latin American region (CAPA 2013). The regional averages for airports per million people also trump every major global region except for North America (excluding Mexico).

TABLE 1.1 REGIONAL AVERAGES OF AIRPORTS PER 1,000,000 PEOPLE

	Airports per 1,000,000 people
Latin America	26.4
Europe	8.7
Asia	5.0
Middle East	4.5
Oceania	20.4
Africa	5.4
North America (Excluding Mexico)	39.5
Globe	9.1

Data Source: CIA World Factbook

Important questions emerge from the discrepancy between the "weak" aviation infrastructure and the high number of airports present in the region: Why does the Latin American region have such a high number of airports? Are these airports effective recipients of public and/or private spending? What constitutes strong "aviation infrastructure"? Does aviation infrastructure differ from other types of "hard infrastructure"? Is the Latin American region falling both economically and socially stunted due to a lack of strong infrastructure?

In attempts to explain the high number of Latin American airports, we can perhaps look to its intense terrain. Latin America contains the Andes Mountains, Darien Gap, Atacama Desert, and Amazon River Basin, with the Atlantic Ocean surrounding the Caribbean nations. The Andes Mountains are the longest continental mountain range in the world, expanding 7000 km long and 200 to 700 km wide. The Amazon Basin covers over 35.5% of South America, and its Amazon rainforest, the largest rainforest in the world, covers over 5.5 million km.[2] It is possible that this extreme terrain causes a high number of scattered airports to be more vital for transporting both people and goods effectively, relative to other parts of the world.

Whatever the reason, Latin America has more airports per capita than almost every region in the world yet falls $5,000 short of the GDP global average per capita. A robust analysis of airports throughout the Latin American region, their efficiency, and their possible economic effects can offer insight into Latin America's current and future development and competitiveness.

Airport infrastructure is a solid microcosm for understanding the complexities of infrastructure projects and their effects for multiple reasons. Airports are historically public works projects, with local and national government institutions controlling the development and financing of the projects. As with other types of transport infrastructure, airplanes move both cargo and passengers. Major airports also require significant regulation and management.

In this analysis, I used a mixture of methods to draw connections between airport infrastructure and development. First, I investigated foundational research in the fields of development and infrastructure to help guide my testing and conclusions. Then, I analyzed regression analyses between the quantity of infrastructure types (i.e., waterways, roadways, railways, and airports) to see if the pure amount of infrastructure types affects global competitiveness. The World Economic Forum (WEF) measures global competitiveness based on countries' current mechanisms that affect long-term economic competitiveness. Finding that the amount of infrastructure *does not* correlate, I created an airport infrastructure index by combing measurements of airport connectivity, efficiency of air transport services, and passengers per million, and the index highly correlated with global competitiveness. Finally, to capture why infrastructure needs and levels may differ from country to country, I completed a case study which compares Bolivia and Chile. These two South American countries border each other, and on the surface, their infrastructure levels are relatively close. However, their economic outcomes differ dramatically.

Because of a lack of literature specifically targeting the connection between airport infrastructure and global competitiveness, this project is semi-exploratory. There is evidence that the overall level of infrastructure is correlated with economic growth (Aschauer, Kessides, Kim, Cidell), but airport infrastructure is exceedingly difficult to measure and may be an outlier among major transport infrastructure due to its high costs, rapid speed of transportation, and ability to pass over geographically intense areas.

Chapter 1: Research Design

Data

To compare data points between countries and global regions, I constructed a cross-sectional dataset composed of variables related to countries, including their population size, infrastructure levels, and economic and social development. I collected these variables from the CIA World Factbook, the World Bank, the World Economic Forum, and the Social Progress Imperative.

<u>CIA World Factbook</u>

- Population Size (July 2021 est.) – The US Bureau of the Census calculates the exact numbers by using population censuses, registration systems, and sample surveys.
- Number of Airports (Most recent year) – The World Factbook counts all airports and airfields, paved/unpaved and retired/open, recognizable from the air.
- Km of Railways (Most recent year) – This measurement accounts for the total length of railway networks and their complimentary parts.
- Km of Navigable Waterways (Most recent year) – This entry totals the length of navigable rivers, canals, and other inland bodies of water.
- Km of Roadways (Most recent year) – This measurement includes the total length of road networks, both paved and unpaved.
- Exports (2019 est.) –The overall US dollar amount of merchandise exports on an exchange rate basis.
- Imports (2019 est.) – The overall US dollar amount of merchandise imported, including the costs of insurance and freight, on an exchange rate basis.

- Real GDP/capita (Most recent year) – The World Factbook finds this variable by dividing GDP (PPP basis) by the population of the country on July 1 of the same year.

World Bank

- Number of Airline Passengers (2019 or before est.) – Estimates from either the International Civil Aviation Organization or Civil Aviation Statistics of the World. I decided to obtain the estimates from before 2020, as the Covid-19 pandemic caused global travel levels to drop dramatically.
- Air Cargo (2019 or before est.) million ton-km = metric tons x km traveled – Estimates from either the International Civil Organization or Civil Aviation Statistics of the World. The statistic accounts for the volume of freight, express, or diplomatic bags carried on each flight from takeoff to landing. The final statistic represents metric tons multiplied by kilometers traveled.

World Economic Forum Global Competitiveness Report 2019

- Efficiency of Air Transport Services – This value is from a survey question which asked, "In your country, how efficient (i.e., frequency, punctuality, speed, price) are air transport services?" The respondents could answer on a scale of 1-7, with 1 being "extremely inefficient, among the worst in the world," and 7 being "extremely efficient, among the best in the world." Using the weighted average answers to this question, the WEF normalizes the scores on a scale of 100.
- Airport Connectivity Score – The International Air Transport Authority (IATA) measures the number of available seats from each airport to the destinations offered. Then, IATA

weighs the importance of the seat by the size of the destination airport. Lastly, IATA sums the weighted totals for all destinations and airports in the country to produce a score. The World Economic Forum (WEF) takes this score and applies a log transformation to the raw values puts the normalized scores on a scale of 100.

- Global Competitive Index – The WEF has measured countries' "drivers for long-term competitiveness," both on a macroeconomic and microeconomic scales, every year since 1979. These "drivers" are "organized into 12 pillars: Institutions; Infrastructure; ICT Adoption; Macroeconomic stability; Health; Skills; Product market; Labour market; Financial system; Market size; Business dynamism; and Innovation capability" (WEF 2019, 7). The World Economic Forum claims these elements "provide leads to unlock economic growth" (WEF 2019, 8), The WEF weighs over 110 variables to calculate this multidimensional measurement.

<u>Social Progress Initiative</u>

- Social Progress Index (2020) - The Social Progress Index "measures country performance on many aspects of social and environmental performance which are relevant for countries at all levels of economic development." The measurement excludes economic indicators so that the relationship between economic development and social development can be analyzed. The measurement's three main dimensions are basic human needs, foundations of well-being, and opportunity (socialprogress.org). The Social Progress Imperative calculates this index by using 53 social and environmental outcome indicators.

Most of these variables can be separated into two categories: input variables or output variables. The input variables are relevant to transport infrastructure or airport infrastructure specifically. General infrastructure figures include the number of airports, navigable waterways, roadways, and railways. As the last type of major transport infrastructure, I hoped to find a concise figure to represent the number of ports, but I was unsuccessful. The airport infrastructure figures include the number of passengers and cargo moved by plane, the airport connectivity score, the number of airports, and the efficiency of airport transport services score.

The output variables are variables that I believe directly correlate with economic and social success. They include imports, exports, GDP per capita, Global Competitiveness Scores, and Social Progress Index scores.

Variables not categorized as “input” or “output” help define the samples (e.g., name of country and region, population size).

As for qualitative data, I utilized a research database to collect scholarly, peer-reviewed journal articles and reputable newspaper articles on topics related to transport infrastructure, economic development, airports, foreign trade, and state of Latin American airport infrastructure. When these mediums did not cover the more niche topics, I utilized aviation-related websites.

Hypothesis Testing

Firstly, I compile the main ideas from foundational research examining the relationship between economic development and infrastructure to guide my testing and conclusions on the quantitative analysis sections. Additionally, this section of the thesis will determine if scholars already accept specific notions about infrastructure’s effects on development.

