Effect of Diffusion Innovation on Emerging Countries:
Brazil Case Study

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

From the printing press to the smartphone, the diffusion of new technologies has intertwined the history of human progress. Despite its importance, however, the diffusion of innovation remains an elusive process that fascinates researchers and policymakers alike.

This thesis aims to explore the implementation of innovation in emerging countries and see how it affects the economy. The topic is an important area to investigate because of the wave occurring in countries like Africa, where there is a transition from an agricultural-only economy to an economy mixed with technology. This thesis will provide insight into what common patterns need to occur for innovations to create a significant impact on these emerging markets. This paper will also provide a crucial skill for engineers to know since our goal is not just to create something innovative but groundbreaking. As explained later, a secondary learning objective is how government policies and industry demands can play a prominent role in creating change in any country.

The STS portion will use the SCOT framework to gain understanding and insights to see how technology benefits the quality of life for nations. We will use case studies as our specific framework, as they provide valuable tools for understanding complex issues that textbooks cannot fully comprehend. (Lynn, 1999). Brazil is a strong economy, strong relative to not just its surrounding neighbors but also to the world. What used to be an agricultural country dependent on its natural resources initially has begun to export capital goods. The transition was not due to a concrete solution but a mixture of various factors that created the grounds for success to spawn from the country.

The paper will provide an ethical analysis of technology diffusion in developing countries, including the impact of technology transfer on economic development, and

government policies, and recommendations for a more equitable and sustainable approach to technology diffusion. Through the lens of the Brazil case study, we hope to learn patterns and answers to effectively increasing prosperity with a focus on technology and innovation.

Background

Ask any person in Brazil who Pele is, and no one will disappoint in expressing with great emotion how amazing he is. Enter any restaurant or nightclub and hear music never experienced anywhere else. What kind of country is Brazil, and how can it tell us more about emerging countries? Brazil, a country that was born out of Portuguese colonization, was first a monarchy. After declaring independence in 1820, Brazil was primarily an agricultural country as the natural resources were plentiful.

The government abolished slave labor in the late 1800s when outside actors forced the government to do so. The government, in response, began directing the economy to become more stable through public policies. It opened its borders for trade and made appeals for workers to work in the fields. It suffered harsh competition from imports, and as a result, it imposed high import tariffs. Much of the government's funds would become sourced through import tariffs which would benefit the domestic market. This portion would change in the latter half of the 20th century when different sectors would push to take more significant portions of the market, especially technology. There are problems that the countries constantly face. One is poor education, as illiteracy was widespread in the 20th century. Even now, the demand for more education reforms is prevalent. Though there was much success in what Brazil achieved from the time of its independence, innovation played a significant role.

Definitions

Before any additional research, a definition of terms is critical, and this is to ensure that the author and reader are thinking on the same level plane.

The first term is innovation. Badiru (2021) goes deep into explaining the fundamentals of innovations. Innovation is a typical misnomer since people typically associate it with a product. Particular objects like AI or drones become seen as technology innovation when it is the process that enables products that are the innovation. Even with the clarification, the definition of innovation can be vague since, at its core, it is simply a new method. Therefore it is essential to specify which definition of innovation we will use to avoid ambiguity and strengthen our argument. Badiru defines *innovation* as the following: "Innovation is creatively re-engineering solutions, for problems which may not yet exist, by actualizing new ideas into valuable processes, services, and goods." This definition focuses on adding value to pre-existing products and markets. This description is a fitting definition for the thesis since part of this paper examines how technology influences the positive increase of emerging markets.

A second definition related to innovation is innovation systems. Innovation systems are essential to define since innovation systems are the groundwork that allows innovations to occur. An innovation system is an interaction of people, technologies, and processes that produce innovations. The importance of human factors is a commonly overlooked aspect when thinking about innovations. We can use innovation systems to analyze and gain quantitative measurements. *National Innovation Systems* (NIS) is a term used to describe a country's innovation system, typically consisting of the relationship between government and diffusion. Metcalfe (1995) says NIS is "The institutional framework that contributes separately or collectively to the development and diffusion of new technologies and provides a structure

within which governments shape and improve policies that influence innovation processes." Much of the literature used for this paper mentioned two types of innovation systems. First is the linear model, which divides stages of innovation into four general stages: Basic research, → Applied research, →Development → (Production, and) Diffusion. The second is the interactive model, where different stages can interact, and there is no linear progression of stages but can go back for improvement.

