The Missing Economic Diversity of the Colombian Amazon: An Economic Complexity Approach for Caquetá, Guaviare, and Putumayo

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An Economic Complexity Approach for Caquetá, Guaviare, and Putumayo

Sebastián Bustos, Timothy Cheston
and Nidhi Rao

CID Research Fellow & Graduate Student
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Executive Summary

Alarming rates of forest loss in the Colombian Amazon have created a perceived trade-off that the only means of achieving economic prosperity is by sacrificing the forest. This study finds little evidence of this trade-off; rather, we find that economic development and forest protection are not an either-or choice. Forest clearing is driven by extensive cattle-ranching as a means to secure land titles. In essence, the loss of some of the world's richest biodiversity is the result of some of the least economically complex activities that fail to achieve economic prosperity in the region. If anything, the acceleration in deforestation has accompanied a period of economic stagnation.

The existing economic model in the Amazon – centered on agrarian colonization and mineral extraction – has not generated prosperity for the people, all while failing the forest. The exceptional diversity of the Amazon's biome is not reflected in the region's economy. The Amazonian economy is best characterized by its low diversity and low complexity. A significant proportion of employment is linked to public administration – more than in other departments of the country. Very little of the production in the departments is destined to be consumed outside the departments ("exported").

This study seeks to define an alternative economic model for the Colombian Amazon from the perspective of economic complexity with environmental sustainability. Economic complexity research finds that the productive potential of places depends not only on the soil or natural resources, but on the productive capabilities—or knowhow—held by its people. This research finds that the Colombian Amazon will not become rich by adding value to its raw materials or by specializing in one economic activity. Rather, economic development is best described as a process of expanding the set of capabilities present to be able to produce a more diverse set of goods, of increasingly greater complexity. This model starts from the base of understanding the existing productive capabilities in Caquetá, Guaviare, and Putumayo, to identify high-potential economic sectors that build off those capabilities to achieve new, sustainable pathways to shared prosperity.

Achieving shared prosperity in the Amazon depends on the connectivity and opportunity in its urban areas. The primary drivers of greater economic complexity – and prosperity – are the cities in the Amazon. Even in the remote areas of the Amazon, the majority of people in Caquetá, Guaviare, and Putumayo live in urban areas. The low prosperity in the Colombian Amazon is driven by the lack of prosperous cities. The report finds that Amazonian cities are affected by the lack of connectivity to major Colombian cities that limit their ability to 'export' things outside the department to then expand the capacity to 'import' the things that are not produced locally as a means to improve well-being.

The economic complexity model finds opportunity for diversification across four pillars:

- ***Sustainable agroforestry***: intensifying agriculture to enter new areas of the bioeconomy, to scale those agricultural products, and their processed potential, that thrive in the given soil type of non-forested areas of the departments. This includes a focus in maximizing yields, where crops consistently afford higher value than extensive cattle-ranching, to integrate the environmental sustainability of new activities.
- ***Tourism***: while a base exists, the study found missing coordination of a strategy to provide a more complex ecosystem of high-value industries of tourism operators, hotels, restaurants, and related services limits the volume of visits and spending in the sector.
- ***Logistics services***: transport services were found to be a critical missing input that hinder the complementary profitability of new industrial sectors.
- ***Professional services***: in specific instances, e.g., the oil industry in Putumayo, related professional services were not well represented, but offer areas for employment growth.

Figure i. High-potential Diversification Opportunities for CGP

Focusing on diversification requires a new approach to economic policy in the Amazon. Diversification requires a place to learn to do something that today, by definition, does not exist. The economic challenge in the Amazon is that there are too few new activities that can build from existing capabilities because of the low diversified economy. This challenge requires attracting new economic activities that do not currently exist. Diversification is a risk-laden process, rife with coordination failures, as it presents a chicken-and-egg problem: no one wants to develop new capability if there are no industries that require it; and yet no industry wants to locate in a place that lacks the required capability. Economic policy must carefully consider how to attract missing capabilities to the region, which requires distinct state capability than expanding the provision of public services, i.e., building more schools or expanding electrical lines. Economic policy should be territorial across three geographies of opportunity: (i) ***in cities***, through tourism services, transport services, professional services, and agro-processing industry; (ii) ***in rural non-forested areas***, in more intensive crops and sustainable agroforestry; and (iii) ***in forest areas***, based on ecotourism, carbon markets for reforestation, and forest protection services.

The report concludes by recommending the creation of an Amazon Productive Development Taskforce to coordinate national, departmental, and local government entities – as well as private and non-government associations – to implement productive policies for the region. The need for diversification requires a Taskforce that can coordinate and prioritize interventions in the Amazon to coordinate productive diversification. The focus of the Taskforce must be in coordinating new investment along with the technical and operational knowledge that success requires. In the same way ProColombia aims to attract global investors in promising productive sectors to come to Colombia, so too must the Taskforce, call it ProAmazonia, reach other parts of Colombia to attract investors to come to these departments' specific opportunities.

Promoting a new economic model in the Amazon will require both attracting new productive capabilities to the region's urban areas and finding new, environmentally sustainable solutions to the region's connectivity challenge. Shared prosperity is easier to achieve in urban areas than in the forest. Public resources are being allocated in precisely the wrong direction in the Amazon, with scarce funds being spent at the most remote parts at the edge of the forest to build tertiary roads and bridges for a few families, while underinvesting in urban roads, water, sewage, and housing where the majority of people live. The solution to deforestation, as with that of creating shared prosperity, relies on generating better opportunities in cities to pull more people in from rural areas to reduce the pressure on expanding the agricultural frontier into the forest.

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1. Introduction

Colombia ranks as the most biodiverse country for its size in the world. The crown jewel of that diversity is the Colombian Amazon, with its large continuous forest coverage that is home to a spectacular array of plants and animals. Even among its sparse human population, the cultural diversity of the Colombian Amazon is singular, with over 50 indigenous groups inhabiting the region. This paper studies the three departments that form the gateway to the Colombian Amazon, Caquetá, Guaviare, and Putumayo. The three departments each rank among the most diverse departments in Colombia, in areas of vegetation, animal life, the environment, and culture.

The exceptional diversity of the Colombian Amazon is missing one aspect: the economy. The three departments are among the least diverse and the least complex in the types of economic activity present. As a result, the Amazon covers 35 percent of the country's territory, but contributes only 1 percent of GDP. The economic model in the Colombian Amazon has narrowly focused on extraction. The model has been in place since the first colonial expeditions to the region came in search of gold and the first settlements formed to extract rubber. The pattern continues to modern day, as even a recent National Development Plan (2014-2018) includes these departments in two regional economic groups with a specialized focus on mining and natural resource development.

Ultimately, the complex biodiversity of the Colombian Amazon is being destroyed at alarming rates by some of the least complex economic activities, such as cattle-ranching. The Peace Agreement marks a landmark moment to prioritize the transformation of the rural economy. The government committed to bring its long-neglected rural communities into the fold with first-ever department-specific development plans. Through crop substitution programs and major public infrastructure investments, the plan envisions an alternative development model for the Amazon based on new dimensions of agroforestry and public services. The logic of the focus on a new agricultural vocation for the Amazon, as one that would compete with the region's forests or environmental economy, was never explicitly considered. Regardless, a lack of public resources to fund these projects has stalled implementation of many of the rural transformation efforts, with a mere four percent of the rural reform measures having been completed, at more than one-third of the way into the Peace Agreement. The economy in these departments continues to be described by a limited focus on extraction and extensive cattle-ranching. The promise of an alternative development model remains unfulfilled.

The need to analyze alternative economic strategies for Caquetá, Guaviare, and Putumayo remains a pressing priority to ensure greater economic development that is consistent with environmental sustainability. This paper uses a data-driven approach to analyze economic opportunities, termed economic complexity, that recognizes that the productive potential of these departments depends not only on the soil or natural resources, but on the knowhow or productive capabilities held by its people. This research finds regions do not become rich by adding value to their raw materials or by specializing in one economic activity to produce more-of-the-same goods. Rather, economic development is best described as a process of productive transformation to expand the set of capabilities present to be able to produce a more diverse set of goods, of increasingly greater complexity.

Achieving greater economic prosperity is not the sole policy goal for these departments. Given the environmental services provided by the Amazon Forest, from providing the drinking

water for large parts of the country to acting as a carbon sink to combat climate change, the identification of new economic activities to drive greater prosperity must not be at the expense of harmful deforestation. This paper applies new indicators to assess the contribution of different economic activities to deforestation as incorporated into the economic complexity methodology to ensure greater diversification and growth are not at the expense of environmental sustainability.

The primary drivers of greater economic complexity – and prosperity – are the cities in the Amazon. These dual objectives of economic prosperity and forest protection hold a critical geo-spatial dimension: cities offer greater economic complexity, yet it is not in these cities where deforestation is happening. This applies across Amazonian contexts, in Florencia, Colombia as well as in Iquitos, Peru, or Manaus, Brazil. Even in the least densely populated areas of Colombia, people want to live in densely populated areas. In each of the three Amazonian regions studied, Caquetá, Guaviare, and Putumayo, the majority of people live in urban areas. This corroborates the findings of our global research over the past two decades that prosperity results from expanding the productive capabilities available locally to diversify production to do more, and more complex, activities.

The low prosperity in the Colombian Amazon is driven by the lack of prosperous cities. Shared prosperity is easier to achieve in urban areas than in the forest. Public resources are being allocated in the wrong direction in the Amazon. Scarce funds are being spent at the most remote parts of the forest's edge to build tertiary roads and bridges for a few families, while underinvesting in urban roads, water, sewage, and housing where the majority of people live. By not achieving greater complexity in its cities to attract more workers, the lack of alternatives in the cities in the Colombian Amazon is putting pressure on access to land by expanding the agricultural frontier into the forest. As a result, arresting deforestation should not have to come at the cost of halting growth. In the Colombian Amazon, there is still vast room for people to live more densely to pool resources, grow markets, and diversify knowhow to enter more complex activities. The solution to deforestation, as with that of creating shared prosperity, relies on generating better opportunities in cities to pull more people in from rural areas to reduce the pressure on expanding the agricultural frontier into the forest.

This report is one of a series of research papers by the Growth Lab at Harvard University, with funding from the Gordon and Betty Moore Foundation, entitled Advancing Economic Development and Environmental Sustainability in the Amazonian States in Colombia. The other reports in the series aim to provide complementary perspectives on the binding constraints to achieving more rapid, sustained growth in these departments and the drivers of deforestation, along with a synthesis of the department-specific and national policies to promote prosperity.

The report is structured as follows. The productive capabilities in each department are presented to better understand what exists, to then analyze what is feasible. This base is compared to peers in remote parts of Colombia, as well as peers in other Amazonian regions outside of Colombia, to better understand the activities that can overcome remoteness and be productive in a similar environment, including those industries currently missing in Colombia. The report then presents the methodology used to analyze the comparative advantage of each department and to analyze what other industries require similar capabilities as those that exist. Using unique data for this report, we turn to answer the question of what do other Amazonian regions outside of Colombia know how to do that the Colombian Amazon does not do or is the economy of the Colombian Amazon driven by Colombia, its remoteness, or something specific to forest economies. The next section presents the results of the economic complexity

methodology to identify high-potential economic activities to drive prosperity in each department, along with new green filters to ensure environmental sustainability. The final section analyzes the public policies and change agents required to achieve entry into these new activities. First, however, the report starts by explaining the conceptual basis on the need for economic complexity to deliver a new economic model focused less on the soil but takes a human-centered focus on adding capabilities to existing capabilities.

2. Economic Complexity: An alternative economic model based on human capabilities

What is the competitive advantage of the Amazon rainforest? For much of its national history, Colombian officials have had few answers to this question. The Amazonian departments were more notable for the absence of the state than for its presence or for their lack of inclusion in national strategies.[1] National policies governing the Amazon region held two broad lines of value. One purpose was achieved by the set of policies established the National Park system, the Indigenous Reserves and Afro-Colombian areas that value the protection of the forest and its peoples in one of the largest protected area systems in the world. This contrasts with the second purpose—extraction—to gain access to raw materials and the basic connectivity required to move minerals to markets outside the region. The extractive approach to regional development dates back to the first colonial settlements in the region and up to the recent National Development Plan (2014-2018).

The idea of regional specialization centered on raw material extraction has long been ingrained in the mind of policymakers in Colombia (and across much of the world). As it happens, the belief that countries should specialize is also one of the most dangerous ideas in development. While intuitively powerful, this conventional wisdom fails to prove true empirically. Individuals specialize, as often do firms. But countries and regions diversify. Greater individual specialization translates into the diversification of production at the regional and country levels.

Similarly, adding value to raw materials is not wrong, but limiting—and sometimes blindingly so. Often, policymakers present raw materials as if their own. However, most global products are not developed from a single raw material only available locally. The successful models of industrial development over the past century, (e.g. South Korea, China, but even within Colombia, Antioquia and Bogotá) have not developed through a strategy centered on their raw materials, but on strategies that aim to overcome local resources (e.g., an airlines hub opened market for cut flowers produced near the Medellin airport). Starting from the products that can be shipped by air for a location with an international airport hub is a better strategy than focusing on what can be found in the soil and how to add value to those raw materials. In the same way, approaching the Amazon forest solely for its raw materials is limiting, considering the greatest natural resource is the forest itself. An approach that recognizes the potential economies of preserving and touring the natural capital of the forest opens more opportunities. Yet, this requires a distinct set of capabilities.

[1] Part of that exclusion is due to how recently the departments in this study were established as departments, with Caquetá becoming a Department in 1981, and Guaviare and Putumayo in 1991 through the constitutional reform process.

Economic research finds that development increases its potential not necessarily by adding more value to raw materials, but by adding related capabilities to already existing capabilities. Economies, in general, do not get rich by specializing intensively in the production of the same things that they already produce. Quite the contrary: the true productive transformation and the secret of development consists in expanding the knowledge base and taking advantage of it to produce and export a greater diversity of more sophisticated goods. Those departments that are capable of expanding their productive capacities towards complex products—that require higher levels of knowledge—tend to grow faster. Rather than being commodity-driven, this is a decidedly human-driven approach to development. This is the theory of economic complexity.

The theory of economic complexity is based on the idea that the production of goods and services requires raw materials, labor, and machinery, but also tacit productive knowledge, or know-how, necessary to combine these elements in a place (Hausmann, Hidalgo et al., 2011). Goods and services differ in the variety of productive knowledge that they require to be produced competitively. While some activities require little know-how and few inputs, there are products and services that are extremely difficult to produce because of the specialized and specific skills required. It is these last products and services that we will classify as complex. This type of knowledge or know-how tends to be one of the main factors limiting the transfer of technology, and therefore the productive diversification of the world's economies. It is also the most difficult part of technology to transmit and teach, since it is only acquired through experience and practice. It resides, more than in books or manuals, in people's brains; the know-how required by most economic activities is acquired through experience and results from the collective combination of different capacities.

To better understand this notion, we can make an analogy between the capabilities (know-how) of a department and the game of Scrabble.[2] In the game, players arrange the letters on the available tiles to produce words. In the same way, companies (players) in a place bring together a variety of different capacities (letters) available in the local economy to create a product (a word). These capabilities take the form of a knowledge pool (e.g., chemical engineer, assembly line worker), infrastructure (e.g., electricity, water), supply chains, public goods, among others. Places with a limited range of capabilities (few letters) can produce a limited range of low-value goods and services (words) (short words). As a place adds new letters (or abilities), the number of words that can be created increases exponentially, words can get longer, or become more valuable. Thus, the creation of the most complex words requires the local availability of a wide range of letters. Departments differ in the variety of letters they have, and for that reason they differ in the models they are able to build with them. This plays out empirically: the most complex products are only produced in places with the most diverse set of capabilities. Economic development results from a process of expansion of these productive capacities towards the production of an increasingly diverse and less ubiquitous number of goods.

[2] Examining the existing capacities in a department through the products that it is capable of producing is equivalent to inferring the quantity and variety of letters in its basket by analyzing the words that it is capable of constructing. A department is capable of making a product competitively following the notion introduced by Balassa (1964) of Revealed Comparative Advantage (RCA). According to this idea, a department has comparative advantages in the production of a good when the importance of that product within its export basket is greater than that of the same product in the world's export basket (RCA>1).

3. Productive composition and evolution of the Colombian Amazon

The productive potential of Caquetá, Guaviare and Putumayo depends on the existing productive capacities in each department. Thus, we will begin by describing the composition and productive knowledge present in the region. Although capabilities or knowhow are not directly observable, their quantity and diversity can be inferred from the goods and services that a place is capable of doing.[3] By observing production patterns across different places and over time, it is possible to construct two quantitative indicators: the Industry Complexity Index (ICI) on the amount of skills and knowledge required to manufacture a product or provide a service; and the Economic Complexity Index (ECI), for the agglomeration of knowledge in an economy.[4]

In the case of Colombia, industry presence can be measured by a few different data sources: exports, social security, or firm-level data (see Appendix 2 for a discussion). Considering the advantages and disadvantages of the different data sources, it was decided to use for this report the employment data from the Large Integrated Household Survey (GEIH). Alternative datasets, particularly PILA social security data or Dunn and Bradstreet firm data, are limited to formal firms' employees which are less present in the Amazonian departments. GEIH has the advantage of annual reporting for the past decade in each department, with representative data in urban areas. Additional data are added from the agricultural census to study rural productive sectors in each department. The use of employment composition in GEIH is informative as it indicates the productive industries in each department, and how it compares with other parts of Colombia.

