Panama beyond the Canal:
Using technological proximities to identify opportunities for productive diversification

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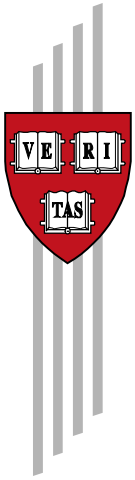

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Executive summary

In recent years, Panama has become one of the fastest growing economies in the world. Leveraging on the activities of the Panama Canal, the country has doubled its income per capita over the last decade. A modern sector specialized in logistics, financial services, communications and trade has spurred economic growth and provided a consistent foreign exchange surplus in the balance of services. Growth in the service sector has, in turn, demanded considerable investment in construction, the leading growing sector in Panama, which has tripled its share within gross domestic product (GDP) in ten years. Private non-residential construction and large public infrastructure projects such as the expansion of the Canal, *Tocumen* airport, and the Metro of Panama City account for most of the boom. Another pillar of growth over the acceleration period has been trade, namely leveraging on Panama´s excellent trade infrastructure to channel merchandise from Asia to Central America and the Caribbean. A recently-created vibrant air-traffic hub in Panama City features as another factor in the country's economic boom.

Growth has decelerated recently, mostly as a consequence of a slowdown in construction, and a deterioration of trade volumes going through Colón Free Trade Zone, in particular those en route to Venezuela and Colombia (Hausmann, Santos and Obach, 2016).[1] Non-residential private investment in construction cannot indefinitely grow at a faster rate than the economic sectors it caters to. Once the stock of basic infrastructure needed for the expansion of the service sector is in place, construction will decrease in relative importance and decelerate. A continued growth spurt at the observed pace via public infrastructure would require an ongoing portfolio of mega projects in execution. The key challenge for Panama is to identify what drivers of growth will take over as the spearheads of the economy once the current boom subsides.

The expansion of the Canal opens a great opportunity for Panama to begin considering diversification into more complex economic activities, while at the same time expanding its sources of foreign exchange. Given that not all of the activities have the same likelihood of succeeding in every place, it essential to evaluate the skills that the economy has developed around the services surrounding the Canal, and to identify higher value-added activities (goods and services) where these skills can be redeployed.

High levels of income inequality remain one of Panama's most striking features. The construction boom has created a vibrant labor market for non-skilled workers, encouraging a significant migration from low-productivity agriculture in rural environments to construction sites in urban areas. This has been the main driver of

[1] In the case of Venezuela, decreased trade volumes resulted from the collapse of imports amidst a foreign-exchange crisis. The case of Colombia is different, as the country unilaterally decided to impose an additional 10% tariff on textiles and footwear coming from the Colón Free Zone. In February 2016 Panama sought arbitration from a World Trade Organization Expert Panel. The issue remains unresolved.

poverty and income inequality reduction that has occurred over the previous decade. Nevertheless, Panama remains among the top five most unequal countries in the world.[2] Now that the construction boom is decelerating, and a modern service sector demanding high skills is expected to carry the torch, there are risks of losing some of the social progress achieved thus far. These dynamics only highlight the need to promote more complex economic activities across all provinces of Panama, in order to re-distribute growth and make it more inclusive. This report is aimed at evaluating what skills Panama has developed at national and sub-national levels, and, based on those skills, identifying more complex activities that lie nearby in terms of productive capabilities.

We know that a consistent feature of development, both across and within countries, is that richer places tend to produce a larger variety of goods, that on average very few countries are able to make. Alternatively, relatively poorer countries and regions tend to produce fewer goods, that on average many places are able to make (Hidalgo, Klinger, Barabasi, and Hausmann, 2007). This counters conventional wisdom, which states that societies should specialize in a narrow set of activities in which they have competitive advantages.

The progressive accumulation of productive capacities and know-how, which allows places to produce a larger variety of goods competitively, does provide an account of structural transformation that is more consistent with the dynamics we observe in the evolution of countries. The premise behind this theory, originally presented by Hausmann and Hidalgo (2009), is based on the idea that capabilities and know-how are not observable, but are signaled by the number and nature of the products that a place is able to produce competitively. Regions lacking many capacities will only be able to assemble a relatively modest number of activities (little variety), which will also be feasible in many other places (higher ubiquity), and therefore will not bring much value-added. Countries that accumulate many capacities will be able to amass a relatively large number of activities (large variety), which will only be replicable in a small number of places (lower ubiquity). As they expand their stock of productive capacities, developing regions diversify their productive mix into a larger number of products which can only be produced in fewer places.

In this context, the process of diversification poses a chicken-and-egg dilemma: Nobody wants to acquire skills for an industry that does not exist, and as long as those skills remain absent, it is unlikely the industry will develop. Hidalgo and Hausmann (2009) have provided insights on how societies have come around this dilemma: Countries do not diversify randomly, rather, they spread towards activities that demand capabilities similar to those they already possess. Current productive capacities and know-how can be recombined and redeployed into new, "adjacent," economic activities.