The third term is globalization. Ferguson (2012) best defines the term in his book, *Globalization: The Return of Borders to a Borderless World*. Similar to innovation, globalization, in the scholarly sense, holds a variety of definitions. Some focus on the idea that globalization leads to the softening of borders, while others focus on the global networking that occurs through economic ties. Ferguson's globalization definition inspired ours: "the widening, deepening and speeding up of worldwide interconnectedness in all aspects of contemporary social life, from the cultural to the criminal, the financial to the spiritual." This definition upholds how we will view the diffusion of innovation as a process affected by more than just economic ties.

The fourth term is the diffusion of innovations, a key term since many elements of the diffusion of innovation show its complexity. Rogers (2003) explains the diffusion of innovation "as the process in which an innovation is communicated" through specific channels over time among the members of a social system. Key terms in the stated definition are time, specific channels, social systems, and innovation itself (which we already defined). Time-related diffusion has two aspects: the decision process of passing on the information and the process of adopting it. Specific channels are the processes that people use to create and share new ideas with others that they may mutually understand. Social systems are the social aspect of an

innovation system. The definition of innovation is already defined. It is also important to note that all of the factors that contribute to the diffusion of innovation can be affected by government policies.

An interesting remark about the diffusion of innovation was made by Geroski (1999) when he said, “Diffusion is as much a process by which new technologies are developed as it is a process by which usage spreads, and this means that there is probably not a hard and fast distinction to be drawn between technology policies design to generate new technology and those designed to increase the usage of existing technologies.”

Literature Review

The scope of this literature review was to gain an understanding of what diffusion of innovation in emerging economies looked like, how much the innovation itself played a role in impacting the economy, what the relationship between government and innovation was, and what common factors found when looking at Brazil and its diffusion of innovation. The range of literature goes from journals to books to articles on the web. The benefit of this literature review was the ability to gain different perspectives and opinions as various authors viewed significant factors differently.

Winter’s “Do Artifacts Have Politics” (1980) discusses how technology impacts people, whether it was the creator’s intent or not. He gives examples of how technology in the past caused trouble because it gave a significant advantage to a group of people. Although these inventors did not create the technology with the intent, it happened so. Why? Winter argues that the way technology affects people is not just what the author intends but also the system in place. Those technologies that favored one group over the other were due to the system that surrounded the technology allowing it so. It was not the creator’s intent, but they should have been more

aware. Understanding these intents shows that it is the system and innovators who play a role in the effect of the technology outcomes.

Aslam's *Globalization Helps Spread Knowledge, and Technology Across Borders* (2018) shows how globalization positively affects the world by allowing the transfer of global knowledge. He does not deny that there are some adverse effects of globalization, but he argues that the positive effects of globalization are significant. It highlights two positive effects of the spread of technology: globalization builds up and strengthens emerging markets, and technology leaders benefit from globalization. When looking at emerging markets, they saw that technology transfer increased innovation capacity and labor productivity growth. The transfer offsets the recent global slowdown of innovation for these emerging countries. Finally, the author argues that the spread of technology is not one way. When a country can benefit from globalization, typically, researchers find that the country can spread technology that benefits the traditional technology leader. This framework gives a basic general view of globalization and technology transfer.

Although Casadella focuses on Mexico, Indonesia, Nigeria, and Turkey (MINT) in her book *Innovation Systems in Emerging Economies: The Mint Case* (2018), she brings an essential look at national innovation systems (NIS) in emerging economies. A strong suit that Casadella brings is her literature review. She looks through many lenses at the theoretical concept of emerging economies, specifically economic and innovation theories. A vital part of the book was understanding how to view these NIS. Casadella uses Nelson's Narrow/Broad framework to generalize the NIS understanding of the benefits of grouping similar matters to find trends. However, even without the framework (as some do not see its credibility), Casadella states how general traits of NIS of emerging economies can be seen, such as local and global markets

playing a significant role in the diffusion of innovation. Overall this gives a general insight into emerging economies and how experts view them.