Before comparing the productive activities of the departments under study with other parts of Colombia, a first question is how diverse is the production of Colombia compared to other countries? The data allows for an interesting comparison with the United States. The effective number of industries, calculated as the inverse of the Hirschman-Herfindahl index, for Colombia is 52 sectors, while for the United States it is almost double (96). The fact that Colombia as a country has a high concentration of employment in a few sectors raises the question of how some

[3] To implement the calculations of economic complexity we must determine what products or industries are produced in each place. With this objective, we follow previous work and calculate the employment ratio of each industry-place, with respect to the total employment ratio of the industry. This index is commonly used in the international trade literature (using exports as a measure of intensity, known as the Revealed Comparative Advantage index or Balassa 1965 index) and in the urban economics literature (known as the local ratio, calculated using employment, following its first use from Florence (1939)). This index indicates, for each place-industry combination, the multiple of times that an industry is present—in terms of quantity produced, number of jobs, or exports—compared to the national average. Thus, it is natural to say that an industry reaches a sufficient concentration and is significantly present in a locality when this index is equal to or greater than one.

[4] We can calculate the economic complexity of the departments under study using the estimation of the presence of industries in the different departments of Colombia. Although this form would be internally consistent, it would leave those found in Colombia as more or less complex industries. A reasonable question is whether the complexity of the industries based on what is observed in Colombia is a reasonable measure of the intrinsic complexity of the production processes. For this reason, in this study we will use the measurement of the Industry Complexity Index (ICI) using data from an economy with a greater variety of productive compositions. In particular, we will use the United States data, and we will benefit from a particularity of the economic complexity index; This is equivalent to the ICI average of the industries present in a locality. In this way, for the calculation we will use the ICI estimated using data from cities for the US We will estimate the complexity of industries for the United States using the County Business Patterns (CBP) database published by the Census Bureau (https: http://www.census.gov/programs-surveys/cbp.html). As the Census censors part of the data, with observations omitted to ensure the anonymity of signatures, we will use the version corrected by Eckert et al (2021) (https://fpeckert.me/cbp/).

of Colombia's remote areas are supposed to achieve greater diversity if the country itself has failed to diversify (see Box 1 for a discussion).

The concentration of employment in Colombia, at the national level, in a few sectors is even more valid for the three departments under study. For Caquetá and Guaviare, the effective number of industries is 42 and 45, respectively. Figure 1 shows a visualization of the industrial composition of employment in Colombia at the national level, and also for Caquetá, Guaviare, and Putumayo.

The production of the three departments under study highlights the importance of jobs linked to government and commerce. The State is a significant employer, especially in Guaviare and Putumayo (Figure 2). Commercial activities (retail) employ a higher proportion of workers than the rest of the country. Agriculture and livestock are a relevant employer only in Caquetá, where it is the largest employer. The proportion of workers in agriculture in Guaviare and Putumayo is notoriously lower than in the rest of the country.

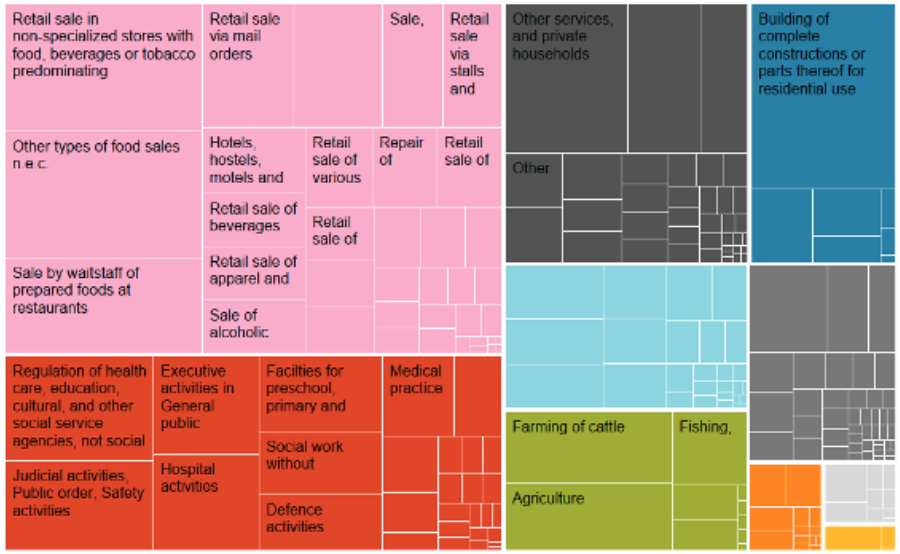
The absence of a manufacturing sector is evident in the three departments under study. Rather, production in the three departments is concentrated in the non-tradable sectors that depend on federal fiscal transfers (see Table 2 for a discussion). The few manufacturing companies that do exist (for example, bakery products) are generally for local consumption, with little manufacturing sold outside the department. High complexity industries do not have a large presence in the three departments. Low-income departments can generally still contain a high-complexity business, as a basis for studying “positive deviance,” or how a high-complexity business exists in a low-complexity environment. There is no such industry in the three departments under study.

Figure 1: Industrial composition of employment in Colombia, and in Caquetá, Guaviare, and Putumayo

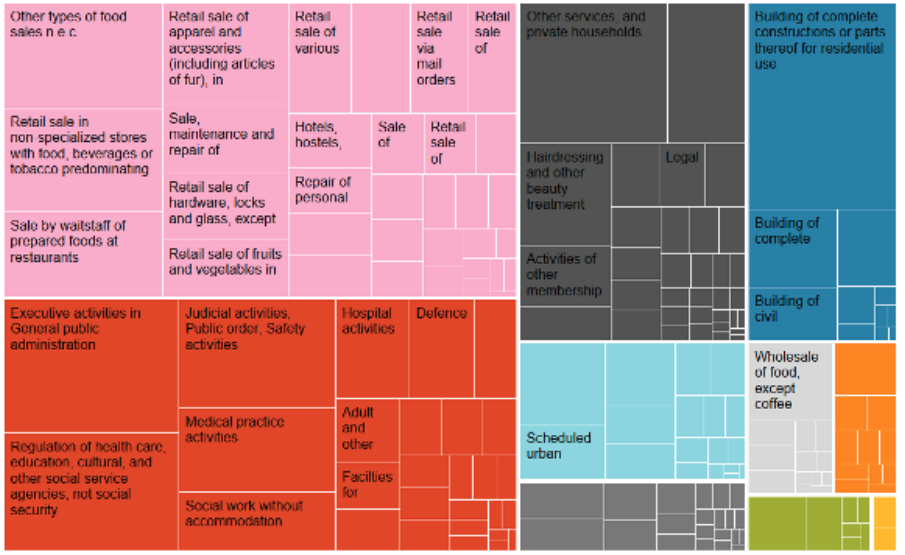
Colombia

Caquetá

Guaviare



Putumayo



Box 1: The Missing "Internationalization" of Colombia

One underappreciated approach to economic development is in the transfer of knowhow across narrow business networks. Bahar, Hausmann, and Hidalgo (2013) found this to be this case internationally, as the probability of a new export for a country is 65 percent higher if a neighboring country exports that product. The same process happens within countries: growth poles often lead to the same industries being created in lower-income, lower-complexity cities in the country, whether through firm subsidiaries being created, spinoff firms, or worker flows. Hausmann et al (2016) provide evidence of this in the case of Chiapas, the poorest state in Mexico, where the government mandated an auto assembly firm based in the high-tech city of Monterrey to open a subsidiary in Chiapas following the 1994 Zapatista uprising. That firm went on to expand into other parts of Chiapas, as an exceptional high-complexity firm that has succeeded in a low-complexity setting.

Theories of economic convergence predict a similar pattern, where lower income settings should afford a higher marginal return on investment, resulting in faster growth. In practice, empirical studies find little evidence of economic convergence. One explanation for the lack of catch-up of poorer locations is the nature of technology itself: the challenge of transferring knowhow (*tacit* knowledge) as the slowest element of technology to transfer, as it resides in brains through lengthy periods of learning by doing, describes the unequal nature of technology transfer across individuals and societies. Rather, knowhow tends to transfer over tight networks with lengthy interactions or by "moving brains" via channels of migration and worker movement. Coscia, Cheston, and Hausmann (2017) find evidence of this in Colombia: poorer municipalities that share tight communication networks with richer municipalities show evidence of income convergence. By contrast, poorer municipalities that belong to a richer department do not show evidence of convergence. The study concludes that regions are poor because they are disconnected from the social and business channels through which technology diffuses, rather than alternative explanations of bad institutions.

These findings highlight the importance of an economic policy approach that targets connecting the Amazonian departments to higher-complexity cities in Colombia. Just as ProColombia is responsible for attracting new knowhow from international firms to Colombia, so too must the economic units of the departments aim to create a "ProCaquetá" office that attracts firms that already exist in Colombia to come to Caquetá.

Part of the assumption of this approach, however, is that Colombia, as a nation, has been successful enough in attracting new knowhow to diversify production into higher-complexity industries. Unfortunately, compared to a decade prior, Colombia's economy has become less complex, falling 7 positions in the Economic Complexity Index to rank 55th out of 133 countries for the latest 2019 data. Diversification is occurring at too slow a pace in Colombia to meet its growth ambitions, as the few sectors that have been added to the country's exports since 2004 only add up to $6 per capita, or less than one percent of the country's exports.

New findings from Nedelkoska et al (2021) point to the missing "internationalization" of Colombia that has not tapped into its rich resources of knowhow flows to attract new capabilities to Colombia. Many of channels for technological diffusion are not adequately prioritized in Colombia. The wealth of human and social capital held by the Colombian diaspora can be mobilized to return home to launch new sectors. Immigration, particularly before the massive

exodus of Venezuelans into Colombia, was too low into Colombia to attract and retain new knowhow. Business travel, for conferences and university research, was found to drive professional engagement in frontier areas in Colombia, but not adequately considered in policy approaches.

Without sufficient progress in attracting new knowhow to the growth poles of dynamic, international cities that can diversify the economy into higher complexity areas, the benefits of enhancing business networks of the Colombian Amazon to these city poles are diminished. The feasible set of industries for the Amazonian departments will likely be confined to the set that exist elsewhere in Colombia, as the Amazonian departments do not hold the complexity to push the technological frontier of Colombia. One possible exception to this would be in forest-based industries not suited to other parts of Colombia, such as the case of acai, which originated from a knowledge transfer and machinery from Brazil. Part of the answer to increasing the complexity of the Colombian Amazon will come from advancing the internationalization of Colombia to strengthen channels of technological diffusion into Colombia. Nevertheless, there is ample room to diversify the Amazonian departments into productive sectors that exist in Colombia, as is explored in this report.

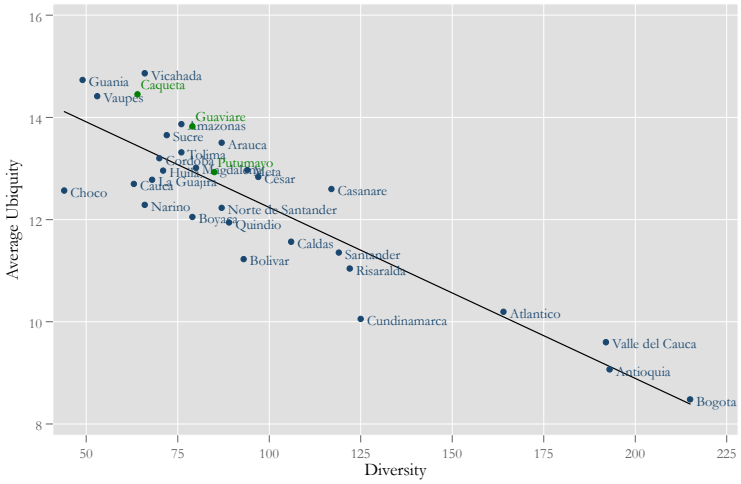
Estimation of the economic complexity index of the Colombian departments

As a first approximation for economic complexity, we can calculate the average diversity and ubiquity of each locality. Diversification refers to the number of different products that a department or region is capable of producing (and exporting to other departments and countries); while ubiquity refers to the number of departments that are capable of making a product. Past research has demonstrated an inverse relationship between ubiquity and diversity, which at the national level, is calculated based on **intensities by industry** (states, departments, cities, or metropolitan areas within the same country).[5] This inverse relationship, in essence, corroborates the initial intuition of the *Scrabble* metaphor: places that have a greater agglomeration of know-how are able to produce a more varied and sophisticated set of goods and services (high diversity), which, on average, very few other places are able to produce (low ubiquity). In contrast, places with low know-how agglomeration tend to produce a smaller variety of goods and services (low diversity), which, on average, many other places are capable of producing (high ubiquity).

In Colombia, the inverse relationship between diversity and ubiquity is clearly defined at the Department level (Figure 2). Bogotá, Antioquia, and Valle del Cauca are the departments with the greatest diversity by industry, with industries that are, on average, of low ubiquity. At the other extreme, we find Caquetá, Guaviare, and Putumayo, identified in green in the figure, which are not very diverse, and with an average ubiquity that tends to be higher than expected according to the linear trend. This suggests that the industries present in the three departments tend to be common and unsophisticated.

[5] See Hausmann, Morales and Santos (2017) for the analysis of the provinces of Panama, Barrios et al (2018) for states in Mexico, Reynolds et al (2018) for the case of states in Australia, and Hausmann et al (2020). for Peru. Hausmann and Hidalgo (2009) were the first to show this inverse relationship between diversity and average ubiquity for countries.

Figure 2. Average ubiquity and diversity in Colombia



Economies differ in terms of the complexity of their productive structures. A first approximation of this, as we saw previously, is in the diversity of industries or products. However, diversity is an incomplete indicator as not all industries are equally sophisticated. For this reason, it is possible to use ubiquity as a measure of sophistication under the premise that only a few places – those with the highest level of productive knowledge – will be the ones that will be able to develop the most complex products and industries. The innovation proposed by Hausmann and Hidalgo (2009) is to use diversity and ubiquity iteratively – what they call the Method of Reflections – to correct the information of these indicators for places and industries. The result is the Economic Complexity Index (ECI) for places, and the Industry Complexity Index (ICI) for industries. For economic development, the importance of these indices is that it has been empirically shown that they are highly correlated with per capita income and the capacity for economic growth (Hausmann et al 2014).

Figure 3: Map of economic complexity of the departments of Colombia

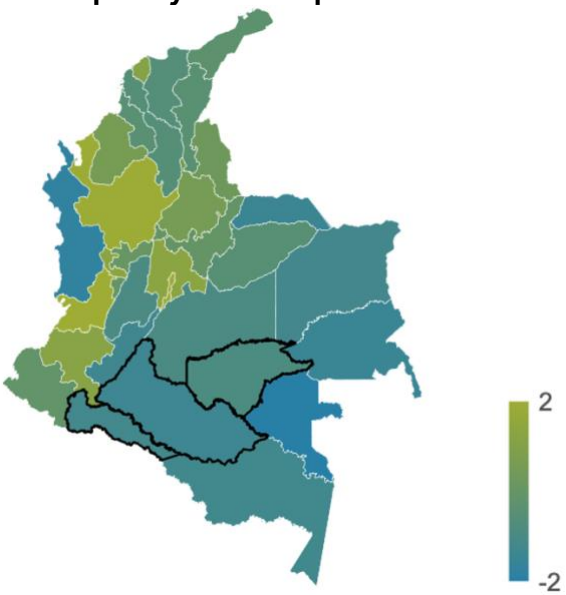
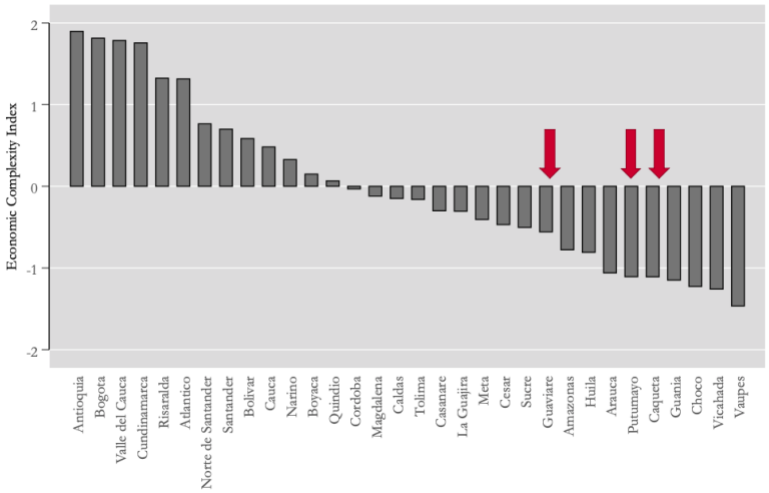


Figure 4: Economic Complexity of the departments of Colombia



The economic complexity of Caquetá, Guaviare and Putumayo turns out to be relatively low compared to the rest of the Colombian departments. Figures 3 and 4 show the ECI estimate for each department in 2019. While Valle del Cauca, Antioquia and Bogotá lead the ranking, we find Guaviare, Putumayo, and Caquetá in positions 21, 24 and 28, respectively, among the 32 departments. From 2012 to the present, this estimate is fairly stable over time (Figure A.2 in Appendix 1). Despite the Peace Accord, oil price shocks, and other events of the past decade, Guaviare, Putumayo, and Caquetá started out with relatively low complexity and demonstrated little ability to improve their position. What is worrying about this result is that economic complexity is empirically associated with higher income levels and with higher growth rates. This suggests that accelerating the growth of these regions will be a difficult task, but not impossible. One way to accelerate growth is to move to other sectors the existing ones that are similar in terms of productive capacities. This is why we introduce in the next section a new component to the conceptual framework: the Industry Space.