[2] By 2012 the GINI coefficient in Panama was 0.52, the fourth highest in the world. Source: World Development Indicators, World Bank.

This paper is aimed at identifying productive capabilities already in place in Panama, as signaled by the variety and ubiquity of products that the country and its provinces are already able to produce and export competitively. The study then goes on to detecting opportunities for productive diversification based on technological proximity of products or industries.

We define the values of our proximity matrix by estimating the conditional probabilities for a country to be competitive in one product, given that it is competitive in another product. The idea is that if two sectors require a similar set of capabilities, the fact that one of them already exists in a place suggests a high likelihood for competitiveness on the other.

We estimate proximity using three different methodologies, and then pick the most appropriate one according to its capacity to predict the evolution of employment and the appearance or disappearance of sectors. Our first proximity matrix between pairs of products is estimated by their tendency to co-locate. This approach was first used by Hausmann et al (2014), as applied to the tendency of pairs of exportable goods to co-originate from the same country. The second approach we use estimates proximity for a pair of sectors by the relative frequency in labor flows between these sectors. That is the principle behind the proximity matrix derived for Sweden (see Neffke and Henning, 2013; Neffke, Otto and Weyh, 2016), as well as the Colombian and Mexican Atlases of Economic Complexity[3]. Unfortunately, we were unable to obtain data on labor flows from the Social Security office in Panama (*Caja del Seguro Social*). Working under the reasonable assumption that technological proximity between sectors is not country-specific, we were able to convert the Swedish labor-flows-based proximity matrix to its Panamanian correspondence. The third approaches for estimating the proximity matrix is based on the similarity of the vector of occupations or tasks of the labor force in each of the sectors. The Brazilian sub-national complexity tool "*Dataviva*" follows this approach[4]. In the case of Panama, the population census captures information on both the economic activity and occupations for each of the surveyed individuals in the labor force.[5]

In the case of Panama, the proximity-matrix built on all three criteria had predictive power, but the one based on occupation similarities between pairs of industries proved to be the most useful. We first apply this analysis to Panamanian exports of goods at the national level. At the national level, any assessment based on Panama's exports must first be corrected for re-exporting. Using data provided by the National Customs Authority of Panama (ANA, for its Spanish acronym), we were able to pin down true Panamanian exports of goods. The picture that emerges reveals a very low number, around 1% of GDP, mostly made up of low-complexity agricultural and mining products.

[3] http://datlascolombia.com and http://datos.complejidad.gob.mx, respectively.
[4] http://dataviva.info
[5] Given that the identification of productive capabilities depends on the level of employment, some significant changes might have occurred since the last population census (2010).

Using occupation-similarities, we identified opportunities for diversification in exportable goods at the national level. Given its very basic structure of exportable goods, our analysis of potential diversification opportunities for Panama identified more downstream products within the Food and Vegetables category as the most attractive opportunities. The list comprises products used by the printing industry (supply materials for newspaper, journals and magazines), paper and paperboard products (paperboard labels, toilet paper, cartons). Beverages also ranked well (water, beer, other fermented beverages), as did other preparations of cereals, flour, and starch (bakery products, malt, cereals). A more strategic sector that showed up, one that demands covering longer distances in terms of capabilities, was Chemicals and Plastics. Dyes, Paints and Inks (mostly paint and varnishes), Plastics (polyamides, plastic sheets, plastic tubes and fittings, packing lids) and Soaps, Waxes and Paints (lubricants, cleaning products, soap) were the sections within this sector that came out with more potential.

Our approach in exportable goods provides a roadmap for identifying potential opportunities in exportable goods, but overlooks the fact that Panama's strongest capabilities and know-how are to be found in the exportable services sector. To address that, we relied on more granular data of observable capacities used by different sectors, as reported in population and economic censuses. We have picked three illustrative provinces that have very distinct characteristics that justify different approaches to export diversification: Colón, Darién, and Chiriquí.[6] These have been chosen as representative examples that demand different approaches from an industrial policy standpoint.

Colón is a relatively developed region, and, as such, exhibits a significant variety of industries, which on average are only found in few Panamanian provinces. Interesting opportunities are relatively close, which could, in turn, help expand the province's complexity by making even further opportunities accessible. The potential for diversification in Colón shows up in modern services such as logistics, as well as a variety of commerce and trade services. Surprisingly, we find relevant manufacturing sectors at a nearby distance, such as plastics (plates, sheets, vases, containers), foodstuffs (beer, preparations of meat and fish), and paper (newspapers, journal, periodicals, cartons).