Reddy's *Global Innovation in Emerging Economies* (2011) covers global innovations in primarily BRIC countries, which stands for Brazil, Russia, India, and China. The section about Brazil shares the structure of the innovation systems and uses case studies to go through some innovations that have occurred in Brazil from the 1980s to the 2000s. Significant emphasis was placed on the R&D sector as well as government involvement. They argue that foreign investment typically leads to a mutual beneficiary relationship between the country and the multinational company. Multinational companies bring competition to the market, encouraging local companies to invest in their innovations team. Multinational companies, especially national universities, bring knowledge and capital into the R&D sector. The multinational companies' interns get access to the local market. The author argues that Brazil has several factors which incentivize multinational companies to partner with a country like Brazil over other Latin American countries. Some of the factors include location, policy incentivization, and cost. This partnership connects with the thesis when synthesizing how foreign influence can be a pivotal contributor to the success of technology diffusion in emerging economies.

Koeller et al. covered a similar topic to Reddy on the changes in Brazil's innovation systems in their journal, "Achievements and Shortcomings of Brazil's Innovation Policies" (2009). An economic rebuild occurred from the 1980s-2006 thanks to policies implementing and utilizing the Brazilian R&D resource. Compared to Reddy, Koeller gave more essential details about the results of these changes. The book's format focused on the chronological order of events rather than specific case studies. The benefit was seeing clear cause and effect, as Koeller argued. The book shows that by 2007-2008, the lasting transformation desired through the

policies was absent. Koeller points out how the resources available for R&D provided through the government needed full utilization due to inefficiently approving projects. Also, the mutual relationship between foreign direct investment (FDI) typically benefited more investors than the nation. They saw that these FDIs changed ownership rather than directly investing in the Brazilian R&D teams they had stationed. They also saw that the more these foreign companies participated with Brazil, the less technological efforts were made. Through Koeller, we see that policies occasionally perform for their intended purposes, and the government's involvement with R&D has to be more intentional and carefully thought out.

Rodríguez-Morales explores the relationship between Brazil's government and the sugarcane industry using the political economy analysis framework in his journal, "Convergence, Conflict and the Historical Transition of Bioenergy for Transport in Brazil: The Political Economy of Governance and Institutional Change" (2018). The format they used to explain the scenario was going chronologically, dividing the timeline into six periods (1900s - present). The central technology the authors were investigating was biofuel made from sugarcane. The core factors they considered were the government and the sugarcane industry's conditions when conducting the analysis. These conditions were primarily whether the group favored the increase of biofuel production. As they covered each period, they would note the conditions of the government and the private industry and what they would play out regarding the production and sale of biofuel. A side note is that the authors did recognize other factors that increased the production/consumption of biofuel. This article was relevant for this thesis because it dived deep into how crucial the relationship between the government and private industry is. An extra benefit of this paper was that it covered Brazil when it went through three different types of

government: dictatorship, military government, and democracy, allowing us to get more pattern insights on different governments and their policies.

Dorè's journal titled "Brazil's economic growth and Real (div) Convergence from a very long-term Perspective (1822-2019): An Historical Appraisal" (2022) covers the economic path of Brazil. Dorè looks into the history of Brazil from the period of its independence to the current. Articles and literature stated before have gone over the history of Brazil in specific gazes of innovation, specific technology, and certain relationships between actors. However, this article's scope was vast, covering more generic history while focusing on Brazil's economic performance and government attitudes. Dorè paid much attention to the country's GDP per capita and international performance to judge its economic state. She, like Rodríguez, also broke history into periods, but these periods were broken up based on the type of government that was dominant nationally.

Regarding technology, the article provided more numerical data that showed how much technology took hold of the Brazilian economy. Interestingly, these numbers alone told a story of the government's policy priority and how this affects innovation diffusion. This journal will contribute to analyzing how governments can recognize patterns and increase the chance for more stable technology diffusion.

Vieira et al. go over the history of rural extension in Brazil in "LA HISTORIA DE LA EXTENSIÓN RURAL EN BRASIL: DE LA REPRODUCCIÓN A LA REFLEXIÓN" (2020). Vieira et al. cover the creation of Technical Assistance and Rural Extension (ATER, an acronym in Portuguese) from 1930 to the present. They highlight how the government at both state and federal levels used innovation diffusion tactics to modernize the rural areas of family farmers. A large section of the article goes over the different policies that the government passed to

modernize the rural sections. Different policies show how the government had to adapt to teaching the farmers, primarily since the science of diffusion tactics and innovation diffusion were studied well in the later parts of the 20th century. The article showed that the government alone could not be the factor that changes the rural scene in Brazil, but multiple other factors had to be in play for the extension to occur. The authors conclude with the status of Brazil's rural areas for family farmers needing considerable improvements even after all the policy changes that occurred. However, the author is hopeful as the government is taking necessary steps to get the desired expectation they set forth with the creation of ATER. The article is significant to the topic as it shows the different tactics of diffusion innovation implemented in Brazil. Even though Vieira et al. did not specifically quote Rogers' factors of diffusion innovation, the obstacles they faced showed that the factors that Rogers mentions play a significant role. It was a direct example of the government attempting to force a diffusion of innovation.