Box 2: Beyond public transfers: the balance of payments of the Amazon departments and their "export" sector

The high level of net transfers received by the Amazonian departments allows for a higher level of internal spending in relation to the exchange of goods (via exports to other departments). In turn, this higher level of local spending due to transfers increases the equilibrium exchange rate between the value of tradable and non-tradable goods, raising wages in the non-tradable sector and making local tradable production less competitive internationally. Thus, high public transfers work like a new form of Dutch disease. Since the departmental government cannot solve it by a devaluation, the local economy is highly skewed towards employment in non-tradable sectors (most particularly the public sector). High federal transfers and the concentration of public services in their capitals result in a distorted labor market that finds in the non-tradable sector (retail trade) a viable alternative to the lack of a production base.

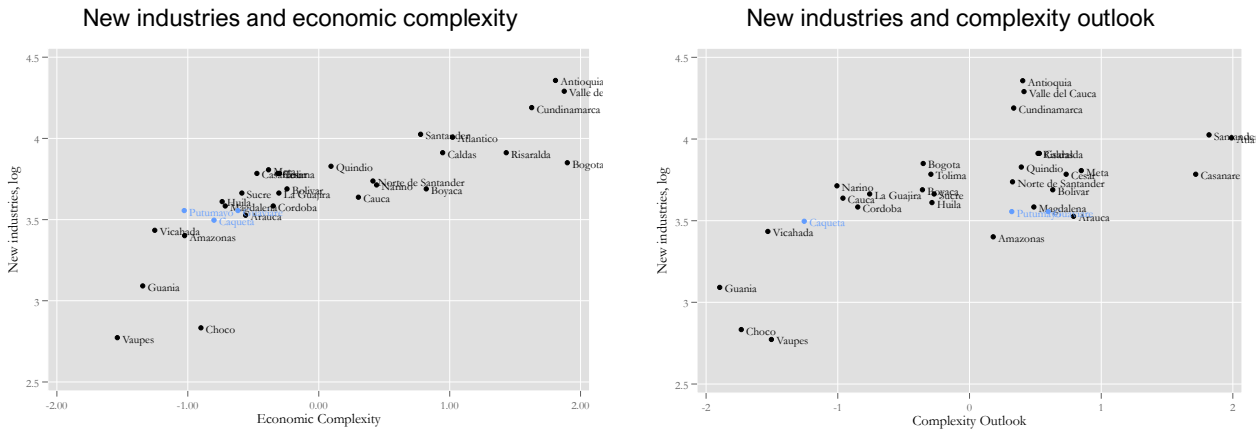
To solve this problem, the public services themselves must be oriented towards broadening the productive base to diversify the economy and reduce the need for federal transfers. Against trade and service competitors, manufacturing plants have to offer higher wages, which in effect limits the feasible set of new industries.

New industries and lost industries

Economic growth is driven by diversification into new products that are increasingly complex. The speed at which Caquetá, Guaviare, and Putumayo have diversified, and the complexity of those activities, inform whether there is sufficient policy coordination to achieve economic goals. At the same time, which activities have been lost where they are no longer competitive also sheds light on the challenge of diversification in these departments. Next, we will show the composition of the new industries and those that were lost to better understand the opportunities and restrictions they face.[6]

Departments with greater economic complexity and with a better position in the Industry Space tend to develop a higher proportion of new industries. Figure 5 shows the relationship between the number of new industries (in logarithmic scale) and economic complexity, and the complexity outlook, respectively. The complexity outlook is a measure of how many new complex activities are close to the department's current set of productive capabilities. The measure shows that Guaviare and Putumayo are well positioned with several complex industries nearby for their level of complexity. The higher the complexity and the better position in the Industry Space, the greater the frequency with which industries are added.

Figure 5: New and lost industries, and their distance to competition



How is employment distributed in new industries? So far, the analysis in this section treats all industries equally, but we know that industries differ in the amount of employment they create. For example, an industry with a small market might be defined as new with a few jobs, while an industry with a large market would need a large number of jobs to be defined as a new presence. Figure 6 shows the composition of employment in the new industries in the three departments under study. In this visualization each rectangle is proportional to the number of jobs, and industries are grouped by sector using the same colors. We can see that in the three departments a relevant proportion of employment comes from manufacturing industries. It is true that all three departments are starting from a low base, but identifying these manufacturing companies and understanding their growth challenges presents a promising opportunity. For the rest, education

[6] To determine which are new industries or industries that have disappeared, we must make certain definitions. We will call new industries those that were not present between 2012-2014, which we will define as an average revealed comparative advantage (RCA) of less than 1/4, and that between 2018 and 2019 had if they were present, with an average RCA equal to or greater than one. Similarly, we define companies that disappear as those that between 2012-2014 had an RCA equal to or greater than one, but between 2018 and 2019 had an average RCA of less than 1/4.

presents a sector of great growth in Putumayo. In Guaviare, the real estate sector registered significant employment gains, while Caquetá saw large gains in activities of membership organizations.

Figure 6: Composition of employment in new industries

4. Amazonian peer comparison: Identifying opportunities beyond Colombia

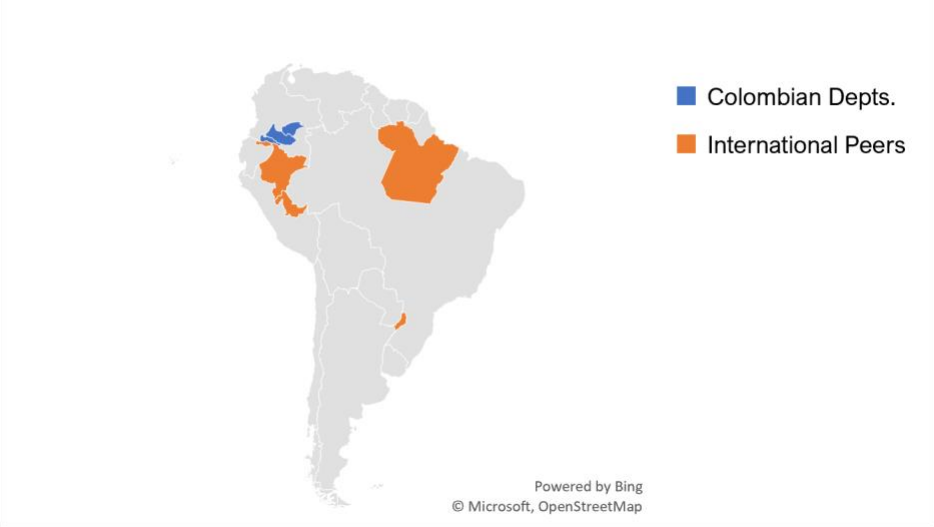
What defines the capabilities—and potential—of the Colombian Amazon: Colombia, its remoteness, or the forest? Is the Colombian Amazon more similar to other remote parts of Colombia or other Amazonian regions outside of Colombia? So far, the discussion of the productive capabilities and economic dynamics in Caquetá, Guaviare, and Putumayo has been in relation to the rest of Colombia. This answers the important question of what does Colombia know how to do that the Amazonian regions in Colombia do not. Another way to approach to this question to identify diversification opportunities is to ask what do other Amazonian regions outside of Colombia know how to do that the Colombian Amazon does not do. That is, in other remote parts of the Amazon forest, what economic activities are viable that are not present in the Colombian Amazon? To answer these questions, we define a set of Amazonian peer regions from all subnational territories across South America. The regions are selected as having the most similar climate, soil, and geographic conditions to the Colombian Amazon, to then compare their economic structure to identify what is feasible in peer regions.[7]

[7] The peer regions were calculated using a Euclidean distance matrix between vectors of standardized parameters including elevation, precipitation, temperature, accessibility, agricultural production yield, and forest cover.

Relative to a combined profile for Caquetá, Guaviare, and Putumayo, the analysis identifies four Amazonian peers:

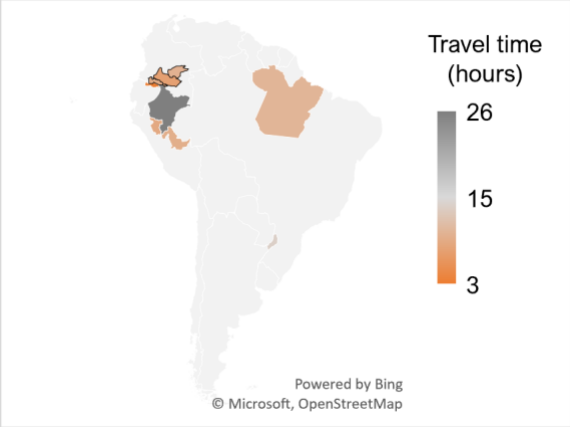
Posadas, Argentina[8]
Pará, Brazil
Sucumbíos, Ecuador
Loreto, San Martin and Ucayali, Peru

Figure 7. International Amazonian Peers to the Colombian Amazon & Distances to Cities

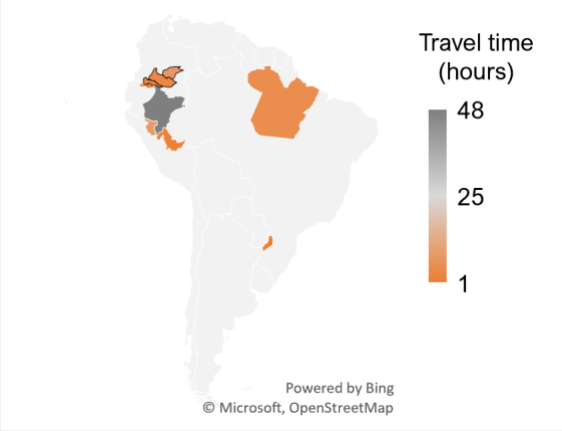


Average Travel times
Hours

To Large Cities



To Medium Cities



Source: authors' elaboration based on Global Friction Surface, Open Street Maps and Google Maps.

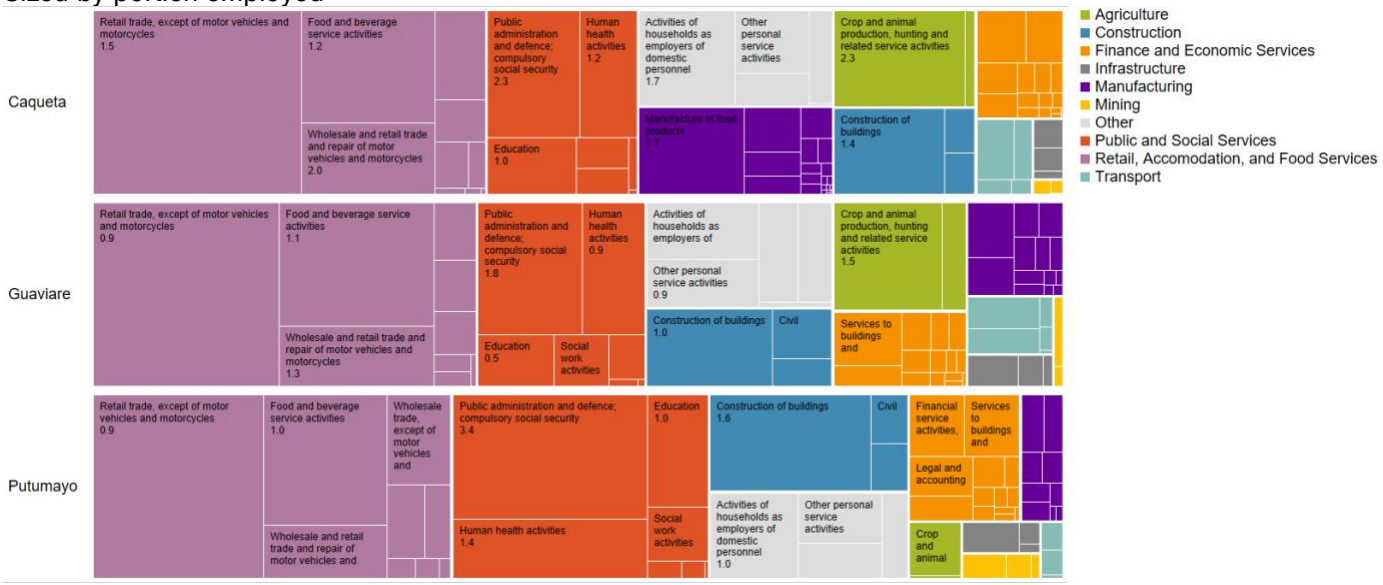
[8] Posadas, Argentina is notably not part of the Amazon rain forest but shares similarity across the dimensions of climate, soil, and geography to merit inclusion as a peer, more than other regions of the Amazon, while noting the title of Amazonian peer is not fully accurate.

It is also important to note that these Amazonian peer regions are also similar in their remoteness as measured by their distances to major cities. Their degrees of similarity in this regard are therefore also indicative of what we may be able to understand what kind of employment exists in similarly remote areas.

In setting the baseline to compare employment composition across Amazonian peers, Caquetá, Guaviare, and Putumayo show a high degree of similarity between them in the relative importance of retail and the public sector. In order to construct comparable employment composition across peer regions, we use urban observations from household or labor force surveys in each peer country.[9] Each of the three Colombian departments have large employment shares in retail trade, food and beverage activities, and wholesale trade (Figure 8).

Using a proxy for informality, the data reveal that the majority of employment in the Colombian Amazon is informal (Figure 9)**.** Informality is proxied by respondent's contribution to a pension fund, using the Gran Encuesta Integrada de Hogares (GEIH). Informality is highest for retail employment, which includes retail trade, wholesale, food and service, accommodations, etc. Only retail trade in motor vehicles registers as a sizeable source of formal retail employment in these departments.

Figure 8. CGP's Employment Compositions
Sized by portion employed



Sources: authors elaboration based on Gran Encuesta Integrada de Hogares (GEIH)

[9] The data for these analyses draw from household or labor market surveys from each country, concorded to the ISIC Revision 4 using the data from 2019.Given the variation in geographical levels across the raw surveys, the data utilize the best available locations to match the selected peers. Only urban observations were used for these analyses to maintain a consistent composition for comparison.

Figure 9. CGP's Employment Compositions, by formality
Sized by portion employed, by informal

Sources: authors elaboration based on Gran Encuesta Integrada de Hogares (GEIH)

An employment comparison across Amazonian peer regions reveals a shared importance of retail and the public sector, with a few important exceptions. Retail's share of employment is highest in Colombia, Ecuador, and Peru's region, while also significant in Argentina. Only Brazil's peer region features a small share of retail, which may result from data comparison challenges. In Para, Brazil, construction and the public sector represent the majority of urban employment. Interestingly, the importance of public sector employment is not unique to Colombia's three departments, as the public sector employs a sizable share across all peer Amazonian regions, most notably in Brazil and Argentina. Agriculture represents the second highest sector of employment in Peruvian Amazonian peers. Mining is a high relative share of employment in Ecuador, though mining employment is present in all peer regions except Brazil.

The Amazonian peer comparison presents a challenging reality for the complexity potential of the Colombian Amazon. Bioeconomy is not a significant share of employment in any peer region. The recent engagement of our Growth Lab team in Loreto, Peru, can confirm that the significant employment in crop, animal, and hunting sector in the region is not the bioeconomy that is referred to in current thinking. This does not preclude bioeconomy activities from having significant growth potential, but the economic engines of Amazonian regions lie elsewhere. The premise of diversification is to add new sectors, not to exclude sectors, but these findings are useful to create a more balanced message of the potential of the bioeconomy along with the current ceiling that it is not a significant employer in Amazonian regions. A similar takeaway applies to manufacturing, which is present in all Amazonian peer regions but as a small share of employment in all peers studied. The peer analysis fails to identify a high-complexity industry that manages to exist in the remote forest.

Figure 10. Amazonian Employment Compositions
Sized by portion employed

Sources: authors' elaboration based on: Gran Encuesta Integrada de Hogares (Colombia), Encuesta Permanente de Hogares (Argentina), Pesquisa Nacional por Amostra de Domicilios Continua (Brazil), Encuesta Nacional de Empleo Desempleo y Subempleo (Ecuador), Encuesta Nacional de Hogares (Peru)

The economic challenge across these Amazonian peer regions is that its cities do not export, in that they sell few things outside the city. What a city is able to export or sell outside the city determines the success of the city. The dominant presence of retail and the public sector, alongside small manufacturing and agricultural sectors, reinforces how little Amazonian regions export outside their regions. By failing to export, this further limits the capacity to import those items the place does not produce. The need to expand exports to be able to afford the imported inputs for more complex activities describes a fundamental coordination challenge behind the economic prospects in the Amazon. The only revenues coming from outside the region are public spending and employment. The private sector is comprised of retail and construction services that depend on local demand. Across the Amazonian peer regions, remoteness reigns, as there is no silver bullet of a high-complexity industry produced only in the forest that can overcome the long distances and weak coordination of industrial policy in these regions.