Secondly, I investigate if the quantity of an infrastructure type per capita (e.g., km of roadways, km of navigable waterways, number of airports, and km of railways) statistically correlates with global competitiveness. Latin America has more airports per capita than almost every region in the world, but Chile (33rd) and Mexico (48th) are the only Latin American nations to rank in the top 50 for global competitiveness (WEF 2019, 15). Additionally, the regional average of GDP per capita is less than $5000 the global average. With this information, it would seem as though the number of airports does not correlate with global competitiveness. Though, infrastructure can quickly become complex.

Infrastructure needs differ by location or local population. For example, people generally travel via car, train/metro, or foot for daily travel. In highly populated areas, droves of people use the same stretch of roadway or metro tracks to travel to their destinations. One highway or sidewalk is a complex mechanism, allowing people to accomplish their specific tasks.

Infrastructure quantity can also depend on geography. Some countries have naturally formed navigable waterways, supplying longer and perhaps more easily accessible routes than man-made waterways. Building a road across a flat prairie is cheaper than building a road that crosses a bay or a mountain range.

The complexities of infrastructure make it difficult to hypothesize whether quantity of infrastructure correlates with global competitiveness. However, I hypothesize that kilometers of railways and roadways per capita will be statistically correlated while kilometers of waterways and number of airports will not. Railways and roadways are extensive infrastructure projects that serve people on daily tasks, and the existence of these structures is a sign that states have the money and desire to fund sizable public works. Latin America, as a surface-level case, hints that the number of airports does not trend towards global competitiveness. Paraguay and Bolivia have the most airports in the region, but they are also two of the most uncompetitive countries in Latin

America. As aforementioned, waterways can be naturally occurring, and I believe their existence depends more on nature than major infrastructure projects.

Next, I explore the complexities of infrastructure by compiling an aviation infrastructure index. The five variables (e.g., number of airports per capita, number of air passengers per capita, amount of cargo transported via aircraft per capita, airport connectivity, and efficiency of air transport services) included in the creation of this index all relate to airport infrastructure.

Intuitively, the more cargo transported via aircraft per capita should correlate with global competitiveness. Products typically transported via aircraft need to be moved rapidly and safely due to their high value and/or urgency (Hyland Shipping 2019). Countries transporting more high-value goods (e.g., medical products, artworks, luxury goods) per capita most likely are more economically developed than resource/agrarian-based economies. Efficiency, the number of airline passengers, and connectivity of infrastructure should mirror economic global competitiveness. The efficiency measurement shows that effective frameworks, such as private businesses, regulatory agencies, and other externalities, exist to support the aviation industry in respective countries. Connectivity and the number of airline passengers ought to correlate with global competitiveness because these indicators measure the actual usage and necessity of passenger flights. Inhabitants of countries with higher GDP per capita can afford flights for personal/business travel.

Finally, I use a comparative analysis of Chile and Bolivia to understand the existing reasons for infrastructure in Latin America. I imagine geography and regional politics are the main factors responsible for the high number of airports. After all, airports can be fashionable structures. In Buenos Aires, it is common to lounge outside the airport and watch the airplanes take off while drinking beer and picnicking, as seen in *Anthony Bourdain: Parts Unknown*. I also hypothesize that some of the existing infrastructure or lack thereof may be a remnant of colonialism, when the Spanish and Portuguese built systems to extract wealth from the colonies to gain global power.

Methods

Initial Steps

To begin my research, I collected both qualitative and quantitative data simultaneously. I compiled journal and newspaper articles into an annotated bibliography, and I gathered open-source variables related to development and infrastructure levels.

While learning about the complexities of "development" from academic works, I found indicators that exhibited both economic and social development. I discovered that GDP per capita is not as robust as the World Economic Forum's Global Competitiveness Score nor the Social Progress Initiative's Social Progress Index.

Transforming the Data

After collecting the quantitative data and organizing it within Excel by country, I eliminated countries with fewer than one million inhabitants. Many of these countries are not effective cases to use in an analysis because they are outlier countries. For example, Luxemburg has a population of 639,000, but is the fifth-wealthiest nation-state in the world on a PPP per capita basis. If included, it would be a small sample by population but would nonetheless skew my research because it is exceedingly strong economically. In addition, the inclusion of a country like Tonga would skew my analysis because it is a unique, geographically small island nation with a population of 105,000 and a GDP per capita (2019) of $4,903.

Next, I used population size to scale relevant variables by population. First, I divided several variables by total population, then I multiplied the "per capita" version by 100,000 or

1,000,000 to make the variables comparable and more conventional numbers. For example, Afghanistan has a population of 37,466,414, and a total of 46 airports. I divided 46 by 37,466,414 and then multiplied by 1,000,000 to get 1.22 airports per 1 million inhabitants. This process creates figures that are proportional to “per capita” figures without using exceedingly small numbers (e.g., 0.00000122 airports per capita). While analysis is possible with these small figures, it is easier to compare numbers in a more common form. I completed this process for several variables, including number of airports, air cargo, railways, roadways, and navigable waterways.

If a “per capita” figure was composed of conventional numbers and not small fractions, it made more sense to include on a “per capita” basis, and I did not complete the process of scaling the numbers by 100,000 people or 1,000,0000 people. The number of air passengers/capita typically yielded figures close to 1 already, so I compared these numbers on a “per capita” basis. Also, exports and imports per capita are typically in the hundreds/thousands already, so there was no need to scale them up.

Next, I sorted the countries into seven global regions based on cultural, regional, and ethnic differences: Latin America, Europe, Asia, the Middle East, Africa, Oceania, Africa, and North America without Mexico. Theoretically, global regions are subjective and can be defined by researchers. For example, I defined “Latin America” as all Spanish/Portuguese-speaking countries in the Americas/Caribbean with over 1 million inhabitants. Caribbean and South/Central American countries with histories affiliated with French and British colonialism (Belize, Suriname, Jamaica, etc.) were omitted from “Latin America,” as this thesis attempts to exclusively study the “Latin American” region. I sorted the data by region to find regional averages and medians. Countries that were omitted from a region are included in the global averages. The regional and global means/medians were found to make it easy to quantitatively compare regions and countries.

Foundational Works Research

The initial qualitative data collected was divided into four subcategories: Transport Infrastructure and Economic Development, Airports in Regional Development, Foreign Trade and Economic Development, and the State of Latin American Airport Infrastructure. Within these subcategories, I covered the main ideas and/or theories constructed by academics.

Major Transport Infrastructure Regression Analysis

Aviation infrastructure's effects on global competitiveness could not be determined without comparing it to other transport infrastructure, including roadways, railways, and waterways. Comparing cross-sectional data of transport infrastructure and their relationships with global competitiveness allowed for general questions about quantity of infrastructure types to be answered.

For this comparison, I first completed descriptive statistics of each variable scaled for population and make general conclusions. I mainly learn that all transportation infrastructure variables are positively skewed, meaning that the data leans towards a select few cases. Using natural log is a generally accepted way among statisticians to change the shape of a positively skewed variable's distribution without losing the primary characteristics, such as order. After transforming the data using natural log, I followed a recurring process done by the WEF in the *Global Competitiveness Report* to normalize the variables on a scale of 100. The highest natural log value for a given statistic received a 100, and the remaining values were scaled out of 100, with the top performer as a basis for their rescaling. This process created infrastructure-specific scales, based on relativity of a certain infrastructure type. This created an effective way to compare infrastructure types because the pure number of an infrastructure-type does not allow comparisons between the types. 800 km of roads per person does not equal 44 airports per capita, but scores out of 100 for both variables can give general ideas about where a country ranks globally.

When the data was transformed using natural log and normalized on a scale of 100, I completed bivariate linear regression models within Excel for each infrastructure type. From these regression models, I knew the strength of the relationship and the statistical significance (the p-value) of said relationship. After regressions were complete, I discussed the strength of the relationships between infrastructure quantity (for each type) and global competitiveness and their statistical significance. I then offered insight into the relationships. This section tested if quantity of infrastructure correlates with global competitiveness and hinted at which infrastructure types correlate with global competitiveness the most.

Airport Infrastructure Index

My regression analysis showed that the quantity of airports is not correlated with global competitiveness. I attempted to define and test true “airport infrastructure” by creating a multidimensional index of several elements related to aviation.

Indexes create “composite” variables by combining several variables, and these values are often more likely to be accurate than just a single measure. The primary reason for creating this index is that “good infrastructure” is difficult to measure. Thus, an index comprised of related variables can hopefully capture an accurate measurement of “airport infrastructure” for countries.