Analysis

The diffusion of technology and innovation plays a vital role in Brazil.

One factor already seen is Research and Development (R&D). With a good R&D infrastructure, it is easier to see how innovative technology could develop. It aids Brazil that through the government's willingness to open itself more globally, Foreign Direct Investment (FDI) and Multinational Companies (MNC) have been pouring into Brazil seeking economic ventures. A problem Brazil has is that it does not necessarily utilize these FDIs and MNCs for its long-term growth. Many of these investments primarily benefited the foreign private sector (Koeller, 2009). Still, it is not to say there was no benefit, as some MNCs such as Motorola or Rhodia would allow for the expansion of the R&D in Brazil (Reddy, 2011). Rhodia, for instance, would allow university researchers to use their private laboratories if the research was something

of interest to Rhodia. Then what long-term growth was missing from these FDIs and MNCs? Over the time it has been part of Brazil, few products would develop for the global market. Many companies that would come as MNCs would develop products for the local Brazilian market and could have been more innovative. It is not to say that specific adaptations for the local market were not innovative. These technologies were already working in domestic markets like the United States and would bring them to Brazil to make more profit. Though there are more R&D opportunities from FDIs and MNCs, established Brazilian R&D would significantly impact the country (Koeller, 2009).

Another factor that would play into Brazilian diffusion of innovation was public policies made by the government. As mentioned previously, domestic R&D is more significant in contributing to Brazil's long-term growth than R&D sponsored by foreign investors. This domestic R&D would come from government policies that demanded domestic companies have a sector of R&D eligible for subsidies. In the definition of diffusion of innovation, there are vital factors that contribute to the diffusion of innovation. One of them was understanding the culture and people. Innovation can not carry the people's desire for innovation (Vierira et al., 2020). It is a hopeful outlook as the innovation system that the government pushes considers diffusion science. Although Brazilian government policies failed in the past due to not accounting for those factors, currently, many systems are implemented to help spread technology, like the rural farmers for sustainable farming or bioenergy for fuel consumption.

A final factor when considering the diffusion of innovation is the people of Brazil themselves. The people are not just the farmers, scientists, or students but also the general consumer. Their demands and opinions shape the policies that the government makes. There are, of course, specific groups of people that directly affect the diffusion of innovation. Brazil needs

to increase its education resources. By 1990, only 19% of the population was illiterate, and although Brazil had one of the most significant increases in education expenditures by 2009 (Dorè, 2022), the overall population needs more education. This problem is because more researchers and people with higher degrees are needed. Brazil has a shortage of researchers; part of the shortage is the lack of education. Another specific group that influences the diffusion rate is Brazil's private sector. When looking at the studies of Rodríguez-Morales, it is clear that demand for innovation came when there was substantial expansion in the field (2018). These robust expansions only occurred when the government and the private sector converged to expand. In the early stages, it was indeed the government that took greater charge, but it was the private sector that continued to carry the expansion after it was more established.

These three factors are significant but are not alone in influencing the diffusion rate of innovation. Even now, the full scope of Brazil's trajectory is unclear but with the recent events. Factors not considered deeply, like military and social media, leave open for more research. However, these three factors alone can lead to significant changes in Brazil and the hope for better change.

Conclusion

Brazil has a complex government history, going through at least three different types of government in the past century. However, it is undeniable that Brazil provides a fountain of information on emerging markets as it is evident throughout history that they continuously try to improve and stabilize their economy. One of their steadfast efforts to improve and stabilize their economy is through the diffusion of innovation. There needs to be more than just Brazil alone to understand the full scope of emerging economies, but they lay out a flexible framework that

other countries could pick up. Engineers must continually innovate and consider how these emerging economies diffuse innovation for real change to occur.

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