When looking at measures of comparative advantage, Caquetá and Guaviare show added specialization in agriculture, while Putumayo increases the role of the public sector. Beyond total employment, we estimate where each region punches above its weight, or holds revealed comparative advantage (RCA), drawing on employment data.[10] As shown in Figure 11,

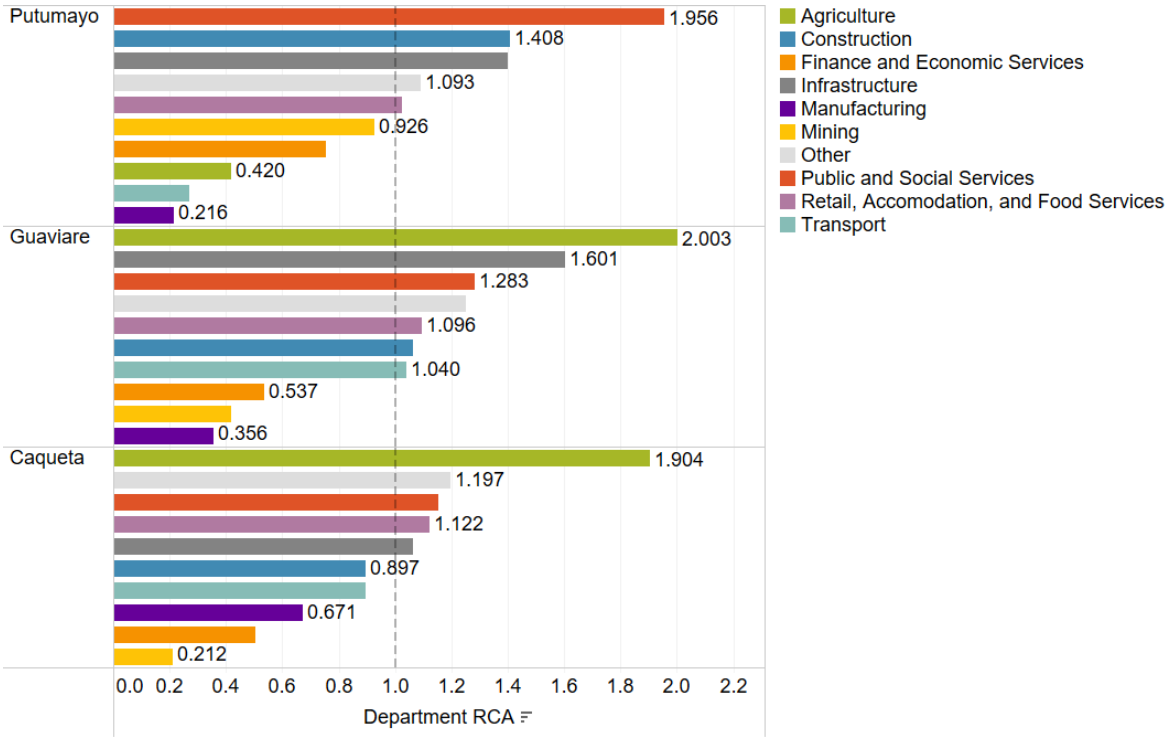
[10] We use a modified Balassa (1964) Revealed Comparative Advantage (RCA) metric:

$$Amazonian\ Region\ RCA = \frac{Amazonian\ region\ employment\ share\ in\ \ Industry\ X\ in\ Country\ A}{National\ employment\ share\ in\ Industry\ X\ in\ Country\ A}$$

Due to limitations in data availability in the household and labor surveys in the Amazonian regions, the RCA metric draws on employment data rather than export data. A particular place exhibits a revealed comparative advantage for a given industry if the share of employment in the Amazonian region for that given industry exceeds the national employment share for that industry. In other words, an Amazonian region demonstrates a revealed

Putumayo also demonstrates a high RCA in construction and infrastructure, more so than Caquetá and Guaviare. All three departments demonstrate an intensification in infrastructure and retail specialization. Figure 12 provides a more disaggregated visualization of Colombia's industrial composition, sized by these RCA values at a more granular industrial level. Putumayo has a disproportionately high employment in finance and professional services related to the minerals sector. Guaviare's specialization concentrates in the higher presence of non-governmental organizations, while Caquetá intensifies further in public and retail sectors.

Figure 11. CGP's ranked industrial RCAs
RCAs computed at the 1-digit industry level



Sources: authors elaboration based on Gran Encuesta Integrada de Hogares (GEIH)

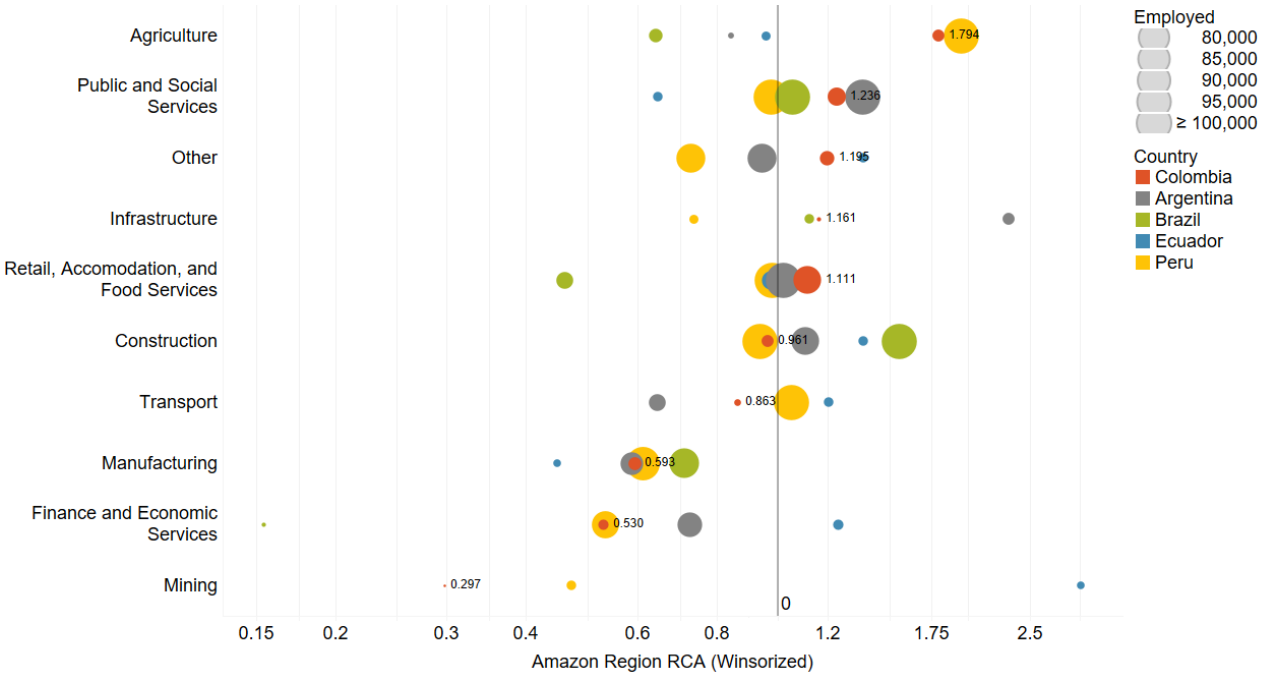
comparative advantage in an industry if it employs more than its "fair share", or a share that is at least equal to its country's employment share for that industry.

Figure 12. CGP's Employment Compositions
Sized by RCAs at the 2-digit industry level

Sources: authors elaboration based on Gran Encuesta Integrada de Hogares (GEIH)

Examining the comparative advantage of Amazonian peer regions reinforces the challenge of manufacturing and the reliance on public services and retail in remote places (Figure 13). These measures of revealed comparative advantage compare the relative share of employment in each sector to the other regions of the same country (given that the data used are national datasets, this ensures the desired relative comparator set. For example, while Para, Brazil's employment share in the public sector was high vis-à-vis other country datasets, when compared within Brazil, the relative share of public sector employment is closer to average for Brazil. Posadas, Argentina, shows the highest relative presence of public sector employment. Most of the Amazonian peer regions, except Ecuador and Peru, have a high relative presence of the public sector. Relative to its peers, Colombia exhibits its highest comparative advantage in agriculture and retail sectors. By contrast, not a single peer region specializes in the manufacturing industry. The peers also show a lack of comparative advantage in finance and economic services, except for Ecuador. By disaggregating employment composition to a 2-digit level to identify more specific industries that peer regions specialize in, the study holds interesting lessons for manufacturing and mineral services (Figure 14). Peru and Brazil's Amazonian regions now have a large RCA for manufacturing but in highly specific industries: paper products, tobacco, and textiles. Ecuador also holds greater specialization in specific business services, particularly mining services. Colombia is more balanced across the specific industries in specializes in, although scientific research and finance increase their relative specialization.

Figure 13. Amazonian Region ranked industrial RCAs
RCAs in logarithmic scale



Sources: authors elaboration based on: Gran Encuesta Integrada de Hogares (Colombia), Encuesta Permanente de Hogares (Argentina), Pesquisa Nacional por Amostra de Domicilios Continua (Brazil), Encuesta Nacional de Empleo Desempleo y Subempleo (Ecuador), Encuesta Nacional de Hogares (Peru)

Figure 14. Amazonian Region ranked industrial RCAs
Sized by RCAs at the 2-digit industry level

Sources: authors' elaboration based on: Gran Encuesta Integrada de Hogares (Colombia), Encuesta Permanente de Hogares (Argentina), Pesquisa Nacional por Amostra de Domicilios Continua (Brazil), Encuesta Nacional de Empleo Desempleo y Subempleo (Ecuador), Encuesta Nacional de Hogares (Peru)

The Amazonian peer region comparison presents some challenging findings for economic outlook: most Amazonian regions hold comparative advantage in public services and retail sectors, including Colombia. The peers' comparison provides a descriptive

understanding of the kinds of industries that have thrived in these remote regions. While controlling for climate and geographic similarities allows for important economic comparisons, gleaning recommendations from this analysis should further consider historical and political contexts. Some peers have notably high representation in a specific sector, such as mining in Ecuador's Amazonian region and paper manufacturing in Brazil. The analysis fails to find a silver bullet industry that exists in other Amazonian regions outside of Colombia that can remain competitive despite their remoteness.

5. Technological proximity and the Industry Space

How easy is it for the Amazon departments to diversify production? This depends on how easy it is to use the technological capacities present in each place to produce another. Traditionally, this redistribution is supposed to be smooth and continuous. Rather, a number of recent studies beginning with Hausmann and Klinger (2006) find that the ability to redistribute capabilities is highly unequal, with some capabilities easily reusable while others offer little opportunity.[11]

The speed at which a place can diversify and increase its complexity depends on the technological distance of an available pathway to enter industries related to existing capabilities. The original measure of technological distance between two products, proposed by Hausmann and Klinger (2006), is based on the probability that a country has of exporting both goods at the same time. Based on this indicator, a network of products is defined (the Product Space) that is used to locate the productive capacities of a place, which are manifested in the goods that that place is capable of exporting with a revealed comparative advantage. Seen in this way, the distance between two products serves to predict the patterns of productive diversification and structural transformation observed at the country level in the medium and long term (Hausmann et al, 2011). For the sub-national context, and in line with our definition of revealed comparative advantage, we create a measure of proximity between each pair of industries (including services). We can calculate proximity as the probability that each pair of industries will co-locate their production.[12]

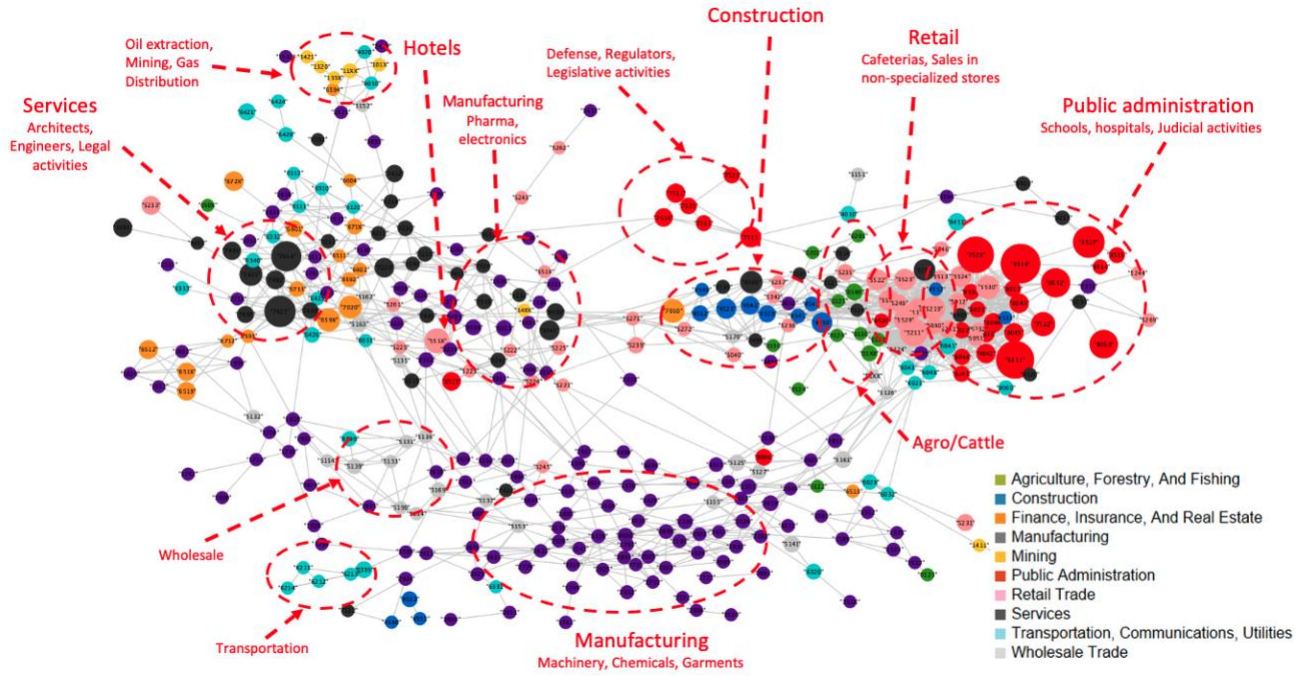
Figure 15 presents the Industry Space using the colocation of industries. This is a simplified representation of the network that describes the technological relationship between industries. Each of the 380 nodes represents an industry that can correspond to the manufacturing, service, or government activity sectors.[13]

[11] This confirms the *Scrabble Theory analogy*: some letters can be easily reused in many other words, while other letters are used in just a few words.

[12] Once again, we will use data from the United States, which allows us to take advantage of a great variability of industries, locating their production in cities with different sizes and characteristics. Another way to calculate the technological proximity between industries is using the frequency with which they are produced within the same establishment. This measure, suggested by Coscia & Neffke (2017), imposes an additional level of rigor, since it is much more feasible for two goods or services to share productive capacities if they are produced through different combinations of capacities within the context of the same company.

[13] Its size is proportional to industry employment in the United States, and the colors indicate the sectors to which each industry belongs. To simplify the visualization, nodes/industries are connected by links to other nodes when the technological proximity (or probability of co-location) is highly significant. We use an algorithm that locates the nodes spatially in such a way as to minimize the tension between the links, facilitating the visual representation.

Figure 15: The Industry Space



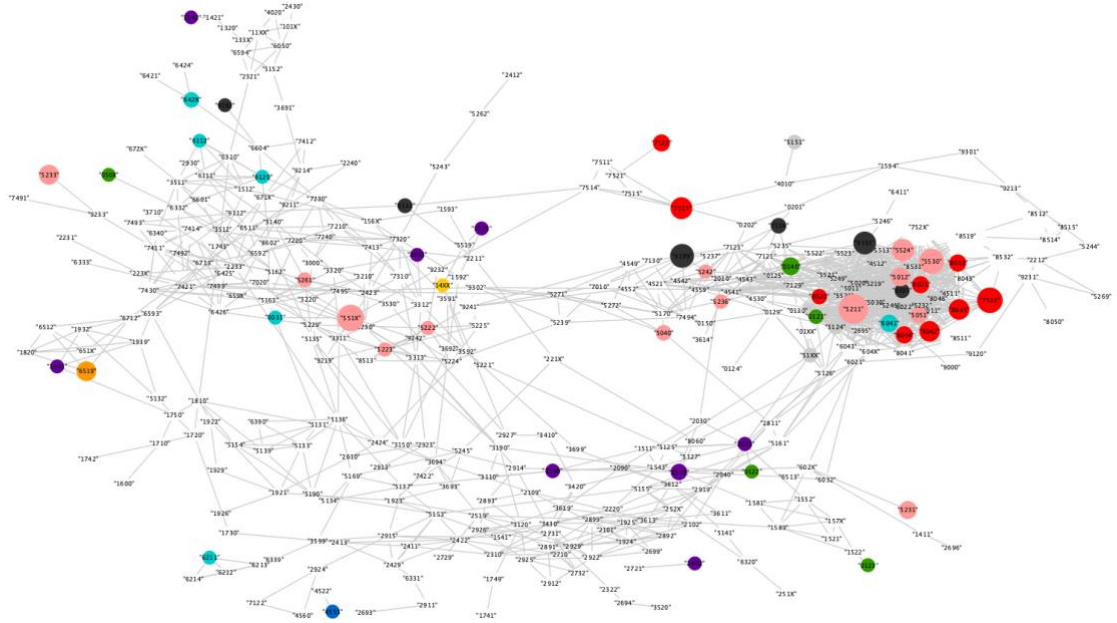
The Industry Space allows us to graphically observe the formation of industrial *clusters* that emerge naturally from the data. In the visualization we identify and name some of the clusters. On the right there is a large component that brings together the public administration, retail trade, agro-livestock, and construction. To the left, there is a component that brings together several clusters, including pharmaceuticals, professional services, and hotels. It is interesting to note that on the periphery of this component are the extractive industries of oil, gas, and mining. The location of oil so far from chemicals means that oil-producing localities rarely produce chemicals (mainly made from oil). This confirms the findings of Hausmann, Klinger, and Lawrence (2008) that very few places that export raw materials also export their processed forms or transition their production to further processing.

The shape of the Industry Space, with some dense areas with well-defined clusters, and other sparse areas, confirms the uneven or imperfect nature of reusing existing capacities to enter new sectors. Below in the visualization is a third component that groups mainly manufacturing activities, and two other clusters related to wholesale trade, and transportation and logistics. The distance between the manufacturing cluster and the other clusters reflects that the location of manufacturing often requires proximity to transportation and logistics systems, but not to retail, utilities, or raw materials.