I loosely based the construction of the index on the Human Development Index (HDI) and general benchmarking tactics used in the equity market. HDI assesses human development by combining its key dimensions: a long and healthy life, knowledge, and a decent standard of living. These various dimensions are averaged to find a more accurate representation of people and their capabilities. The “decent standard of living” variable is based off the GNI per capita (PPP $), and these figures are logged to “reflect the diminishing importance of income with increasing GNI” (hr.undp.org). Then, these transformed figures are averaged with the life expectancy index and education index to formulate the composite HDI.

Like HDI, I focus on gathering variables that cover various dimensions. For aviation, I included the number of airports per capita, number of air passengers per capita, amount of cargo transported via aircraft per capita, airport connectivity, and efficiency of air transport services. I also used natural logarithm with some variables to reflect the diminishing importance of change and to account for skewness.

To make sure the index relates with global competitiveness, I derive methods of benchmarking from the equity market. A standard strategy of testing performance of a portfolio, a mutual fund, or a specific investment manager is to benchmark the returns with respected indexes like the S&P 500, the Dow Jones Industrial Average, and the Nasdaq 100. I benchmarked my aviation index variables with global competitiveness, making sure the aviation variables included were statistically related with global competitiveness.

To accomplish this “benchmarking,” I use multivariate regressions with all five initial variables (X) that I believe correlate with global competitiveness (Y). I report the results, including the R-Square of the model, then eliminate the variables that do not have a significant level of significance, or $p > .05$ level. Then, I complete another multivariate regression with only the statistically significant variables and report the results, highlighting the R-Square of the model. The final “airport infrastructure index” offers what dimensions of aviation infrastructure are indicative of global competitiveness, and I make conclusions about these dimensions.

Comparative Case Study

A vital and last step of this thesis includes a case study between two Latin American countries. I incorporated a most similar with different outcome (MSDO) design, analyzing two countries who share levels of infrastructure but have different global competitiveness outcomes. Then, I research their infrastructure, economies, development, and airports being built to help comprehend the complexities infrastructure and airport infrastructure includes.

Chile and Bolivia are both situated in the Andes Mountains and share a border, but their economies and political histories are remarkably different. Chile has the highest Global Competitiveness Score, at 70.5, and the highest SPI index, at 83.34, of the region. Bolivia, on the other hand, ranks towards the bottom of the region with both of those measurements, outranking only Nicaragua in global competitiveness and El Salvador, Guatemala, Honduras, and Nicaragua in social progress index.

Bolivia has the second highest number of airports/100,000 in the region, trailing only Paraguay. Both Paraguay and Bolivia are landlocked countries, so perhaps air transport is more vital to their economies. Chile and Bolivia’s levels of infrastructure are relatively similar, with their railways and roadways/capita on the higher end of the entire region.

Besides airports per 100,000 population, Chile outperforms Bolivia in every other attribute except for roadways, but Bolivia’s land area is 300,000 km^2 larger than Chile. Most notably, Chile’s exports are the second highest $ amount/capita of the entire region, while its amount of air cargo/1 million is by far the highest in the region. It moves a total of 67.3 million ton-km per million people while Bolivia moves only 1.9 million ton-km per million people. An economic overview states that Chile has a "market-oriented economy characterized by a high level of foreign trade… Exports of goods and services account for approximately one-third of GDP." Meanwhile, Bolivia is a "resource rich country and remains one of the least developed countries in Latin America because of state-oriented policies that deter investment" (CIA World Factbook 2021). However, my initial data showed that Bolivia's level of infrastructure was on the higher end/capita of the region.

I expect that an overview of both countries' infrastructure, economies, development, and airports being built can help demonstrate the complexities of infrastructure and airport infrastructure.

TABLE 1.2 COMPARISON BETWEEN CHILE AND BOLIVIA'S INFRASTRUCTURE

Attribute	Bolivia	Chile
Population as of July 2021	11,758,869	18,307,925
Land Area (km^2)	1,083,300	743,5332
Real GDP/capita	8,724	24,226
Number of airports (paved/unpaved and retired/open)	855	481
Airports per 100,000 (2013)	7.27	2.63
Number of Passengers/Capita (2019)	0.35	1.16
Air Cargo 2019 (million ton-km)	22.9804	1232.4110
Air Cargo/1 million (million ton-km)	1.9543	67.3157
Airport Connectivity Score (2019)	30	57.8
Efficiency of Air Transport Services Score (2019)	43.3	65.7
Railways (Km)	3960	7282
Railways (km) /100000	33.6767	39.7751
Roadways (km)	90568	77801
Roadways/100,000 (km)	770.21012	424.9580
Imports (USD)	10,142,000,000	87,505,000,000
Imports/capita (USD)	862.4979	4779.6241
Exports (USD)	9,632,000,000	90,626,000,000.00
Exports/capita (USD)	819.1264	4950.0967
Global Competitiveness Index (2019)	51.8	70.5
SPI Index (2020)	69.23	83.34

Data Sources: World Factbook, World Bank, World Economic Forum, Social Progress Index

Chapter 2: Foundational Research

Transport Infrastructure and Economic Development

Since the 1980s, scholars have evaluated the relationship between transport infrastructure and regional economic development (Rokicki and Stepniak 2018, Aschauer 1989, Cidell 2014, Kessides 1993). In an overview of infrastructure and regional development, Bröker and Rietfeld (2019) determine that there is no consensus on the productive effects of infrastructure. Julie Cidell (2014) notes that the key problem preventing researchers from agreeing on the relationship between the two is a chicken-and-egg question of which originates first.

Three main opinions prevail within the debate linking infrastructure and economic development. One camp argues that overall investment in hard infrastructure increases economic production, leading to higher GDP. Critics of this theory argue that certain infrastructure types have stronger effects than others on production output. Another camp believes that investment in infrastructure does not cause economic production to increase. Rather, the infrastructure allows the existing resources and services to truly flourish. Therefore, a country without a strong workforce or significant resources will not make up for its financial shortcomings by building more infrastructure. The final argument within this field is that the economic effects of infrastructure are difficult to measure. For example, the effects can be significantly long-term and widespread, and it is not possible to attribute all financial strides to infrastructure development.

A monumental paper by Aschauer (1989) indicates that a general expansion in hard infrastructure (streets, highways, airports, mass transit, sewers, and water systems) explains increased economic productivity. Aschauer used an output elasticity equation, a mathematical formula that measures how a specific change in one input variable affects the change in the output, to prove his theory. Aschauer divided the change in GDP (output) by changes in nonmilitary public spending (input) and found a significant relationship. Clarke and Batina (2017) replicated Aschauer's methodology with expanded time-series data for 1949-2015 and were shocked by how the results held up almost perfectly. Rokicki and Stepniak (2018) claim that many studies using empirical methodologies, like Aschauer's, find contradictory evidence. For example, a study by Kim (2006) used large numerical models featuring economic theory alongside empirical data from Korea, and the hybrid methodology found that investment in airports, roads, railways, and seaports are effective investments in the short run. However, the findings showed that investment in roads and railways caused the most positive effects on production in the long run. Therefore, Kim's analysis highlights that infrastructure types' effects vary.

Alternatively, the World Bank Senior Economist Christine Kessides argues that infrastructure projects alone do not create economic potential, they only help it develop (Kessides 1993). Using both microeconomic and macroeconomic data, Kessides concludes that economic growth and quality of life do not develop solely due to investment in physical infrastructure. Rather, the services produced via the infrastructure cause the development. For example, the study notes transport infrastructure yields less time and money spent moving raw materials, meaning the workers' time can be spent accomplishing productive activities that increase economic returns on labor. In the quality-of-life capacity, the study highlights that transportation infrastructure increases access to clean water, sanitation, recreational activities, and medical attention. Although noting the general benefits caused via infrastructure investment, Kessides asserts a country must have complimentary systems and efficient resources if an infrastructure project's goal is to improve economic and social development.

Due to the debates surrounding productive effects and infrastructure development, Esfahani and Ramirez (2003) accounted for the simultaneity between the two by creating an economic model to account for the changes in institutional and economic factors that mediate infrastructure. The study provides evidence of a substantial impact of infrastructure on GDP growth but also deduces that "institutional capabilities that lend credibility and effectiveness to government policy play particularly important roles in the development process through infrastructure growth" (Esfahani and Ramirez 2007, 471). Thus, they argue that strong governmental institutions with efficient public spending on infrastructure increases economic development. Sturm and Groote (1999), on the other hand, determine interpretations and results surrounding infrastructure and development are exceedingly challenging to decipher because the methodology must account for short-term expenditure and long-run effects.