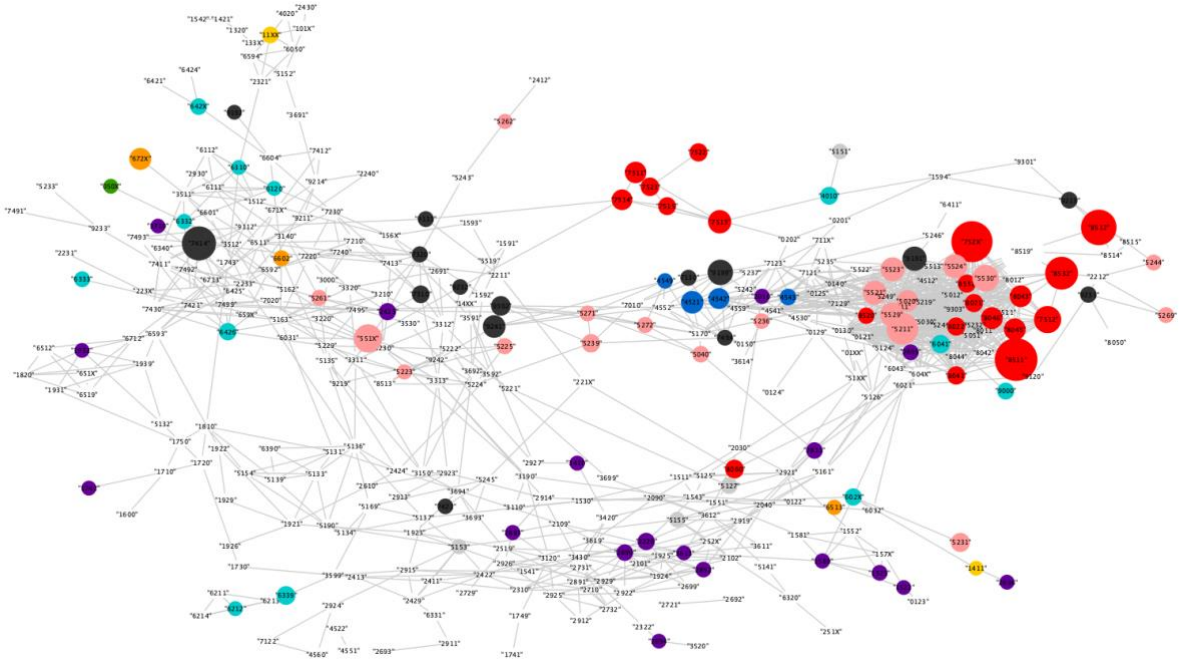
Opportunities to enter more complex activities depend on the existing capacities in each department. We can use the Industry Space visualization to graphically show the position of the departments under study, and thus observe the spatial location of the present economic activity and which industries are nearby. Figure 16 shows the Industry Space for each one of the departments, showing with more marked colors those industries where there is a relevant productive presence in each department.

Figure 16: Position of Caquetá, Guaviare, and Putumayo in the Industry Space

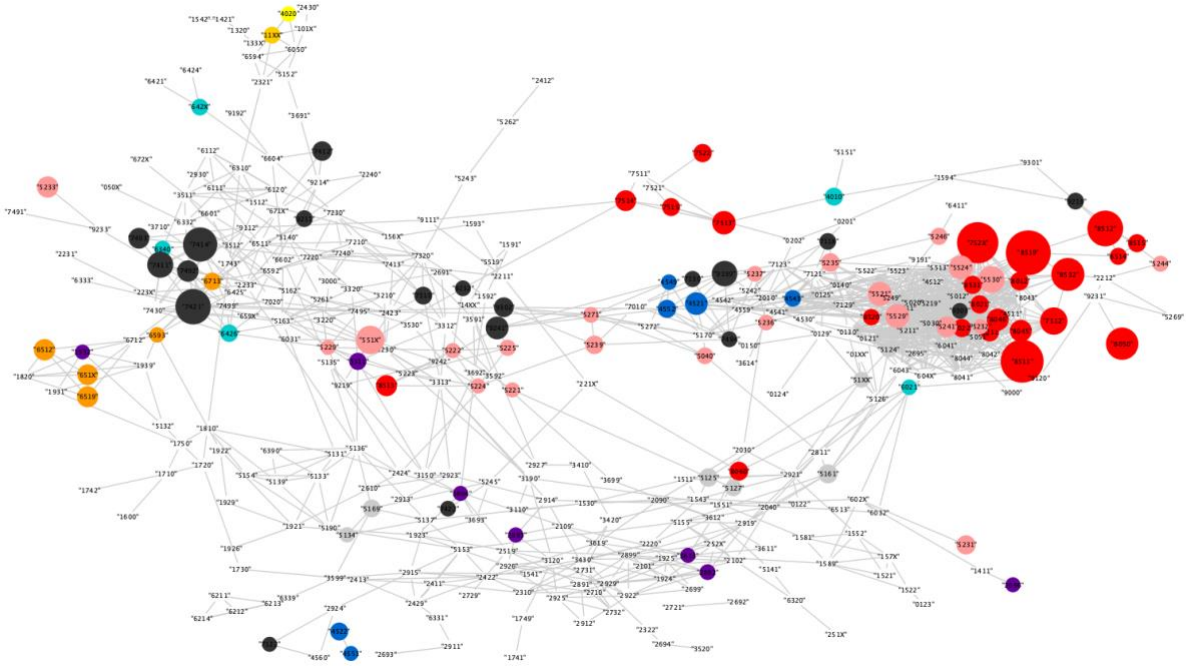
Caquetá



Guaviare



Putumayo



Caquetá shows significant presence in the public administration and retail trade clusters. For the rest of the clusters, Caquetá exhibits an industrial presence that seems to be isolated, without forming agglomerations of related industries, which we will see later in this document may hinder the development of new industries. It is important to note that Caquetá is the only department under study that has significant development of agricultural and livestock industries.

In the case of Guaviare, we also observed a significant presence in the public administration and retail trade clusters, including some additional industries to those present in Caquetá. There is also a presence in different clusters, and although there are industries that are dispersed in the Industry Space, it is possible to see a certain agglomeration of industries.

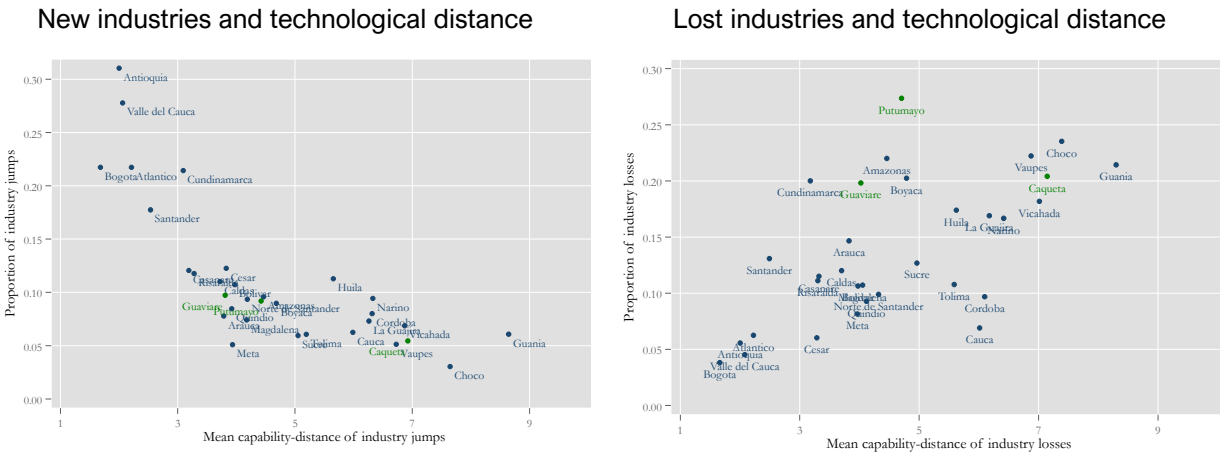
Finally, we comment on the case of Putumayo, in which there is also a presence in the public administration and retail trade clusters. One difference with respect to the two previous cases is that there seems to be a greater presence in the professional services cluster. It is plausible to think that the significant presence of the oil industry partially explains a demand for specialized services.

Comparison between observed and expected new industries

One way to validate the relationship between industries and accumulated capacities in the case of Colombia is to show how distance (in the Industry Space) correlates with the creation of new industries or those that have disappeared in each department. Figure 17 shows the relationship between distance and the frequency of new and defunct industries. In the left panel, we see the relationship for new industries; the horizontal axis shows the average distance of the industries that appeared in each department, while the vertical axis shows the number of new industries (as a proportion of industries to be developed). The negative relationship suggests that the departments that developed the highest proportion of new industries did so by adding industries that were, on average, closer to their competencies. The

right panel of Figure 17 shows the relationship for industries that disappeared; the horizontal axis shows for each department the average distance of the industries that disappeared, while the vertical axis shows the proportion of industries that were lost over the total number of industries present. The positive relationship indicates that the departments that lost the most industries were in those industries that were furthest from the productive competences of each department.

Figure 17: New and lost industries, and their distance to the competencies of each department



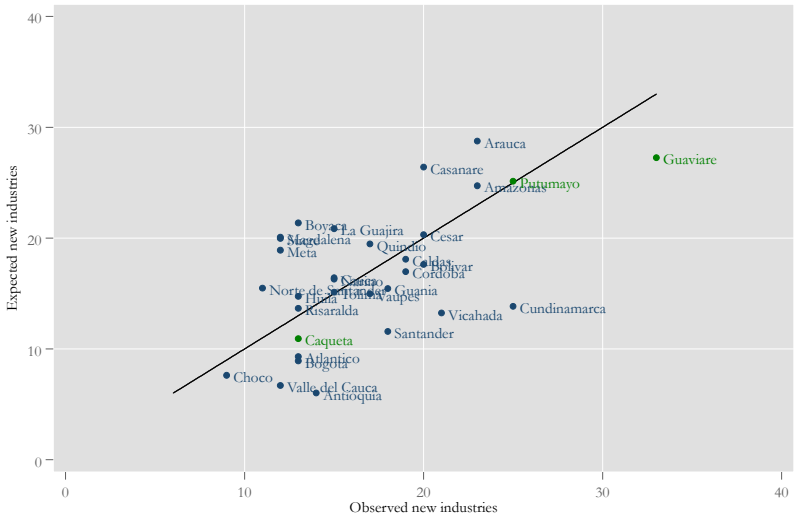
The relationship presented in Figure 17 highlights the importance of the position in the Industry Space. Industries closer to the capacities of each department – measured by distance – are more likely to appear, and less likely to disappear. An empirical exercise using regressions in Appendix 1 validates the importance of our measure of distance as a strong predictor of the probability of adding new industries or industries that may be lost. The regression indicates that a 100% increase in the distance of an industry from the capabilities of a department is associated with a 40% decrease in the probability of its appearance as a new industry (Figure A.3 in Appendix 1). Similarly, a 100% increase in the distance of an industry from the competencies of a department is associated with an increase from 33 to 110% in the probability that the industry will disappear.

A summary of the evidence presented so far is that the number of new industries added, and industries lost is similar in the three departments. In addition, we show that in relative terms the new industries in the department of Caquetá seem to be more distant from their current competitions and therefore with a greater risk of remaining. An additional question in this context is whether the frequency of jumps is higher or lower than what we should have expected given the conditions. For this, we use the estimates from Figure 17 again, and we make a prediction within the sample of the number of new industries and compare it with the number of new industries observed. [14]Figure 18 presents the result for the different departments, on the horizontal axis is the number of industries added in 2018-2019, while the vertical axis shows the expected number of industries. The 45-degree line is added to facilitate the comparison, in such a way that departments located above the line turn out to be cases where a greater number of new industries could be expected relative to what was actually observed. The latter is what describes Guaviare

[14] To validate this exercise, the ideal would have been to make an out-of-sample prediction. For example, having used one period of time to make an estimate, and then in a second period having compared the prediction of new industries with the number observed. Unfortunately, the extension of periods is not long enough to perform this exercise.

and Putumayo: although they added a high number of industries (in absolute terms), the estimate suggests that we should have expected a higher number of new industries.

Figure 18: Comparison between observed and expected new industries



6. Diversification opportunities

The economic opportunities of Caquetá, Guaviare and Putumayo depend on the possibility of developing new industries, and if possible, more complex industries than what currently exists. The productive diversification process is not random and tends to be highly related to the skills and capabilities developed by the existing industries in each place. Hidalgo et al (2007) show this intuition empirically, documenting that the new sectors exported by each country tend to be related to previously competitively developed sectors. The relationship between industries is given by the Product Space, where its analogue in this study is the Industry Space.

The strategy space of Colombia

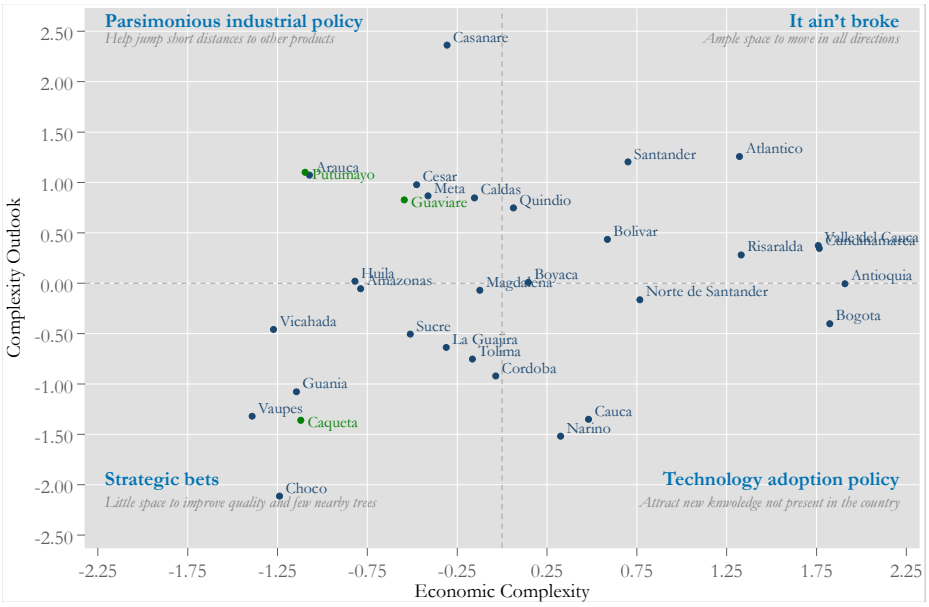
What actions should be taken to improve economic opportunities? To answer this question, it is important to consider whether the department has sufficient technological capabilities to support growth (economic complexity) and how easy it is to add new capabilities (complexity outlook). The three departments under study appear to be of low complexity according to the estimates. One question that we can ask ourselves is to add other industries, possibly more complex, given the industries present in each department and their position in the Industry Space. Indeed, the complexity forecast combines two ideas: first, what is the technological proximity between industries that are present and those that are absent but that could be developed; and a second idea, on a differential assessment of industries according to their complexity.

The strategic space of Colombia's departments is presented in Figure 19. The strategic space asks whether a department has enough technological capabilities to support growth (economic complexity) and how easy it is to add new capabilities (the complexity outlook). The three departments under study lack sufficient complexity to support strong growth. The departments differ in the ease of adding new capacities, with Caquetá in the worst position.

In the quadrant of low complexity and low complexity prognosis, we find Caquetá. This quadrant contains cases where the industries present are not sophisticated, and those that are close in terms of technological proximity are not very attractive. This situation requires a policy that actively helps to attract new companies and resolve the restrictions that hinder the emergence of more complex industries. Since there are no complex and close industries, riskier bets must be made, outside of the department's current remits.

Guaviare and Putumayo are in the quadrant of low economic complexity and high complexity outlook. Given the better position in the Industry Space, it is easier to find more complex industries in relative proximity to what exists. The policy prescription is to facilitate the development of what is close. It is interesting to describe the situation of relatively complex departments, but with a low complexity outlook, as is the case of Bogotá. In this case, the industries not present in Bogotá, which in theory could be encouraged and developed, turn out to be less complex than those already present. For this reason, the industrial policy to consider in this case is to attract industries, technology and processes that are not present in the country.

Figure 19: The strategy space of the departments of Colombia



Diversification strategies

The evidence suggests that Caquetá, Guaviare, and Putumayo are states of low economic complexity, and although they differ in their position in the Industry Space – Guaviare and Putumayo seem to be in a relatively better position – all three states will find it difficult to add new industries. In particular, the evidence from the previous section indicates that the number of new industries in Caquetá was low but higher than expected, while for Guaviare and Putumayo the number of new industries was higher, but lower than expected.

Consequently, not all places have the same potential, and for each place not all non-existing industries are equally viable. the diversification strategy must consider three dimensions. First, ***distance,*** or how similar the industry is to existing industries. The distance can be interpreted as a measure of how risky it is to try to tackle the industry, since further technological distance requires adding new capabilities that are not proven locally. The second is ***complexity,***

which depends on how many other places are capable of producing that good or service, and how many other products those places can produce. More complex products tend to support higher wages. And the third is ***strategic value*** (Complexity Opportunity Gain) or how close (or connected) the industry is to other highly complex products, where many links open up more opportunities for future diversification.

What complicates the diversification strategy is the negative relationship (or *trade-off)* between complexity and distance. More complex industries tend to be attractive because they are associated with higher income levels. These complex industries, however, are closer to places that are better positioned in the industry space. That is, for locations with few or loosely related industries in the Industry Space (for example, with most industries on the periphery of the Industry Space, presented in Figure 16), it will be more difficult to add complex industries. In addition, in the case that complex industries develop, if these industries are very distant from the competencies of the place, the evidence presented suggests that it is likely that these industries will not last over time and will disappear. These difficulties suggest that actions will depend on different productive development strategies. For example, we can think of strategies that emphasize the feasibility and success in the development of these industries, and in this case assign greater relative importance to the distance variable, over the complexity of the industry. An alternative strategy could, for example, look for a riskier bet, assigning greater importance to the complexity of the industries, granting less importance to the distance of the industries to the existing competitions in each department. In this section we will discuss these possible strategies.