As Rokicki and Stepniak (2018) argue, no true consensus on infrastructure spending and development prevails among scholars, but most specialists seem to agree that the two coexist. The coexistence is especially prevalent in the studies of foreign trade and international investment. Kessides's (1993) alternative conclusions state that infrastructure affects costs and services in international trade, and these systems determine international competitiveness and export/import markets. Kim's (2006) research on Korea's development found an existing correlation between transport infrastructure investment and foreign investment into the national private sector.

Comparing the debates on infrastructure led me to develop several assumptions. First, most scholars agree that infrastructure spending and development are correlated, and the reasons for this development can quickly become complex, as seen in the analyses of Kessides (1993) and Esfahani and Ramirez (2007). Also, Kim (2006) accounted for the various functionality of infrastructure types and showed that their economic effects differ, highlighting the fact that roadways and railways cause the most positive effects on production in the long run while investment in airports, roads, railways, and seaports are effective investments in the short run. This result hints that infrastructure analyses should be more concentrated rather than "general" like Aschauer's study (1989).

Airports in Regional Development

This section offers insight into airports and their roles. The effects of airports can vary depending on what is transported, the political goals of the infrastructure project, the local population's demand, and the services offered. Scholars typically focus on one aspect of airport infrastructure within papers rather than an all-encompassing research question. Perhaps classifying the effects of airport infrastructure is too complex because of the many possible externalities of moving both people and cargo, so measuring the actual "airport infrastructure" is a clearer approach.

Two forms of transport infrastructure that mostly affect international trade are airports and shipping ports. Substantial literature focuses on airport infrastructure and its impact on economic development, but the studies struggle to measure all the effects due to airports' varying functionality.

Rosenthal and Strange (2004) deduce that the efficient movement of cargo and people produce positive externalities that develop the region surrounding the airport. Bowen (2002) concludes that airports yield superior access to global flows of people, goods, money, and information.

Some studies concentrate on airports' localized effects. Percoco (2010) shows that an increase in both airport infrastructure and air traffic generally cause an uptick in firms coming to a region, adding more jobs to the economy. One possible reason for this general uptick comes from Kellenberg (2015), who argues that airports lower international trade costs and lead to more domestic firms in both countries involved. Bel and Fageda (2008) utilize a case study of European corporations to discover that proximity to airports is a key factor in choosing headquarter locations, so firms could also be moving domestically to be closer to an airport, thereby altering the local economy.

Scholars believe the level of connectivity of an airport also affects the local economy. Campante and Yanagizawa-Drott (2016) investigate the effects on international flights on local economies, and they reason local economies experience an annual .8 percent GDP increase when the area has airport interconnectedness.

In addition, some argue that the positive effects of airports depend on much more than just their existence, such as the airport's local population and size. Halpern and Brathern (2011) conclude that the effects of an airport depend on its location's population size and demand for the airport. Lian and Ronnevik (2011) use Norwegian surveys to argue that large airports are preferred over small airports due to more services.

Other studies investigate airports as a causation of economic competitiveness. The World Economic Forum's annual *Global Competitiveness Report* aims to assess factors that are indicative of "long-term competitiveness" to help countries "shape new models and standards… for systemic change on three deeply interconnected areas: growth and competitiveness, education, skills and work, and equality and inclusion" (Schwab 2019). The report includes measurements of both "airport connectivity" and "efficiency of air transport services." The World Economic Forum's usage of these two measurements shows that the organization believes airport infrastructure is pertinent to the global competitiveness and wellbeing of a country.

Researchers also note airports can act as political and economic demonstrations for governments. Lin and Qi's literature review considers the main goals of China's Belt and Road Initiative (BRI) to be "China's way of fulfilling its international development and cooperation needs through an emphasis on transport connectivity and infrastructure building," and the two investigate two major airport projects within the BRI. Lin and Qi determine that the airports' construction to help foster local economic power and prominence amongst nearby Eurasian countries (Lin 2020). If this is the case, China is investing in aviation infrastructure today to secure prominence for the future.

International airport terminals might determine a person's perception of that place. Discussing Southeast Asia's emerging airport infrastructure, Max Hirsh (2016) points out that prominent architects and a large amount of money were involved with the construction of the Hong Kong airport's train station. The train station is known as Hong Kong's "front door to the world," leading public officials to invest extra money into the project with goals of changing the international and domestic travelers' initial perception of the city.

Foreign Trade and Economic Development

According to a critical review by Siddiqui (2015), the benefits of international trade and market liberalization have created heated arguments. International institutions like the World Trade Organization advocate for increased trade liberalization in developing countries, yet some economists have found negative or insignificant effects of market liberalization, especially in developing countries.

Foreign trade is built upon David Ricardo's nineteenth century theory of comparative advantage. The theory claims that global social welfare is most efficient when countries focus on producing the good they can make at a lower opportunity cost and then trade those goods internationally (Sundaram 2009). An updated early-twentieth century version of comparative advantage formulated by Heckscher, Ohlin, and Samuelson proposes that countries should export products they can most efficiently produce with existing resources and import products whose inputs are scarce (Kopp 2021). More recently, neoliberal economist Dianne Krueger (1980) argued that trade liberalization leads to export-based economies and more global competition. These economic theories formed the thought that increased liberalization yields economic growth and overall development (Siddiqui 2015).

Existing literature proves the relationship between exports and total factor production amongst more developed countries. Using time-series data covering Western European and North American countries, Chenery (1983) finds that the regions benefitted economically by increasing exports. A study by Nishimizu and Robinson examines East-Asian industrializing countries like Japan and Korea and discovers the same findings that export expansion yields higher total factor production.

Economists question the true benefits of economic growth caused by economic liberalization in developing countries. Lee and Cole's (1994) research shows that developing countries with liberal economies experienced an extreme increase in imports, yet their ability to produce high-value products remained the same. Shafaeddin (2005) reviewed time-series data from 1980-2000 for multiple developing countries and discovered that income inequality has dramatically increased since governments passed neoliberal reforms in the 1970s. Utilizing Latin America as a case study, Shafaeddin determined that neoliberal reforms in the region benefitted multinational corporations at the expense of domestic, local firms.

Nobel prize winner Joseph Stiglitz understands how developing countries can benefit from international trade with carefully designed trade policies. However, Stiglitz primarily argues that international organizations like the IMF and World Bank lobbied for developing countries to rush into free-market economies in the twentieth century without considering local and national economic factors. This shortsightedness of the international institutions, Stiglitz (2002) claims, limited localized economic growth and fostered an environment for multinational corporations to prosper.

The findings of Stiglitz guide me to contemplate if a score like "global competitiveness" from the WEF, a global institution, truly measures economic advancements on a personal level. His findings also led to me consider liberalized economies within my case study between Chile and Bolivia.

The State of Latin American Airport Infrastructure

Academics usually regard Latin America's overall infrastructure quality to be weak, especially when compared to nations with similar economic levels (e.g., China). Fay and Morrison (2007) report that the region averages upper-middle-income, yet its infrastructure levels fall below countries with middle-income levels.

Like overall infrastructure, Latin American airport infrastructure is considered subpar by experts and institutions. Serbrisky (2012) found that only four airports in the Latin American region are ranked in the top 100 in the world. Airline executives and the public are also aware of this disappointing aviation infrastructure. In interviews with executives from four major full-service airline groups that operate throughout Latin America, every interviewee complains about the lack of airport infrastructure that hinders the region (CAPA 2017).

Perhaps lack of investment attributes to the underperforming airports. Up until the late 1990s, governments in Latin America were almost completely responsible for the construction of airports, and a World Bank report shows that "Latin America invests the least in infrastructure among developing nations” (Fay 2007). But, with the rise of neoliberalism, public-private partnerships (PPPs) emerged to allow for private investment into the industry (Sebrisky 2012). Nowadays, private investment is growing, but the current investment levels are not enough to close the region’s airport demand-capacity gap (CAPA 2018).

Another possible reason that airports in the region underperform is that aviation regulations vary from country to country. O’Connell (2020) emphasizes that Latin American aviation must abide by rules from forty-five different institutions, while European and US aviation follow one authoritative body. Prominent executives from Latin American airlines complained that government regulations hinder their businesses from expanding (CAPA 2017). Not only do the many regulations hurt the airline industry, but the consumers themselves are affected. Airplane ticket pricing in the region is relatively high, and countries like Chile place government charges on both international and domestic flights for funding general expenditures (Gomez-Lobo 2016).

From this broad research, I can infer that the high quantity of airports in Latin America does not tend to translate to efficiency. The region generally has high ticket prices (Gomez-Lobo 2016), a difficult environment for airlines (O’Connell 2020), and relatively low spending on infrastructure projects (Fay 2007). However, I was unable to find scholarly articles discussing why the quantity of Latin American airports is high.

Chapter 3: Major Transport Infrastructure Quantitative Analysis

To further understand the data for major transport infrastructure, I first chose to complete descriptive statistics of the four major infrastructure types within my dataset.

TABLE 3.1 GLOBAL TRANSPORT INFRASTRUCTURE DESCRIPTIVE STATISTICS (ADJ. FOR POPULATION)

	Mean	Median	Std. Dev.	Skew	N
Railways/100,000	30.11	15.45	37.13	2.07	122
Roadways/100,000	709.94	333.67	1062.304	3.81	154
Waterways/100,000	16.06	7.84	25.24	3.19	98
Airports/1 million	9.12	3.72	14.33	3.84	158

Data Sources: CIA World Factbook

The data suggests that countries typically have more kilometers of roadways than of other types of transport infrastructure. Also, the high standard deviation for roads shows that the quantity of roads varies dramatically between countries, relative to other infrastructure types. Most importantly, the descriptive statistics show that all these distributions are positively skewed, meaning much of the total measured infrastructure is concentrated within a few countries, making the medians and means vary greatly. Thus, the distributions are not normal, and the data needs to be transformed. One simple way to transform positively skewed data is to use natural logarithm. Note that some cases yielded negative values for natural log because their initial measurements were less than 1, and these cases were removed from the model. Transforming the data using natural log to adjust for skewness yields the following:

TABLE 3.2 TRANSPORT INFRASTRUCTURE (ADJ. FOR POP.) TRANSFORMED WITH NATURAL LOG (LN)

	Mean	Std. Dev.	Skew	N
Railways/100,000	2.59	1.47	-.68	122

Roadways/100,000	5.90	1.13	.24	154
Waterways/100,000	2.20	1.23	-.03	98
Airports/1 million	1.40	1.31	-.01	158

Data Sources: CIA World Factbook

Now, the skew is almost zero and the order of the means are the same. However, the means and various infrastructure types are more difficult to interpret now. To clear this confusion, I took the logged numbers and created a score out of 100, based on the top-performing country in each of their respective variables. For example, the top country for airports/million (ln) is Paraguay with a score of 7, and Papua New Guinea is next with a score of 6.63. In this scale, Paraguay gets a score of 1, and Papua New Guinea receives a score of 6.63/7, or .947. Then, these scores were translated to 100 and 94.7 by multiplying the decimal scores by 100. This was done for each country in each specific infrastructure type.

This process puts the variables on a normalized scale by using natural logs. Then, putting the scores on a scale to 100 does two things: First, it creates infrastructure-specific scales based on relativity rather than total number. This creates an effective way to compare infrastructure types because the pure number of an infrastructure-type does not efficiently capture how various types work. For example, railroads and waterways can transport large amounts of freight at once, while highways are limited to cars and trucks. Furthermore, global competitiveness statistics are already normalized and are determined by the rank of many statistics rather than just the number of a specific variable. The descriptive statistics of the normalized and scaled values are featured below:

TABLE 3.3 TRANSPORT INFRASTRUCTURE (ADJ. POP) TRANSFORMED WITH NATURAL LOG (LN) (SCALE OF 100)

	Mean	Std. Dev.	Skew	N
Railways/100,000	51.91	22.96	.10	117
Roadways/100,000	65.56	12.56	.24	154
Waterways/100,000	44.98	22.76	.01	98
Airports/1 million	52.83	18.81	-.01	158

Data Sources: CIA World Factbook

From these values, it is clear that countries typically value roadways most, relative to other types of infrastructure. The mean is highest at 65.5, and the standard deviation is lowest at 12.55. This signifies that the level of roadways are more concentrated around the same value and contrasts the initial results that roads differ dramatically by country. According to the means, waterways are the least prevalent mode of transportation across countries. Perhaps these low values are due to commercial waterways being used over and over by large barges and ships and their existence due to natural occurrence.

With the data now ordered, normalized, and scaled similarly, it is possible to complete a series of individual (bivariate) regressions between these normalized and scaled statistics for each infrastructure type (X) and global competitiveness (Y). The results will reveal if quantity of infrastructure is related to global competitiveness and if so, which infrastructure type corresponds the most.

TABLE 3.4 REGRESSION STATISTICS OF NORMALIZED TRANSPORT INFRASTRUCTURE, EACH INDEPENDENT

	Railways	Roadways	Waterways	Airports
Constant	47.52	30.72	60.77	52.6
Coefficient	.27	.45	.03	.15
Adj. R-Square	.31	.21	-.01	.04
Observations	107	128	78	130
P-value	***	***	.66	**

Data Source: CIA World Factbook

When adjusted for population and normalized, the model for railways and roadways yielded an extremely low correlation with Global Competitiveness, both with R-Squared values below 0.4. These two types of infrastructure are land-infrastructure and are responsible for moving both cargo and people daily. These extremely low correlations are statistically significant, as they seem to show that railways and roadways do not explain changes in global competitiveness. Relative to airports and waterways, however, they do. These findings complement Kim's study (2006) which concluded that road infrastructure and railways cause the most positive effects on production in the long run. These results also suggest, at a statistically significant level, that the number of airports per capita do not explain variation in global competitiveness scores.

A multivariable regression did not yield much better results than the variables measured individually. The adjusted R-Square is only .38 for all the variables together, with roadways, railways, and airports being the only statistically significant variables once again.

To reenforce that quantity of infrastructure is not correlated with global competitiveness, I completed bivariate regressions for each infrastructure type without adjusting for population. This allowed me to compare infrastructure without considering for the varying functions of infrastructure because of population size. For example, a kilometer of road is likely to see more use in New Delhi, India than in the rural United States. Again, the initial numbers were highly positively skewed, as seen in the descriptive statistics below.

TABLE 3.5 GLOBAL TRANSPORT INFRASTRUCTURE DESCRIPTIVE STATISTICS (NOT ADJUSTED FOR POPULATION)

	Mean	Median	Std. Dev.	Skew	N
Railways (km)	10356.94	2574	31237.95	7.01	122
Roadways (km)	246001.2	59107.50	787795	6.18	154
Waterways (km)	6525.70	1600	16742.86	4.81	99
Airports (#)	255.21	58	1135.78	10.53	158

Data Sources: CIA World Factbook

The descriptive statistics of the raw quantity of infrastructure show that, once again, roadways are the most common transport infrastructure (not including airports). The standard deviation of roadways also appears to be exceedingly large, showing that countries' amounts of roads largely differ. All the trends are overwhelmingly skewed, as a skew measurement of 1 is considered "highly skewed." Airports have the highest level of skew out of all the infrastructure types at 10.53, meaning that a large portion of the world's airports are within just a handful of countries.

Like with the data adjusted for population, I transformed the data using natural logarithm before comparing the results with Global Competitiveness to rid the distribution of skewness. I did not, however, put them on a scale out of 100, as the goal of this section is to see which variables are statistically significant in bivariate regressions.

TABLE 3.6 REGRESSION STATISTICS TRANSPORT INFRASTRUCTURE (NOT ADJ. FOR POP.), EACH INDEPENDENT

	Railways	Roadways	Waterways	Airports
Constant	32.98	31.75	56.01	54.04
Coefficient	3.57	2.61	.78	1.56
Adj. R-Square	.24	.11	0	.04
Observations	107	128	81	130
P-value	***	***	.35	*

Data Source: CIA World Factbook

This measurement captures overall amount of infrastructure without considering population, and the only figure minorly correlated is railways. Thus, the amount/length of infrastructure is not correlated with global competitiveness, for airports, railways, and roadways. The R-Square for waterways is not statistically significant, but the assumption is that waterways do not correlate. However, this part of the research does not account for efficiency, materials moved, or frequency of infrastructure use.