The exercise that follows should be interpreted as a first approximation to the identification of productive diversification opportunities, and not as a process through which winning sectors are selected. The analysis consists of offering an initial road map that serves as orientation in the formulation of local and national policies. We can use different criteria and assign each one a different importance, to determine a list of industries selected by the strategy. These selected industries should be studied in broader consultative processes, with the participation of the public and private world, to understand their particularities and restrictions. This consultative process must be the basis of an iterative process of analysis that effectively validates its relevance. The databases used in this analysis are at the most disaggregated level possible, but they have their own limitations: they capture data from the formal economy in some departments where informality in the labor market and few foreign transactions predominate, which results in underestimate of the economic activity that is actually present.

Balanced Portfolio and Strategic Bets

The Growth Strategy aims to increase the probability of success of productive transformation efforts. This may involve the selection of industries that are relatively modest in terms of their economic complexity. The strategy seeks to prioritize industries that are close to the productive capacities of each department. Thus, we will assign a weight of 65% to the distance from current capabilities, 15% to the complexity of the industry, and 20% to the strategic value of the industry. The weights were made on normalizations in all the variables.

The Strategic Bets strategy aims to improve the positioning of the department, bringing it closer to more complex industries, even if this implies aspiring to industries that are relatively more distant from the knowledge base and existing productive capacities in each department. Following this motivation, we will define the strategy weighing 40% the distance to current capabilities, and 30% the complexity of the industry, and 30% the strategic value of the Industry Space. In Figures 20 and 21 we show a summary of the industries recommended by

each strategy. The features of each sector are detailed in Figures 22, 23, and 24, for each department. In each case, we will focus on the 25 highest scoring industries for each department. To give an idea of the relative intensity of employment generated by each industry, each one is weighted in the figure by the proportion that it employs in the country in Figures 20 and 21.

The Balanced Growth Strategy is presented in Figure 20 and shows those industries that are more closely related to existing capabilities. It is not surprising that a significant proportion of the industries selected for the three departments are related to agriculture, livestock, and related services, such as veterinary services. Given that our intention is to diversify, but not increase agronomy and extensive livestock farming, our interpretation is that the prescription would be to look for ways to add greater added value to these activities, such as agro-industry or processed foods. A second cluster of suggested industries are commercial service activities, which are surprisingly absent. For example, for all three departments vehicle repair is among the suggested industries, which tells us that this, and possibly other specialized machinery maintenance services, cannot be obtained locally. Probably the sale of certain equipment and its maintenance is only carried out in the large cities of Colombia. Thus, those local producers must face difficulties when they need to maintain their equipment. Finally, another cluster of industries unidentified by this strategy is linked to construction and engineering works.

Figure 21 shows a summary of the industries selected by the Strategic Bets strategy. For the three departments, a first cluster that we can identify is that of transport and logistics services. The absence of these industries, and their selection within what is strategic, can be explained by how remote and poorly connected the urban poles of these departments are with the rest of the country. Again, there is a set of commercial services that we discussed earlier whose development can play a catalytic role by enabling production in other sectors. Finally, among the selected industries are some manufacturing industries. The little relevance in the list tells us that no matter how complex the manufacturing industries may be, and despite the low weighting that we give to distance, these industries are very different and far removed from what the three departments produce.

Figure 20: Balanced Growth Strategy: High-Potential Industries by Department

Figure 21: Strategic Bets: High-Potential Industries by Department

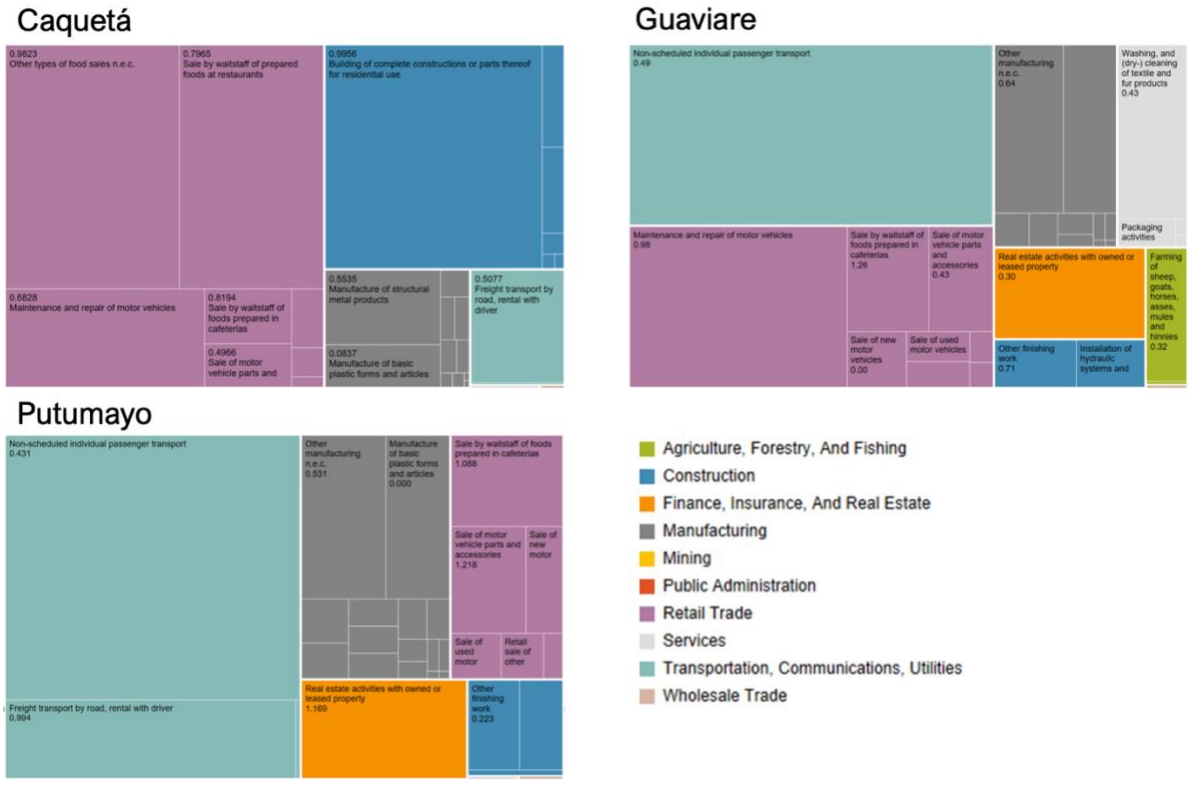


Figure 22: High-Potential Diversification Opportunities in Caquetá

Rank	Industry Name	Industry Complexity	Opportunity Gain	Distance to Existing Capabilities	Employment 2019
Tourism-related Retail Services					
2	Self-service restaurants	◆◆◆◇◇	◆◆◆◇◇	◆◆◆◆◆	0
3	Restaurants with waitstaff	◆◆◐◇◇	◆◆◆◇◇	◆◆◆◆◆	3,519
8	Other food sales	◆◆◐◇◇	◆◆◆◇◇	◆◆◆◆◆	7,380
Other Retail					
1	Renting office machinery	◆◆◆◆◇	◆◆◇◇◇	◆◆◆◆◐	0
5	Renting agricultural machinery	◆◆◆◐◇	◆◆◐◇◇	◆◆◆◆◐	0
14	Consumer products in specialized stores	◆◆◇◇◇	◆◆◐◇◇	◆◆◆◆◆	22
16	Equipment sales in specialized stores	◆◆◆◇◇	◆◆◆◐◇	◆◆◆◆◇	6
Transportation					
7	Sales of motor vehicles	◆◆◐◇◇	◆◆◆◇◇	◆◆◆◆◆	51
9	International freight transport	◆◆◆◇◇	◆◆◆◆◐	◆◆◆◆◇	0
11	Vehicle repair and maintenance	◆◆◐◇◇	◆◆◆◐◇	◆◆◆◆◐	2,822
12	Freight transport with driver	◆◆◆◇◇	◆◆◆◆◐	◆◆◆◆◇	859
15	Sales of motor parts	◆◆◇◇◇	◆◆◆◐◇	◆◆◆◆◐	264
Manufacturing					
4	General purpose machinery manuf.	◆◆◆◆◇	◆◆◆◆◐	◆◆◆◇◇	0
13	Concrete, cement articles manuf.	◆◆◐◇◇	◆◆◆◇◇	◆◆◆◆◐	117
17	Machine tools manuf.	◆◆◆◆◆	◆◆◆◆◆	◆◆◐◇◇	0
20	Rubber articles and tires manuf.	◆◆◆◐◇	◆◆◐◇◇	◆◆◆◆◐	0
21	Plastic forms and articles manuf.	◆◆◆◐◇	◆◆◆◆◆	◆◆◆◇◇	147
24	Paper product manuf.	◆◆◆◆◇	◆◆◆◆◇	◆◆◆◇◇	0
25	Structural metal product manuf.	◆◆◆◇◇	◆◆◆◆◐	◆◆◆◇◇	882
Construction					
6	Equipment Installation	◆◆◆◐◇	◆◆◆◐◇	◆◆◆◆◇	16
19	Site preparation for building construction	◆◆◐◇◇	◆◆◆◐◇	◆◆◆◆◐	0
22	Site preparation for civil works	◆◆◇◇◇	◆◆◐◇◇	◆◆◆◆◆	18
23	Hydraulic system installation	◆◆◐◇◇	◆◆◆◐◇	◆◆◆◆◇	111
Agriculture					
18	Mixed farming	◆◐◇◇◇	◆◆◐◇◇	◆◆◆◆◆	272

Figure 23: High-Potential Diversification Opportunities in Putumayo

Rank	Industry Name	Industry Complexity	Opportunity Gain	Distance to Existing Capabilities	Employment 2019
Retail Services					
1	Renting office machinery	◆◆◆◆◐	◆◐◇◇◇	◆◆◆◆◇	0
2	Paint stores	◆◆◆◇◇	◆◆◐◇◇	◆◆◆◆◇	0
3	Self-service restaurants	◆◆◐◇◇	◆◆◐◇◇	◆◆◆◆◆	0
4	Renting agricultural machinery	◆◆◆◇◇	◆◐◇◇◇	◆◆◆◆◐	0
9	Repair of household goods	◆◆◐◇◇	◆◆◐◇◇	◆◆◆◇◇	87
12	Consumer products in specialized stores	◆◐◇◇◇	◆◆◇◇◇	◆◆◆◆◆	0
14	Packaging activities	◆◆◐◇◇	◆◆◐◇◇	◆◆◆◇◇	0
15	Newspaper or journal publishing	◆◆◇◇◇	◆◆◇◇◇	◆◆◆◆◇	0
17	Dry cleaning	◆◐◇◇◇	◆◆◆◇◇	◆◆◆◐◇	16
18	Equipment rentals	◆◐◇◇◇	◆◆◇◇◇	◆◆◆◆◐	6
19	Paint wholesale	◆◆◐◇◇	◆◆◆◇◇	◆◆◆◇◇	0
22	Photographic equipment stores	◆◆◆◆◐	◆◆◐◇◇	◆◆◇◇◇	0
Manufacturing					
7	General purpose machinery manuf.	◆◆◆◆◐	◆◆◆◆◆	◆◆◇◇◇	0
13	Machine tools manuf.	◆◆◆◆◆	◆◆◆◆◇	◆◇◇◇◇	0
16	Rubber articles and tires manuf.	◆◆◆◇◇	◆◆◇◇◇	◆◆◆◇◇	0
20	Plastic forms and articles manuf.	◆◆◆◇◇	◆◆◆◆◆	◆◐◇◇◇	0
24	Concrete, cement articles manuf.	◆◐◇◇◇	◆◆◐◇◇	◆◆◆◇◇	0
Transportation					
6	Sales of used motor vehicles	◆◆◆◇◇	◆◆◐◇◇	◆◆◆◇◇	0
10	Vehicle repair and maintenance	◆◐◇◇◇	◆◆◆◇◇	◆◆◆◆◇	193
21	Sales of motor vehicles	◆◐◇◇◇	◆◆◐◇◇	◆◆◆◐◇	0
25	International freight transport	◆◆◐◇◇	◆◆◆◆◇	◆◆◐◇◇	0
Construction					
5	Hydraulic system installation	◆◆◇◇◇	◆◆◐◇◇	◆◆◆◆◇	0
8	Finishing work	◆◐◇◇◇	◆◆◐◇◇	◆◆◆◆◇	19
23	Site preparation for building construction	◆◐◇◇◇	◆◆◆◇◇	◆◆◆◇◇	0
Real Estate					
11	Real estate	◆◆◇◇◇	◆◆◇◇◇	◆◆◆◆◇	14

Figure 24: High-Potential Diversification Opportunities in Guaviare

Rank	Industry Name	Industry Complexity	Opportunity Gain	Distance to Existing Capabilities	Employment 2019
Manufacturing					
2	Machine tools manuf.	◆◆◆◆◆	◆◆◆◆◐	◆◐◇◇◇	0
3	General purpose machinery manuf.	◆◆◆◆◇	◆◆◆◆◇	◆◆◐◇◇	0
7	Rubber articles and tires manuf.	◆◆◆◐◇	◆◆◇◇◇	◆◆◆◆◇	0
9	Paper product manuf.	◆◆◆◆◇	◆◆◆◐◇	◆◆◐◇◇	0
12	Plastic forms and articles manuf.	◆◆◆◇◇	◆◆◆◆◆	◆◐◇◇◇	0
19	Paper containers manuf.	◆◆◆◇◇	◆◆◆◆◆	◆◐◇◇◇	0
24	Steam generators, metal tank manuf.	◆◆◆◇◇	◆◆◆◆◇	◆◐◇◇◇	0
25	Other rubber products	◆◆◆◆◇	◆◆◆◆◆	◆◇◇◇◇	0
Retail Services					
1	Renting office machinery	◆◆◆◆◇	◆◆◇◇◇	◆◆◆◆◇	6
5	Paint stores	◆◆◆◐◇	◆◆◐◇◇	◆◆◆◆◇	0
6	Renting agricultural machinery	◆◆◆◇◇	◆◆◇◇◇	◆◆◆◆◇	0
8	Cafeterias with waitstaff	◆◆◇◇◇	◆◆◐◇◇	◆◆◆◆◆	71
13	Equipment sales in specialized stores	◆◆◆◇◇	◆◆◆◇◇	◆◆◆◆◇	0
17	Dry cleaning	◆◆◐◇◇	◆◆◆◇◇	◆◆◆◆◇	57
21	Newspaper or journal publishing	◆◆◐◇◇	◆◆◆◇◇	◆◆◆◆◆	13
22	Funeral services	◆◆◇◇◇	◆◆◐◇◇	◆◆◆◆◇	6
Transportation					
4	Sales of used motor vehicles	◆◆◆◇◇	◆◆◐◇◇	◆◆◆◆◇	0
11	International freight transport	◆◆◐◇◇	◆◆◆◐◇	◆◆◆◐◇	0
15	Sales of motor vehicles	◆◆◐◇◇	◆◆◐◇◇	◆◆◆◆◇	0
20	Freight transport with driver	◆◆◐◇◇	◆◆◆◐◇	◆◆◆◐◇	159
23	Sales of motor parts	◆◆◇◇◇	◆◆◐◇◇	◆◆◆◆◇	23
Construction					
10	Painting and finishing	◆◆◆◇◇	◆◆◐◇◇	◆◆◆◆◇	136
14	Hydraulic system installation	◆◆◐◇◇	◆◆◐◇◇	◆◆◆◆◇	0
16	Window installation	◆◆◇◇◇	◆◆◇◇◇	◆◆◆◆◇	0
18	Site preparation for building construction	◆◆◐◇◇	◆◆◆◇◇	◆◆◆◆◇	0

Tourism

One of the most promising economic sectors for the Colombian Amazon is tourism. Yet tourism presents a specific data challenge in that it appears to be relatively present in each department. Tourism entails a series of retail services, including accommodations, restaurants, and leisure activities, which are highly present in each of the three Amazonian departments studied. When assessing whether a place does their "fair share" of an activity, the presence of these activities in the Colombian Amazon is not because of its true competitive advantage but because of the absence of competing activities. Qualitative interviews reinforced how restaurants and hotels may exist, but there is a known gap that each place is missing a clear integrated system of tourism operators to integrate ecotourism activities with hotel and restaurant offerings that leads tourism growth to be well below its potential. The Colombian Amazon offers potential in eco-tourism in its conservation-oriented travel motivation, to serve both environmental conservation and employment generation. The eco-tourism ecosystem includes a variety of industries that are currently not developed to their full potential in the Colombian Amazon region, such as tourism operators, accommodations and hotels, ecotourism services, translation services, and restaurant and beverages establishments. An advantage of the tourism sector is that it has the potential in the Amazon of generating employment both in urban areas – in terms of transportation and operator services as well as accommodations – and in rural and forest areas for ecotourism services.

Tourism is not new to Colombia, and Colombia has seen increased tourism over time; however, tourism is more prevalent in non-Amazonian regions. While Colombia has demonstrated successful cases of eco-tourism, there is room for growth. Institutionally, Colombia has a regulatory framework that enables eco-tourism. Most recently, Law 2068 of 2020 modified the General Tourism Law to promote conservation in tourism destinations, through control of tourism capacity, tax incentives for ecotourism projects and development of scientific tourism projects. According to USAID's Nature Tourism Market Analysis Report, ACOTUR (Responsible Tourism Association) is the only national-level organization that brings together nature-tourism entrepreneurs, as evidence of the lack of coordination between tourism and environmental sectors.