Chapter 4: Airport Infrastructure Index

As described within Chapter 1, indexes create “composite” variables by combining several “dimensions” of the same mechanism. For this, indexes are often more accurate than single measurements. The primary motivation for creating an index for this research is that “good infrastructure” is difficult to measure, and an index composed of airport-related variables can assist in capturing an accurate measurement of airport infrastructure for countries.

To construct this index, I chose five variables that measure the various functions and overall efficiency of airports. Afterall, airports are multifunctional by nature, moving both passengers and cargo, and their “effectiveness” affects how proficiently both these things are transported. The five variables chosen were airports per million, air cargo per 1 million (million ton-km x km traveled), airport connectivity score, efficiency of air transport services, and number of airline passengers per capita.

As discussed in Chapter 2, Rosenthal and Strange (2004) found that movement of both cargo and airline passengers causes positive economic externalities for the area surrounding the airport. Bowen (2002) determined that airports create more access to global flows of people, goods, money, and information, yet the positive effects of this access are far too multidimensional and complex to measure. Thus, the only effective way to measure the positive effects is to examine the quantity of goods transported. It is this reason that I included both the air cargo per 1 million and passengers per capita variables.

Although the quantity of airports only yielded a R-Squared value of 0.04 when compared with global competitiveness in Chapter 3, the value was still statistically significant. Combined with other values, it might explain some of the variation in global competitiveness. Afterall, Percoco (2010) concluded that more airport infrastructure and air traffic generally increase the number of local firms around the airport, increasing economic production. Kellenberg (2015) also claims that airports reduce international trade costs and increase the number of domestic firms in both countries involved. Therefore, the number of airports in a country must be included within an airport infrastructure index.

Scholars believe the level of connectivity of an airport also affects the local economy. Campante and Yanagizawa-Drott (2016) investigated the effects of international flights on local Economies and found that local economies experience an annual 0.8% GDP increase when the region has an airport with high levels of international interconnectedness. The WEF's "Airport Connectivity Score" concisely measures how connected a country's airport infrastructure truly is.

Lastly, a way to capture the inefficiency and heavy regulated business environment numerically is to use WEF's "efficiency of air transport services" score. O'Connell (2020) highlighted that Latin American aviation follows forty-five different regulatory bodies, leading to inefficient airports.

To understand the data, I again utilized descriptive statistics on the variables I collected and transformed (airports per million, passengers per million, and cargo per million). Airport Connectivity and Efficiency of Air Transport Services were already transformed and normalized by the WEF.

TABLE 4.1 AIRPORT INFRASTRUCTURE DESCRIPTIVE STATISTICS (ADJ. FOR POPULATION)

	Mean	Median	Std. Dev.	Skew	N
Air Passengers/1 million	1272625	282451	3406922	6.84	127
Air Cargo/1 million (million ton-km)	112.64	2.97	530.29	8.15	113
Airports/1 million	9.12	3.72	14.33	3.84	158

Data Sources: CIA World Factbook

Again, these datapoints were positively skewed. Following the methodology in Chapter 3, I transformed the data using natural log. Then, I scaled the variables using the score of the top country in each respective category. Lastly, I put these variables on a scale of 0-100. Note that the countries that yielded negative numbers after being transformed via natural logarithm were removed from the analysis.

TABLE 4.2 AIRPORT INFRASTRUCTURE DESCRIPTIVE STATISTICS (ADJ. FOR POPULATION) TRANSFORMED USING LN (SCALE OF 100)

	Mean	Median	Std. Dev.	Skew	N
Air Passengers/1 million	71.02	72.55	12.93	-.60	127
Air Cargo/1 million (million ton-km)	39.30	37.73	23.42	.17	98
Airports/1 million	52.83	52.83	18.81	-.01	158

Data Sources: CIA World Factbook

To build this index, I first completed multivariable regression analysis with all five airport variables (X) and global competitiveness (Y). Only 83 observations were used to formulate this multivariable regression because some countries lacked one or more of the indicators.

TABLE 4.3 MULTIVARIABLE REGRESSION WITH AIRPORT INDICATORS PREDICTING GLOBAL COMPETITIVENESS

	B	SE B	t	p
Airports/Million (100)	.03	.02	1.15	.25
Passengers/Million (100)	.37	.10	3.78	***
Cargo/Million Score (100)	-.0009	.04	-.23	.82
Airport Connectivity Score (WEF, 2019)	.17	.03	5.65	***
Efficiency of Air Transport Services Score (WEF, 2019)	.24	.06	4.19	***
Intercept	10.31	6.17	1.67	.10
N of observations	83			
Adjusted R-squared	.74			
F-Statistic	47.92			

Data Sources: WEF, CIA World Factbook; *p<.05, **p<.01, ***p<.001

The overall adjusted R-square value for this multivariable regression is 0.74, much stronger than any of the previous regressions that consisted solely of quantity of infrastructure type. The three variables that are statistically significant are passengers per million, airport connectivity score, and efficiency of air transport services. Surprisingly, the amount of air cargo per million did not correlate with global competitiveness. I hypothesized that a country which moves more via aircraft per capita would be more globally competitive. However, that is not the case. For benchmark purposes, the indicators not statistically significant were removed, and the multivariate regression analysis was conducted again with airport connectivity, efficiency of air transport services, and passengers per million

TABLE 4.4 MULTIVARIABLE REGRESSION WITH STATISTICALLY SIGNIFICANT AIRPORT INDICATORS PREDICTING GLOBAL COMPETITIVENESS

	B	SE B	t	p
Passengers/Million (100)	.39	.09	4.67	***
Airport Connectivity Score (WEF, 2019)	.16	.03	5.65	***
Efficiency of Air Transport Services Score (WEF, 2019)	.23	.05	4.45	***
Intercept	10.31	4.89	2.30	*
N of observations	83			
Adjusted R-squared	.74			
F-Statistic	79.95			***

Data Sources: WEF, CIA World Factbook; *p<.05, **p<.01, ***p<.001

All the variables proved to be statistically significant again, and the Adj. R-Square is 0.74, meaning that these variables explain 74 percent of the change in global competitiveness (Y). Because these scores are out of 100 and were put through the same process of normalization, it is clear that passengers per million affects global competitiveness the most, with a coefficient of 0.39, followed by air transport services at 0.23, and lastly airport connectivity at 0.16.

This regression analysis shows that infrastructure *can correlate* with global competitiveness, but the number of airports is not individually correlated. Rather, the use and efficiency factors relating to airport infrastructure are correlated. Again, these factors bring to mind the chicken and the egg question of which culminates first: the global competitiveness or effective and frequently used airports?

It is hard to decipher, but a country with higher incomes, infrastructure for tourists, and tourist sights are more likely to have more airline passengers per capita than countries without these factors. The country with the highest number of airline passengers per capita is Ireland, with 3.26 airline passengers per capita annually. Qatar, the UAE, Singapore, and Finland follow. All five of these sovereign states rank highly for GDP per capita (PPP basis). Singapore, Ireland, Qatar, and the UAE all rank in the top fifteen, with Finland at thirty-two. The average incomes of these states allow their inhabitants to travel both domestically and internationally. These countries are popular tourist destinations as well, with all five having more international tourists than domestic populations in 2019. Lastly, these countries have relatively small populations of under 10 million.

From the results, countries with more tourists and more developed economies most likely have the resources, professional workforce, and need to focus on "efficiency of airport services." The variable "Efficiency of airport services" measures frequency, punctuality, speed, and price, utilizing public surveys. Singapore tops all other countries, followed by Hong Kong, the Netherlands, Finland, and Japan. The UAE (9th), Qatar (16th), and Ireland (25th) are also high on the list, just as they were with passengers per capita. Again, all these countries have relatively strong economies and are heavily visited via aircraft, making airport efficiency a necessity. Culturally, some of these states have exceedingly high standards for order. For example, Singapore is known for having strict regulations and laws designed to maintain peace and order. Similarly, Japanese culture "has long been famed for an intense work culture defined by arduously long hours…" (Demitriou 2020). Thus, perhaps efficiency can also be derived from societal factors and not solely economic factors.

The last statistically significant variable was IATA's airport connectivity measurement, constructed by considering the seats available for each destination which is then weighted by the size of the airport. Then, the weighted totals are summed for an entire country. This variable gives an idea for how in-demand the airports are for passengers and if the airport can fulfill those demands. Interpreting this metric is difficult. The countries with the highest scores all have relatively large populations, as China, Indonesia, Japan, Germany, Spain, the UK, the U.S., and India all received a perfect score from IATA. An explanation for this might be that the countries' large populations ensure that the flights to each offered destination occur daily, multiple times per day.

Although the three statistically variables are difficult to decipher, I averaged the three variables to create the index composite variable and completed a bivariate regression with the index (X) and global competitiveness (Y). I expected the index to be more strongly correlated than the multivariable regression because the outliers for a certain will average out with other variables.

TABLE 4.5 BIVARIATE REGRESSION WITH AIRPORT INFRASTRUCTURE INDEX PREDICTING GLOBAL COMPETITIVENESS

	B	SE B	t	p
Airport Infrastructure Index (100)	.65	.04	6.87	***
Intercept	10.31	4.89	2.30	***
N of observations	83			
Adjusted R-squared	.73			

F-Statistic	217.29	***

Data Sources: WEF, CIA World Factbook; *p<.05, **p<.01, ***p<.001

The bivariate regression with the index yielded an Adj. R-Square value of 0.73, and the p-value of the index is less than .001. Thus, the index is statistically significant, and the index 73 percent explains the variation in global competitiveness with only one variable.

This chapter demonstrates that aspects of aviation infrastructure *can correlate* with global competitiveness, but the pure number of airports and air cargo that is moved are not correlated to a statistically significant degree. The previous chapter also proved that the number of airports did not correlate. I hypothesized that air cargo would be correlated, considering more air cargo per capita would indicate higher levels of trade for a country.

As noted in studies about infrastructure, it is challenging to differentiate if these variables are *causal* for an increase in global competitiveness or just an externality of a high global competitiveness. Most likely, the increase in input variables is an externality because the countries with the top aviation infrastructure already have a general population who can afford to travel via aircraft, therefore causing the aviation infrastructure to be highly efficient.

Chapter 5: Comparative Analysis of Chilean and Bolivian Infrastructure

Shared Histories of Mining and International Investment

Not long after the Spanish conquest of the Americas, mining production began in both Bolivia and Chile. In what is now southern Bolivia, Diego Gualpa discovered the largest silver deposit in human history in 1545, within a mountain known as Potosí. The silver extracted from the mountain was used to create the first international currency, the Spanish dollar, and this massive amount of wealth funded the development of the Spanish empire and its armada. Before railways, the silver extracted here was transported to the Pacific Ocean by llama and mule trains to eventually be shipped to Spain (Lane 2019). By the 18th-century in current-day Chile, the silver, gold, and copper were exported directly to Spain, via the Straights of Magellan or ports in Buenos Aires (Salazar 2002).

These mineral-rich lands brought riches to communities mainly in other parts of the globe (e.g., the Spanish government). Because minerals are hard to transport via llamas and mules, international companies quickly began building railroads in Chile and Bolivia after the locomotive's invention in 1802. Bolivia and Chile both gained independence from Spain in the early 19th century, so the national governments overtook relations with the mining companies. In Chile, private companies built most railroads between 1850 and 1913 for the transport of minerals, mostly potassium nitrate, and lumber (Edwards, 2001). In Bolivia, British investment into railways helped the silver and tin industries grow rapidly (Bignon 2015).

In addition, Bolivia and Chile fought against each other in The War of the Pacific from 1879 to 1884 over coastal territory rich in guano and nitrate. As a result of the 1904 truce, Chile promised to build Bolivia a railway, from Chile's northernmost port, Arica, to the capital of

Bolivia, La Paz (Long 2013). This railway extended more than 400 kilometers and winds through desert and snow-capped mountains.

With partial international funding from mining, the railway systems permitted passengers to travel domestically across rough terrain throughout the 20th-century. Chile's national rail system carried about twenty-seven million passengers in 1973 (Donoso 2013). Although helpful for developing economies and domestic travel, both countries' rail systems declined in the latter half of the 20th-century.

Bolivia's Railroad Decline

Bolivia nationalized its railroads in the 1950s, but a right-wing-military dictatorship led by Hugo Banzer Suarez (1971-1978) slowed funding to the railroads and focused instead on building highways. This change in government spending supplemented a USAID initiative to help build highways across Bolivia (USAID 2007). With this money from USAID and the creation of The National Road Service in 1964, the number of roads increased from 3,000 kilometers in 1964 to over 41,000 kilometers in 1988. With more roadways and not enough resources to maintain the rail system, parts of the rail system fell into disrepair.

Chile's Railroad Decline

Chile's railroad decline can be attributed to right-wing military dictator Augusto Pinochet and the liberal economic policies of the Chicago Boys. From 1973 to 1990, Pinochet's regime promoted "neo-liberal" policies that promoted the privatization of physical infrastructure (Feinberg 2019). As railroad services' revenues declined, Pinochet allowed the companies to go out of business. For example, La Red Norte stretched from northern Chile to Valparaiso, in central Chile, but ceased operations in 1975 because of lack of revenue and government support.

Modern-Day Railway Systems

The high amount of railway infrastructure in both Chile and Bolivia is mostly explained by their economic history of mining. Today, mining is the leading industry for both countries' economies. In 2019, over 70 percent of Bolivia's exports were either precious metals, raw metals, or mineral products, with petroleum gas, gold, and zinc leading the industry (OEC 2019). About 50 percent of Chilean exports are metals and mineral products, led by the production of copper (OEC 2019). Currently, roadways and pipelines help move the majority of these commodities. The previously mentioned extensive 400-kilometer railroad that connected northern Chile and Bolivia is now shut down, and trucks rather than trains carry most of the cargo (Long 2013).

Road Building in Both Countries

The largest deterrent of road building is the high costs. According to the Highway Economic Requirements System in the United States, the cost of constructing a mile of a paved one-lane highway in a flat area costs around $3.5 million. In a mountainous region, the cost of this same development skyrockets to over $10 million (FHWA 2019). While these costs represent the situation in the United States, they give an idea of financial problems South American countries face when constructing highways.

Bolivia's roadway system includes over 90,000 kilometers, but as of 2015, only 11.7 percent of these roads are paved, making Bolivia's road system one of the most underdeveloped in all of Latin America (IDB 2015). This lack of strong roadway infrastructure is especially evident in rural areas, where the amount contributed to national GDP is low, and the rural residents lack access to transportation, quality jobs, and basic services (IABD 2015). On the other hand, about 25% of Chile's roads are paved, including 3300 km of freeways.

Roadway systems in both Bolivia and Chile have room to grow. After all, construction of three of the world's most developed road networks, in the US, China, and India, all have been rapidly constructed since the 1950s. However, costs of road construction are high, especially for mountainous countries like Bolivia and Chile.

Airport Infrastructure Costs and Necessity

For the high costs associated with road building, perhaps the construction of airports is a cheap, short-term alternative to transport goods and people domestically in both Chile and Bolivia. A runway is typically much cheaper to build than a roadway. A 5,000-by 75-foot runway with a ramp, taxiway, fuel farm, and hanger can accommodate a large business airplane and can cost around $10 million (Huber 2021). Unpaved runways with 3,000-foot runways can be even cheaper.

Bolivia has a total of 855 airports, but only twenty-one of these airports have paved runways. Chile has 481 airports, but only ninety of them are paved. Chile has more of an incentive to develop their international airport infrastructure because of their quantity/types of exports and higher volume of air passengers.

Hyland Shipping, a freight company who organizes international shipping, outlines the main products that should be transported via aircraft. Their list includes the following:

- Urgent Goods
- High Volume Goods
- Intercontinental urgent mail
- Spare parts for land vehicles
- Spare parts for the aerospace industry
- Perishable Food
- Materials for fairs and events
- Plants

- Drugs, vaccines, and other pharmaceutical products.
- Live animals
- Luxury Products
- Artworks
- Machinery and accessories for medical use

The Chilean Economy

As noted, Chile moves more cargo by aircraft per capita than any other country in Latin America. This data most likely correlates with the types of goods Chile exports and the nature of its economy. While mining makes up more than 50 percent of its current exports, Chile focuses on exporting high-value fruits like cherries, cranberries, grapes, apples, peaches, and plums, and this sector makes up more than 6 percent of its total exports. Chile also exports luxury goods like wine and several pharmaceutical products, with each of these sectors accounting for around 2 percent of total exports (OEC 2019). According to Hyland Shipping, these products may be shipped internationally by plane.