Colombia has its own success cases of developing ecotourism locales, including Tayrona National Park, located on the Caribbean coast of Colombia. Its creation heavily relied on private sector participation. In 2005, a 10-year concession for tourism services and main tourism zones were given to Santa Marta's Chamber of Commerce and a private travel company (Aviatur and Alnuva) to develop the industry. However, Ojeda (2012) explains that Tayrona's development as a tourism hotspot also led to land-grabbing amongst the elite, which is a risk in the Colombian Amazon without addressing land formalization issues. A 2017 evaluation by Pontificia Universidad Javeriana concluded that the ecotourism industry does not generate sufficient income for local community enterprises and many potential ecotourism sites lack the knowhow to cater to foreign tourists, such as bilingual materials and guides (Parques Nacionales Naturales de Colombia & Semillero en Turismo Responsible, 2018). Their main recommendations center on the need to redesign this industry to strengthen alliances with community enterprises and maintain a continuous effort in skills training.

Sustainable agroforestry and bioeconomy

Sustainable agroforestry offers a significant growth opportunity, particularly as supplementary income for reforestation. Agroforestry falls under the more general concept of the circular economy, or bioeconomy, one where the materials used to produce are restorative by-design, as they are derived from renewable biological resources. Agroforestry provides a potential to drive rural employment without damaging the forest and potential for urban employment in terms of processing plants for the agricultural products produced through this system. Agroforestry crops are highly diversified in Colombia, with more than a dozen known crops being produced in forested areas in the Amazon, such as acai, cacao, natural rubber, and palm hearts. According to an analysis of Colombia's bioeconomy by Henry et al (2017), as of 2015, 34 Colombian companies engaged in bioeconomic initiatives, with about 80% of those companies started as family businesses. At its most successful, an agroforestry business in the Colombian Amazon, Corpocampo, is an international exporter of acai. Smaller businesses, such as Pura Amazonia, have developed more than six product lines in agroforestry crops, such as native products Camu Camu, Copoazú, Cocona, and Arazá, through close coordination with the Amazonian research institute, Sinchi. Agroforestry efforts have developed cooperatives in indigenous territories to produce these crops for Pura Amazonia.

The market potential for agroforestry is limited by the need to create consumer demand for relatively unknown goods. Despite producing a diverse set of agroforestry crops, few native species are known outside of the Amazon, much less outside of Colombia. Acai is a known exception. Pura Amazonia has been more successful in generating the supply of native Amazonian crops by leveraging the expertise of Sinchi in agroforestry production. The binding constraint to Pura Amazonia's growth is the lack of consumer knowledge of those same native agroforestry crops, as there is no Sinchi equivalent in creating consumer demand for unknown products in Colombia. Introducing new foods into the diet is a slow, risky process. These coordination challenges in creating both the supply and demand for agroforestry crops poses a real risk to the scalability of these initiatives.

Agroforestry crops are not a silver bullet for the Colombian Amazon, as they offer room for growth, but also face an apparent growth ceiling. The Henry et al (2017) study concludes that a new economic system is needed in Colombia and places the bioeconomy at the forefront of the new model. Policy efforts in Colombia have been similarly bold in backing the potential of the bioeconomy. The green growth policy of 2018, Consejo Nacional de Politica Economica y Social, aims to increase the number of bio-innovative companies by 86% and increasing the production of goods and services by bio-companies (Canales and Gomez Gonzalez 2020). The Amazonian departments may well be capable of realizing those growth prospects; it is not obvious that that growth would transform employment levels and economic outcomes in the region. As the study of Amazonian peer regions concluded, agroforestry crops do not represent a significant employer in any of the peer regions. Even the success case of Corpocampo is a lesson in the length of time required to reach scale in resolving both supply and demand constraints. The economic returns to both producers and agroforestry businesses have yet to produce evidence of sustainability at scale. Each of the agroforestry crops has a different profit margin, as well as varying risk factors. When considering the need to also change consumption patterns to drive demand for each product, the most likely outcome is that not all of the native agroforestry products will prove viable. Supply and demand factors are likely to converge production to a few products at scale and most likely those non-native species that have a proven market demand.

Intensive agriculture and predicting crop appearances in non-forested land

Agricultural activities vary significantly in the amount of land required to achieve higher productivity. Municipalities in Colombia differ not only in their main crop (Figure 25) but in their dependence on extensive agriculture (Figure 26). Extensive agriculture employs vast expanses of land and few workers or machinery to achieve a certain yield. Intensive agriculture relies on more skilled workers and inputs, such as fertilizer, insecticides, and machinery to produce the same yield on small land plots at high productivity. In the context of extensive agriculture that occurs where the agriculture frontier abuts the forest, creating risks of forest loss, identifying opportunities for intensive agriculture offer the potential to increase incomes and reduce deforestation.

This study developed a new measure termed the Land Extensiveness Dependence Index. This index studies the extent to which agricultural crops are dependent on extensive land plots in order to be productive. When applied to the Agricultural Census from Colombia in Figure 27, the most land extensiveness dependent crops are yam, soy, sugar cane, pear, and grain cocoa (cattle-ranching is not included in the Agricultural Census as its studies crops). Conversely, the least land extensiveness dependent are papaya, pineapple, garlic, onion, and pepper.

Intensive agriculture is repeatedly found to offer significantly higher yields per land area than extensive cattle-ranching. Yet, the Amazonian departments studied continue to rely on extensive cattle-ranching. This begs the question: what crop agriculture is feasible for the non-forested parts of each department? Using the Agricultural Census of crop production by department matched with detailed soil sampling, the study developed a model to predict crop appearances based on the soil types in each department. The results of the predicted rank of crop appearance are presented in Figures 28, 29, and 30 for each department across product prediction, the relative presence of each crop as measured by revealed comparative advantage (RCA, with greater than one defining existing RCA in a crop), and the land extensiveness dependence index of each predicted product and existing products.

Figure 25: Main crop, by municipality

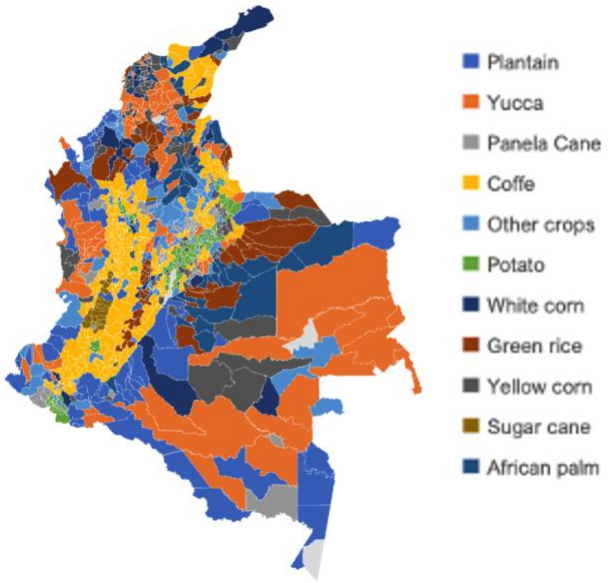


Figure 26: Land Extensiveness Dependence Index, by municipality

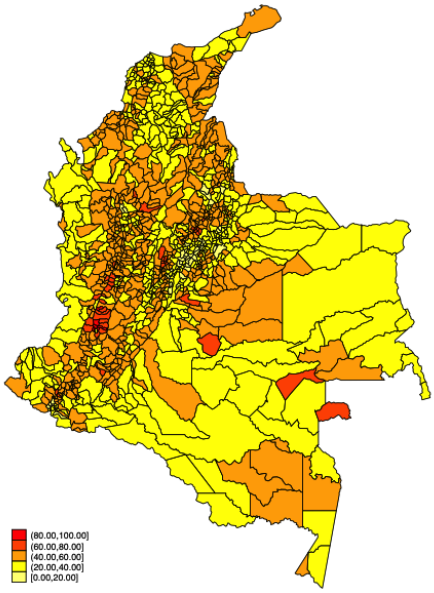


Figure 27: Most and Least Land Extensiveness Dependent Products in Colombia

Most land extensiveness dependent

Rank	Crop	Land Extensiveness Dependence Index	Share
1	Yam	1.00	1.04
2	Soy	1.00	0.15
3	Sugar cane	1.00	4.17
4	Pear	0.74	0.03
5	Grain cocoa	0.74	3.10
6	Panela Cane	0.71	5.61
7	Forage corn	0.69	0.34
8	Sorghum	0.69	0.09
9	Forage barley	0.65	0.05
10	Mango	0.63	0.62

Least land extensiveness dependent

Rank	Crop	Land Extensiveness Dependence Index	Share
65	Papaya	0.05	0.39
64	Pineapple	0.05	1.80
63	Garlic	0.06	0.06
62	Onion	0.07	0.33
61	Pepper	0.09	0.05
60	Orange	0.09	1.05
59	Tomatoes	0.10	0.44
58	Coriander	0.10	0.01
57	Cucumber	0.10	0.02
56	Potato	0.11	3.21

Figure 28: Predicting New Crop Appearances in Caquetá

Probability Rank	Crop	Revealed Comparative Advantage	Area Cultivated Today	Land Extensiveness Dependence Index
1	Coffee	0.05	3,958	0.55
2	White corn	0.37	1,830	0.41
3	Lemon	0.08	591	0.18
4	Grain cocoa	0.98	2,088	0.74
5	Orange	0.04	365	0.09
6	Papaya	0.00	62	0.05
7	Tangerine	0.00	313	0.16
8	Banana	0.50	2,174	0.24
9	Avocado	0.07	215	0.28
10	Soy	0.00	0	1.00
Existing Crops				
	Yucca	2.66	21,203	0.17
	Squash	2.29	4,040	0.19
	Plantain	2.10	20,045	0.32
	Panela Cane	1.94	6,049	0.71
	Yellow corn	1.87	11,155	0.43
	Pineapple	1.78	2,745	0.05

The predicted crop appearance shows potential across a range of tropical fruits, citrus, corn, and coffee in the non-forested parts of the Amazonian departments. The predicted products range from those which are not highly present today, broadly citrus and coffee, to those starting from an existing base, including grain cocoa and banana. The products further range in

the land extensiveness dependence index, from high dependence in grain cocoa and soy, to low dependence in papaya and citrus. The highest-potential opportunity to match soil quality requirements without being dependent on extensive land area is in citrus, across lemon, oranges, and tangerines, which factor into all three departments' lists. The challenge will be that citrus does not currently feature existing cultivation at scale, so should look to transfer knowhow of the sectors from the citrus growing regions of Colombia.

Figure 29: Predicting New Crop Appearances in Guaviare

Probability Rank	Crop	Revealed Comparative Advantage	Area Cultivated Today	Land Extensiveness Dependence Index
1	Papaya	0.17	12	0.05
2	Coffee	0.00	0	0.55
3	Grain cocoa	0.71	453	0.74
4	White corn	0.27	427	0.41
5	Avocado	0.23	85	0.28
6	Yam	0.20	136	1.00
7	Banana	0.02	43	0.24
8	Panela Cane	0.63	753	0.71
9	Soy	0.00	4	1.00
10	Watermelon (Patilla)	0.40	142	0.51
Existing Crops				
	Yellow corn	3.54	5,634	0.43
	Chilies and peppers	3.37	263	0.21
	Squash	3.01	537	0.19
	Yucca	2.60	6,263	0.17
	Pineapple	2.14	1,134	0.05
	Lemon	2.03	739	0.18
	Tangerine	1.79	558	0.16
	Mango	1.56	871	0.63
	Onion	1.56	209	0.07
	Plantain	1.48	4,596	0.32
	Green rice	1.21	2,418	0.25
	Orange	1.20	295	0.09
	Tomatoes	1.10	136	0.10

Figure 30: Predicting New Crop Appearances in Putumayo

Probability Rank	Crop	Revealed Comparative Advantage	Area Cultivated Today	Land Extensiveness Dependence Index
1	Coffee	0.06	1,890	0.55
2	Panela Cane	0.76	3,639	0.71
3	Avocado	0.67	521	0.28
4	Lemon	0.06	427	0.18
5	Tomatoes	0.83	409	0.10
6	Orange	0.12	223	0.09
7	Tangerine	0.00	218	0.16

8	Pineapple	0.76	1,498	0.05
9	Papaya	0.00	98	0.05
10	Soy (soy)	0.46	137	1.00
Existing Crops				
	Plantain	2.40	17,348	0.32
	Yellow corn	1.72	8,269	0.43
	White corn	1.72	4,417	0.41
	Grain cocoa	1.65	4,113	0.74
	Yucca	1.32	11,633	0.17
	Banana	1.07	4,432	0.24

Anti-deforestation filter: Eliminating harm from deforestation-linked activities

In principle, economic diversification is about adding new economic activities, not about stopping certain activities, or doing less. One exception to this principle is in the Amazon rainforest, given the dual objectives of achieving diversification while not harming the forest. This study adds an additional "anti-deforestation filter" to sift out any economic activity that is found to be a significant driver of deforestation.[15] The aim is to ensure forest-friendly development, where the pursuit of economic development is not through the destruction of the forest.

Three activity groups that have been filtered out from the industry opportunity rankings due to links to deforestation are: extensive cattle-ranching, mining activities, and palm oil. The goal is not to eliminate these sectors from consideration altogether, but to recognize that, when unchecked, they have been linked to deforestation events in Colombia, elsewhere in the Amazon, or in other global forests (e.g., palm oil in Indonesia). Efforts have been made to advance sustainable palm oil to reduce or eliminate its effects on deforestation. Similarly, achieving global decarbonization will require a mining boom in the rare earth minerals to power the green technologies behind the energy transition. In Colombia, mining is not a primary driver of deforestation. Yet mining projects contribute not only to direct forest loss but in the tertiary road construction that is associated with further deforestation. In the end, sustainable palm oil and specific mining projects may have a strategic place under a well-governed approach to the Amazonian departments but must integrate forest protection into any cost-benefit analysis.

Achieving sustainable development requires focusing less on empowering activities that harm the forest, particularly cattle-ranching. The bulk of deforestation in Colombia's Amazon is facilitated by extensive cattle-ranching as a more profitable alternative to forest protection services. Policy options must consider how to change relative prices to make forest protection more profitable than cattle ranching as a means of land use, particularly in the forest. Colombia features a set of national policies to promote cattle-ranching in the Amazon, more than it promotes other activities not associated with deforestation. Despite its environmental impact on deforestation, cattle-ranching in Colombia pays relatively low taxes with high levels of informality.

[15] In a study in Loreto, Peru, the extreme isolation of its capital city, Iquitos, meant it was cut off from the electrical grid, where any expansion in economic activity must consider how additional emissions would come from energy sources that may harm the environment. In that case, the emissions levels of an economic activity were used as a filter to consider new economic opportunities. In the three Colombian departments studied, we find city emissions are not constraints in the same way, as the cities are both connected to electrical grids and not as proximate to the forest. As a result, we integrate the objective of not harming the forest by recommending activities that are not found to be central drivers of deforestation in the ecological literature.

At the same time, cattle-ranching provides a legal economic activity that employs a significant share of the population. The focus of policy should be to incentivize better practices in cattle-ranching to improve productivity and to eliminate the use of cattle-ranching as the most efficient means of land speculation that results in deforestation in the Amazon. The policy options report presents some proposals in this direction, to directly address cattle-ranching and to indirectly address it by curbing land speculation: to place forested areas under a legal regime that eliminates future land formalization; to create a national minimum property tax on rural lands; and to create a monitoring and traceability mechanism to guarantee deforestation-free cattle.

An additional analysis finds that the anti-deforestation filter is not necessary – economic complexity methods themselves do not suggest that deforestation-linked activities are high-potential opportunities. The same economic complexity model run without applying the anti-deforestation filter is found to deliver the same set of economic activities. That is, the economic complexity method does not find that cattle-ranching, mining, or palm oil offer greater complexity to the Amazonian departments. This reflects an important lesson for Amazonian economies: the activities driving deforestation are not those that offer a path to greater shared prosperity. Realizing many of the high-potential industries identified would locate in urban areas in these Amazonian departments, far from the forest edge. Thus, these urban economic opportunities pose little threat to greater deforestation. These results support the opposite conclusion: realizing these opportunities in urban areas would drive greater migration out of rural areas to reduce pressures on expanding into the forest.

7. From potential to reality

This study seeks to define an alternative economic model for the Colombian Amazon from the perspective of economic complexity with environmental sustainability. This model starts from the base of understanding the existing productive capacities in Caquetá, Guaviare, and Putumayo, as well as providing innovative solutions to ignite the spark of the untapped productive potential of Amazonian cities.

The Colombian Amazon will not get richer by specializing in more of the same production, particularly in the extraction of raw materials. The three departments under study tend to have production concentrated in a few sectors, which are of relatively low complexity compared to the rest of Colombia. A significant proportion of employment is linked to public administration – a higher proportion than in other departments of the country. Very little of the production in the departments is destined to be consumed outside the departments ("exported"). Growth strategies must carefully consider how to attract missing skills to the region, given the lack of a manufacturing base.

The true productive transformation of Amazonian departments will consist of increasing the complexity of its under-studied cities, by expanding the productive knowledge base to enter new, more complex industries (Figure 31). The new economic model would be based on four pillars:

- ***Sustainable agroforestry***: intensifying agriculture to enter new areas of the bioeconomy, to scale those agricultural products, and their processed potential, that thrive in the given soil type of non-forested areas of the departments. This includes a focus in maximizing

yields, where crops consistently afford higher value than extensive cattle-ranching, to integrate the environmental sustainability of new activities.