Chile's economy has strong neoliberal roots because of policies implemented by Pinochet and the Chicago Boys (Feinberg 2019). It is also considered one of the most educated and modernized countries throughout Latin America, and the World Bank classifies it as having a "market economy" and "high-income economy" (World Bank 2022). By sector, 4.2 percent of total GDP is agricultural, 32.8 percent is industrial, and 63 percent is service-related.

The Bolivian Economy

Comparing cargo moved per capita, Bolivia moves about 1/33rd the amount of air cargo that Chile transports. This variable also accounts for distance moved, and Chile is transporting more items internationally than Bolivia. Its largest trade partner is China, where over 30% of its exports are delivered (OEC 2019). Whereas, Bolivia's largest export destination is Argentina, which receives around 15 percent of Bolivian exports.

Bolivia's economy differs from Chile's. The World Bank classifies Bolivia as a lower-middle income country (World Bank 2022). Historically, the country has relied on extraction of natural commodities like silver, tin, and most recently, petroleum gas. This sector of the economy is likely going to continue to flourish, considering an estimated 10 percent of mineral resources have been extracted despite over 500 years of mining (ITA 2019). Over 60 percent of 2019 exports, by value, were related to natural commodities (OEC 2019). Other parts of the economy are expanding rapidly and as a byproduct, eliminating extreme poverty. The 2019 domestic labor force consisted of 29.4 percent agriculture, 22 percent industry, and 48.6 percent service-related jobs. During democratic socialist Evo Morales's presidential stint from 2006 to 2019, GDP per capita quadrupled, and the extreme poverty rate sharply fell from 38.2 percent to 15.2 percent (INE 2019). Perhaps the nationalization of natural commodities caused this change. On his hundredth day in office, Morales nationalized oil and gas production, the largest sector of exports, with a yearly export value of about three billion dollars (Zissis 2006).

Unlike Chile, Bolivia does not export many items that need to be transported via aircraft. Its main agricultural exports consist of dry goods that do not spoil rapidly, such as nuts and wheat (OEC 2019). Perhaps jewelry, gold, and silver may be exported via aircraft, but these industries only account for a total of two billion dollars per year, about the same size as Chile's wine industry (OEC 2019). Therefore, most of Bolivia's exports can be transported via the longer yet cheaper (once built) transportation options of roadways, ports, or railroads.

One day, Bolivia's economy may develop industries that require aircraft transportation, such as wine in Chile or another luxury good. Investment in airports now may therefore pay off in the future.

Bolivia's Airport Infrastructure

For now, Bolivia's airport infrastructure is very weak. Out of 83 countries included within the airport infrastructure index, Bolivia ranks 77th, with a score of 49.01. The country received a passengers per million score of 73.73, an airport connectivity score of 30.00, and an efficiency of air transport services score of 43.30. Of Latin American countries, only Paraguay ranks lower than Bolivia, with a score of 43.82. Paraguay and Bolivia have the most airports in the region yet receive the lowest airport infrastructure scores. They are also the only landlocked countries in the region, suggesting that lack of seaports causes an increase in airport quantity.

Bolivia's airport infrastructure is relatively young. In 1964, USAID granted Bolivia a loan with advantageous terms to build its first international airport in El Alto. El Alto is located beside La Paz with even terrain, favorable for a large-scale airport. The country now has three international airports and thirteen strictly domestic airports that offer commercial flights for passengers. Sixteen airports that serve passengers in a country of about eleven million seems high.

To make immediate progress with their current airport infrastructure, Bolivia could implement ways to increase connectivity and efficiency. Some proposals have already been implemented. In 2016, Evo Morales announced plans to invest over $700 million into airport construction, citing that this move was to make exports more competitive (Bnamericas 2016). In 2013, Morales nationalized an airport operator owned by Spanish company, Abertis, that oversaw operating the three international airports (Quiroga 2013). Now, the Bolivian Airport Services SA (SASBA) operates these three airports.

Chilean Airport Infrastructure

On the airport infrastructure index, Chile received an overall score of 68.7 and ranked 43rd. It received a passengers per million score is 80.71, an airport connectivity score of 57.80, and an efficiency of air transport services score of 65.70. Although Chile has the highest global competitive score and strongest economy by GDP per capita ($PPP), Mexico (28th), Panama (35th), and Colombia (42nd) scored higher on the airport infrastructure index.

Chile is making investments into airports to increase airport efficiency: In 2019, the government announced a plan to modernize seventeen airports, doubling the capacity of existing terminals and completely redeveloping the main international airport in Santiago (Ennes 2019). In addition, to help boost efficiency, Chile is offering contracts to Swissport, a Swiss aviation services company that provides airport ground, lounge hospitality, and cargo handling services (Swissport 2021). In 2021, Swissport added 6 new Chilean airports to its portfolio, now operating at a total of 8 Chilean airports.

Comparison Takeaways

As seen in this case study, infrastructure can be extremely complex, with types of exports, politics, companies, government spending, terrain, and international investment all affecting its development. Both Chile and Bolivia should continue to improve their roadway infrastructure to transport goods and people domestically long-term. However, due to the costs of building roadways through mountainous regions and the nature of their current economies, perhaps small airports in rural communities can help short-term economic development. After all, major roadway infrastructure projects, like the US interstate system, have only been developing for less than a century. Furthermore, Bolivia and Chile both have populations under twenty million, and major infrastructure projects do not get cheaper when less people live in a location.

Conclusion

This thesis researched how transport infrastructure, specifically aviation infrastructure, relates to overall global competitiveness of a nation. While contributing to the overall field of economic development, this thesis is unique for several reasons. First, it uses global competitiveness as a basis for measuring a country's economic success in the modern world. Next, most of the variables were scaled for population size. Lastly, a comprehensive methodology of quantitative research (e.g., multivariable regressions and an index) and qualitative research (e.g. the case study and examination of prior research) was utilized to truly answer several nuanced research questions. The overall intention of this thesis was to answer important questions regarding the development of the Latin American region.

Primary Findings

Using both quantitative and qualitative research, I hoped to find a clear answer about the relationship between infrastructure and economic development. I found, as much of the research discussed in Chapter 2 concluded, that infrastructure is an extremely complex topic.

My research shows that the positive economic competitiveness cannot be explained solely by infrastructure. In fact, the initial regression analysis done in Chapter 3 shows that the pure amount of infrastructure alone in a country does not affect the overall global competitiveness score. In chapter 4, the aviation infrastructure index *does* show that certain aspects of infrastructure, like efficiency and usage, correlate with global competitiveness. Though, logical thought-processes show that other factors can also affect these metrics, such as preexisting strong economies, tourist destinations, and cultural standards. In addition, the case study between Chile and Bolivia shows that politics, economic history, and level of natural resources affect the level and efficiency of infrastructure in each country.

Although not truly proven to a statistically significant degree, my regression analyses hinted that quantity of railway and roadway infrastructure relates more to global competitiveness than navigable waterways and airports. Kim (2006) found that roadways and railways created the most positive effects on long-term economic growth. The case study showed that most raw materials and exports can be moved cheaply via truck and railcars. However, the case study also showed that the construction of roadways is expensive, especially in mountainous areas.

The expenses of road building show the financial hurdles that countries face when trying to implement infrastructure projects. This is especially hard for countries with relatively small populations and large land areas.

Limitations

My primary regret when conducting this research is the omission of shipping ports from my dataset. Globally, around 90 percent of traded goods are transported via ocean shipping (OECD). Nonetheless, a simple figure showing the number of ports in each country was not readily available.

Potential Areas of Future Research

As my aviation index revealed, elements of aviation infrastructure correlate with global competitiveness. Therefore, more transport infrastructure indexes need to be constructed, especially with roadways and railways. This research could perhaps guide countries to invest in certain facets of infrastructure, such as efficiency and connectivity specific for their major economic sectors.

More research on existing infrastructure is necessary. When researching Chile and Bolivia, I found lacking material that clearly summarized both countries' current levels of infrastructure. The nuances and complexities of infrastructure and economic systems cause challenges to the field of economic development, but more country and/or infrastructure project-specific would help increase effective spending.

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