- ***Tourism***: while a base exists, the study found missing coordination of a strategy to provide a more complex ecosystem of high-value industries of tourism operators, hotels, restaurants, and related services limits the volume of visits and spending in the sector.
- ***Logistics services***: transport services were found to be a critical missing input that hinder the complementary profitability of new industrial sectors.
- ***Professional services***: in specific instances with the presence of the oil industry in Putumayo, related professional services were not well represented, but offer areas for employment growth.

Figure 31. High-potential Diversification Opportunities for CGP

This process requires a new approach to economic policy, away from an extractive approach or the current dependence on government transfers and public payroll, to another that places emphasis on productive diversification and export capacity, first to the rest of Colombia, and from there to the rest of the world. Identifying the industries with the greatest potential does not guarantee their viability. The identified industries should be a basis for a broader consultative process, involving the public and private sectors. Promoting a new economic model in the Amazon will require both attracting new productive capabilities to the region and finding new, environmentally sustainable solutions to the region's connectivity challenge. The accompanying Growth Diagnostics exercise finds that both complexity traps and low connectivity (or remoteness) are the binding constraints to economic development in the region. Consequently, economic strategies must aim to acquire the missing capabilities required for a new economic model, as well as policies that can help the region overcome its remoteness.

Colombia's current bottom-up approach to economic policy may not be suitable to tackle the challenge in the Amazon of entering new productive sectors. Colombia's productive policies have evolved over the last decade from a cluster-based approach to an approach that prioritizes regional strategies. Productive policy has become progressively more place-based over time with key roles given to institutions[16] such as the Regional Commissions for Competitiveness

[16] Colombian productive development policy currently depends on a complex architecture of planning and implementing institutions that work in a variety of areas (e.g., export promotion, competitiveness reforms) and sectors (e.g., tourism, agriculture). DNP and CONPES have taken steps in the direction of coordinated strategy for Amazonian departments, such as the CONPES Document 4050/2021, which provides policy guidelines for protected areas, prioritizing actions to increase natural heritage and cultural conservation, increase connectivity in the areas, boost the

(OECD/UN/UNIDO 2019). The National Council of Economic and Social Policy (CONPES) currently establishes policy priorities for the 2016-2025 period, centered on prioritizing local comparative advantages and regional differentiation, as well as coordination between national, regional, and private sector entities. Although the movement towards a "bottom-up" or participatory approach emphasizing public-private collaboration is likely to be effective at the national level in improving the performance and accountability of national policy, the approach might not be suitable for the objectives of economic policy in the Amazon.

The economic challenge in the Amazon is the absence of a diversified economy. This challenge requires attracting new economic activities that do not currently exist. An approach that prioritizes actions based on the preferences of local actors may not yield new diversification, as the "absent" firms will, by design, not be consulted. Transforming the economic model from an extraction-based model to a capability-based approach will require local buy-in as to the target sectors for diversification. Yet, the approach must critically aim to learn from would-be investors what constrains their investment in the Amazonian departments to coordinate actions to address constraints and accelerate new investment and business creation. In the same way ProColombia aims to attract global investors in promising productive sectors to come to Colombia, so too must the economic units of Amazonian departmental governments create a ProCaqueta, ProPutumayo, and ProGuaviare that reaches to other parts of Colombia to attract investors to come to their department.

We recommend creating an Amazon Productive Development Taskforce to coordinate national, departmental, and local government entities – as well as private and non-government associations – to implement productive policies for the region. Given the need to shift productive development policy to a new economic model for the Amazon, the departments must diversify their economies, to do new things, which, by definition, they do not currently know how to do. This approach calls for a centralized taskforce under the National Department of Planning (DNP) that can coordinate and prioritize interventions in the Amazon to align policies to a new objective. The focus of the taskforce must be in coordinating new investment along with the technical and operational knowledge that success requires. The need to coordinate new knowhow and investment calls for a national approach to prioritize these departments and to coordinate new knowhow.

In effect, this process would aim to add a missing capability in the region: the absence of public-private coordination mechanisms for non-traditional industries. The process must include representatives of the federal and departmental governments with the capacity to mobilize resources and must try to speak with existing and non-existent investors to understand their considerations of the restriction of investing in the local area. This iterative dialogue should be aimed at analyzing the particularities of the sector, its business case and the restrictions that may prevent local investment. The process should aim to create a roadmap to identify possible barriers

effectiveness of the system of protected areas, and increase partnerships between productive sectors. Moreover, the national government – through the Ministry of Trade, Industry and Tourism (MINCIT) and the iNNpulsa agency, alongside local chambers of commerce – has promoted other coordinating initiatives such as the transversal Amazon Regional Pact (*Pacto Región Amazonía*) under DNP's National Development Plan and sectoral clusters in some of the Amazon departments such as the dairy cluster in Caquetá and the tourism cluster in Putumayo. Finally, the Development Programs with Territorial Focus (*Programas de Desarrollo con Enfoque Territorial* or PDET) have been implemented as part of the Peace Agreement's strategy to stabilize and transform the municipalities that have been most affected by violence in the context of the country's armed conflict, and currently include a variety of interventions in the Amazon departments. What is missing is a coordinating entity dedicated to economic development of the Amazonian region that can ensure economic policy is aligned with environmental priorities.

that could be inhibiting the emergence of promising industries, such as specific missing capabilities, public goods, or other market failures, and then propose effective solutions including inter-institutional coordination. The effort aims to create a true territorial plan: starting from a shared understanding of the need to add new capabilities to diversify into higher income activities; and coordinating the search around validating the feasibility of new activities and mobilize actions to address the constraints to achieving the productive potential of the region.

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Appendix 1: Additional Figures

Figure A.1: Industrial composition of employment in Colombia and the United States

Figure A.2: Complexity of Colombian departments in the last decade

	Economic Complexity								Ranking of Economic Complexity							
Department	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Valle del Cauca	1.63	1.64	1.85	1.89	1.78	1.61	1.63	1.93	3	4	2	2	3	4	4	1
Antioquia	2.11	1.90	1.69	1.83	1.79	2.00	1.86	1.87	1	2	3	3	2	2	2	2
Bogota	1.99	1.95	1.88	2.07	2.08	1.93	1.87	1.84	2	1	1	1	1	3	1	3
Risaralda	0.98	1.30	1.68	1.55	1.01	1.13	1.41	1.34	7	5	4	4	6	6	5	4
Cundinamarca	1.57	1.64	1.53	1.28	1.55	2.21	1.69	1.34	4	3	5	5	4	1	3	5
Guaviare	-1.00	-0.74	-0.64	-0.57	-0.76	-0.28	-0.60	-0.58	29	27	24	20	25	18	23	21
Putumayo	-0.87	-0.68	-0.72	-0.61	-0.57	-0.75	-0.99	-0.88	26	24	27	21	20	23	28	24
Amazonas	-1.26	-0.70	-1.08	-0.77	-0.90	-1.09	-1.59	-0.90	31	25	28	25	27	29	32	25
Caqueta	-0.95	-1.52	-1.48	-1.04	-1.14	-1.10	-0.95	-1.01	28	31	32	28	29	30	27	28
Vaupes	-1.20	-1.31	-1.41	-1.47	-1.19	-1.23	-1.36	-1.56	30	29	31	32	30	31	29	32

Figure A.3: Distance as a predictor of new industries and industries that are lost

	Nueva industria			Industria perdida		
	(1)	(2)	(3)	(4)	(5)	(6)
Distancia	-0.032***	-0.026***	-0.043***	0.036***	0.049***	0.125***
	(0.003)	(0.003)	(0.016)	(0.004)	(0.004)	(0.024)
VCR	-0.202***	-0.096	-0.061	0.009***	-0.006***	-0.008***
	(0.059)	(0.077)	(0.084)	(0.003)	(0.002)	(0.002)
Constante	0.277***	0.244***	0.322***	-0.041***	-0.049***	-0.315***
	(0.018)	(0.018)	(0.079)	(0.013)	(0.014)	(0.085)
Observaciones	4,327	4,303	4,303	3,425	3,419	3,419
R^2	0.029	0.222	0.236	0.042	0.365	0.396
EF industria	-	✓	✓	-	✓	✓
EF Departmento	-	-	✓	-	-	✓

Errores standard entre paréntesis
*** p<0.01, ** p<0.05, * p<0.1

Figure A.3 shows an empirical exercise using regressions to see the relationship between probability and our measure of distance in the Industry Space. In columns 1 to 3, the dependent variable measures new industries in 2018-19 (RCA>1), where the sample is conditioned on industries that were not present between 2012 and 2014 (defined as average RCA less than or equal to 1/4). In columns 4 and 5, the dependent variable measures industries that were lost in 2018-19 (RCA<0.25), where the sample is conditioned on industries that were not present between 2012 and 2014 (defined as average RCA greater than 1). The variable of interest is our measure of distance, which turns out to be statistically significant at 1% in all columns. In all the regressions we control for the distance variable in the Industry Space, and for the RCA of the industry, both variables measured in the base period. The difference in the estimates between columns is given by the use of different combinations of fixed effects. The estimation in column 1 indicates that a 100% increase in the distance of an industry from the capabilities of a department is associated with a 3.2% decrease in the probability of its appearance as a new industry. If we control for industry fixed effects (i.e., for unobservable industry characteristics, but fixed across departments), the estimate indicates that a 100% increase in distance is associated with a 2.6% lower probability. Finally, when we additionally control for department fixed effects (unobservable characteristics of the department, but fixed across industry), we find that the probability falls by 4.3%. To check the relevance of this estimate, it is informative to compare it with the unconditional probability of adding a new industry, which in the sample used is 11%. In other words, a 100% increase in the distance results—according to the estimate presented in column 3—in a 40% drop in the probability of adding an industry.

Figure A.3 also presents estimates of the loss of industries. The estimation in column 4 indicates that a 100% increase in the distance of an industry from the competencies of a department is associated with a 3.6% increase in the probability that the industry will disappear. In columns 5 and 6 we control for industry and industry and department fixed effects, respectively. The associated probabilities are 4.9% and 12.5%, respectively. If we compare these estimates with the unconditional probability of losing an industry, which is around 11%, we see that an increase in distance of 100% is associated with a higher probability of losing an industry, ranging from 33 to 110%. In short, our measure of distance turns out to be a strong predictor of the probability of adding new industries or industries that may be lost. This result highlights the importance of the position of each department in the Product Space.

Appendix 2: Colombian data sources for the study

In the case of Colombia, it is possible to estimate the presence of industries with different data sources. A first choice is between using export data or employment data. One difficulty in using export data in Colombia is that exports tend to be assigned to the geographic location where the firms are registered. Thus, for example, in the case of multi-plant companies, production could be wrongly attributed to where the company is registered and not where the economic activity is carried out. [17]

A second option is to use employment data, for which there are at least three sources of data, all with advantages and disadvantages. A first source of data in Colombia is the Great Integrated Household Survey (GEIH). The advantage of this survey is that it is applied to the entire country for the last decade, and with a relatively large sample size. A relevant characteristic for our work, compared to other data sources, is that formal and informal employment is recorded. A disadvantage for our objectives, and despite the sample size, is that it is difficult for these surveys to be representative and adequately capture employment in rural areas. For this reason, this survey for the Amazonian regions of Colombia is only representative of urban locations.

A third option with employment data is the PILA, which registers contributions to social security in Colombia. These data are the data source of the DATLAS project, which describes the economic complexity of cities and industries in Colombia, as well as opportunities for diversification. [18] One advantage of this data is its accuracy in recording workers and the industries in which they work. One drawback of these data is that they only report formal workers, whose proportions are particularly low in rural and remote locations. Additionally, the data available in DATLAS unfortunately does not include cities from the study regions, since they were determined to be too small urban places in terms of population.

A fourth source of data that was considered is the Dunn and Bradstreet (D&B) company register, which contains locations and basic characteristics such as industry, employees, and relationships with other firms, and covers many countries.[19] This last feature is one of the main advantages of D&B, since comparisons can be made across cities, countries, and industries. The disadvantage, which was empirically verified in the analysis of this report, is that representativeness problems can be found in places with high informality. Our analysis found the number of employees for the Amazon departments to be significantly lower than the number of employees reported in other data sources (Census and GEIH), and the distribution of employment across sectors was far from or expected from other data sources.

[17] This happens, for example, with the case of oil, which appears registered mainly in Bogotá, where the central offices of the oil companies are established.

[18] See http://datlascolombia.com/ . DATLAS is a diagnostic tool that companies, investors, and analysts in general can use to improve the productivity of departments, cities, and municipalities. It describes the geographic distribution of productive activities and employment in Colombia by department, metropolitan area, and municipality, and identifies exports and industries with the potential to increase economic complexity.

[19] Dunn and Bradstreet (D&B) is a proprietary database, regularly updated using signature records from each country. The likely data sources used in Colombia are a combination of the records of the different chambers and business associations in the country, as well as other official data sources. This information is not disclosed publicly by D&B.

Appendix 3: Formulas Used

Distance

To estimate the distance in the Industry Space, we must start by defining the technological proximity between industries, which we will call $\phi_{i,i'}$. Thus, the distance of an industry *i* in the department *d*, can be calculated as:

$$Distance_{d,i} = \frac{\sum_{i'}(1 - M_{d,i})\phi_{i,i'}}{\sum_{i'} \phi_{i,i'}}$$

where the subscripts *d* and *i* identify departments and industries, respectively. In this expression, $\varphi_{i,i'}$ is the Industry Space (where for each pair of industries the probability with which they tend to be observed co-located or co-produced is indicated), and where the vector M_{di} is a dichotomous indicator of the presence of industries in each department. This is an intuitive measure: the higher the proportion of industries related to an industry, the higher the density. If few of the related industries are present, or if those that are present are not technologically related, the density in the space will be low, and therefore the distance to existing capabilities of the department will be high, as it is far from what the department knows how to do.

Diversity and Ubiquity

As we have already mentioned, a region is capable of producing or providing a good or service when at least one registered firm is observed in the corresponding industrial code that identifies said good or service - our measure of Revealed Comparative Advantage (RCA). With this, we define as *Mcp* the matrix that indicates with the value 1 if it has the industrial code or product *p* in the place, and 0 if not. Diversity and ubiquity result from adding each row and column of this matrix, respectively. Formally, we define these indicators for industry or product *p* and location *c* as:

$$Diversity = k_{c,0} = \sum_{p} M_{cp}$$

$$Ubiquity = k_{p,0} = \sum_{c} M_{cp}$$

Economic Complexity Index

In order to generate an indicator of the productive capacities or knowhow accumulated in the place, or those required to produce a specific product, it is necessary to use the information on the ubiquity of the product to correct for the diversity they contain. With this information as a base, both the Product Complexity Index (PCI) and the Economic Complexity Index (ECI) of the place are estimated. In the case of products, it is necessary to calculate the average diversity of the places that make them, and the average ubiquity of the other products that those places are capable of generating. In the case of places, it is necessary to calculate the average ubiquity of the basket of goods and services that they are capable of making, and the average diversity of places capable of making those products. These successive adjustments allow us to correct and improve the measurement.

The fact that the diversity of places that exhibit RCA in natural resources is low, despite being low ubiquity activities, allows us to conclude that it is not a sophisticated industry, but rather that it tends to exist only in the places that have these endowments. Traditionally, this recursive process,

called the reflection method, starts from the measures of diversity and ubiquity, and is formally defined as:

$$k_{c,N} = \frac{1}{k_{c,0}} \sum_p M_{cp}\, k_{p,N-1} \quad (1)$$

$$k_{p,N} = \frac{1}{k_{p,0}} \sum_c M_{cp}\, k_{c,N-1} \quad (2)$$

Replacing (2) in (1), we get the following expression:

$$k_{c,N} = \sum_{c'} \widetilde{M}_{cc'}\, k_{c',N-2} \quad (3)$$

Where,

$$\widetilde{M}_{c,c'} = \sum_p \frac{M_{cp} M_{c'p}}{k_{c,0} k_{p,0}} \quad (4)$$

We can see that (3) is only satisfied when $k_{c,\,N} = k_{c,\,N-2} = 1$. This is the eigenvector of $\widetilde{M}_{c,c'}$ associated with the highest eigenvalue. Since this is a vector of 1s, it is not informative. Therefore, we look for the eigenvector with the second highest eigenvalue of the matrix $\widetilde{M}_{c,c'}$, which we define as the Economic Complexity Index. This captures the greatest amount of information from the system of equations, and it is with this that we measure economic complexity. Similarly, calculating the average diversity of the countries that make a specific product, and the average ubiquity of the other products that those countries produce, we have the Product Complexity Index that follows a process similar to the one above:

$$\widetilde{M}_{p,p'} = \sum_p \frac{M_{cp} M_{cp'}}{k_{c,0} k_{p,0}}$$

Complexity Opportunity Gain and Strategic Value of Industries

We can combine the measures of complexity and the position in the Industry Space in two measures. A first measure is the complexity opportunity gain (COG), which summarizes the location of industries in the Industry Space, granting different ratings to each depending on their level of complexity. We formally define:

$$COG_d = \sum_i (1 - distance_{d,i})(1 - M_{d,i}) ICI_i$$

Where ICI_i is the complexity index of each industry. We can also calculate an indicator for each department-industry pair that tells us how much the position in the Industry Space improves by adding a particular industry. Thus, we define,

$$Strategic\ Value = SV_{d,i} = \frac{\sum_{i'} (1 - M_{d,i}) \phi_{i,i'}}{\sum_{i'} \phi_{i,i'}} (1 - M_{d,i'}) COG_{p'}$$