Eastern Panama seems to have the least complex and connected industrial structure in the country. As such, the most promising sectors are still at a significant distance in terms of capabilities. Darién is a case in point. Some of the opportunities that come up in our analysis, such as education and health services, probably reflect the relative shortcomings of the State footprint in this poorest of Panama's provinces. The most interesting sectors such as manufacture of paper products (newsprint, paper, dairies and other edibles) and construction materials (cement) should be considered strategic bets, and will require significant State effort to ignite. Other

[6] While we explore these three cases at length in the paper, visualizations and tables identifying opportunities for productive diversification in the remaining provinces in Panama are in the Appendix.

sectors associated with the tourism industry (ecotourism) and logistic services related to transport of goods are more feasible, if limited in complexity and scope.

Somewhere between Colón and Darién lies Chiriquí. Its diversification opportunities are not as abundant and nearby as the former, and yet not as steep as the latter. Several medium-high complexity manufacturing goods are at relatively feasible distance, mostly related to minerals (metal press, forged metal, primary products derived from iron, coke ovens), construction materials (cement, lime, cast), and goods derived from wood (carpentry, musical instruments). Also, the presence of several activities in wholesale commerce and transport logistics suggests that Chiriquí could leverage its position as a bordering province to the rest of Central America to develop the sectors that are already relatively close to its productive structure.

These results are not meant to be considered as a mandate, nor as the result of a process aimed at picking winners in the lottery of industrial policy. We only provide a roadmap to guide the search for strategic sectors that could potentially help Panama in diversifying its competitive exports of goods and services. These lists only point to potential sectors demanding capabilities that, to a varying extent, are already on site for each of the provinces. A more in-depth industry analysis should ensue, in order to establish market potential, missing capabilities, and what can be done to ease their supply in an efficient way.

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1. Introduction

Rich countries diversify, they do not specialize. It is a consistent pattern that, as countries or communities develop, their productive structures tend to spread into increasingly singular economic activities. In Figure 1, we visualize the diversity and average ubiquity of the export baskets of different countries, along with their level of economic development. The salient feature of this visualization is that, on average, richer countries lay on the high-diversity, low-ubiquity end of the graph, while poorer countries are found on the low-diversity, high-ubiquity quadrant. Rich countries are able to manufacture and export a large number of goods, which on average a smaller number of countries are able to make. Inversely, poor countries tend to produce and export relatively fewer goods, which on average many other countries can make.

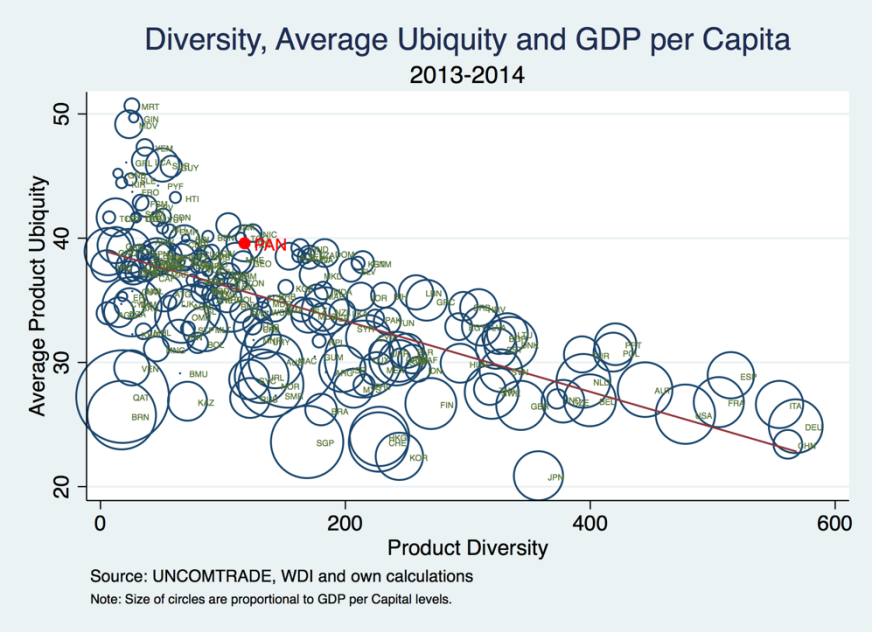

Figure 1. Diversity, Average Ubiquity and GDP per Capita (2013-2014)

These patterns are also evident in subnational industrial structures. Most developed cities or regions diversify into relatively exceptional economic sectors, while the least developed remain concentrated into fewer, more ubiquitous activities. Panama is no exception. Figure 2 and Figure 3 illustrate this dynamic using the level of average industrial ubiquity and the level of occupational diversity[7] per location at the Province and at the District levels, respectively. Again, richer areas of the country move towards the bottom-right end of the visualization, while poorer regions concentrate around the upper-left area.

[7] The relevance of occupation-based metrics in discussing subnational complexity patterns will be explained below.

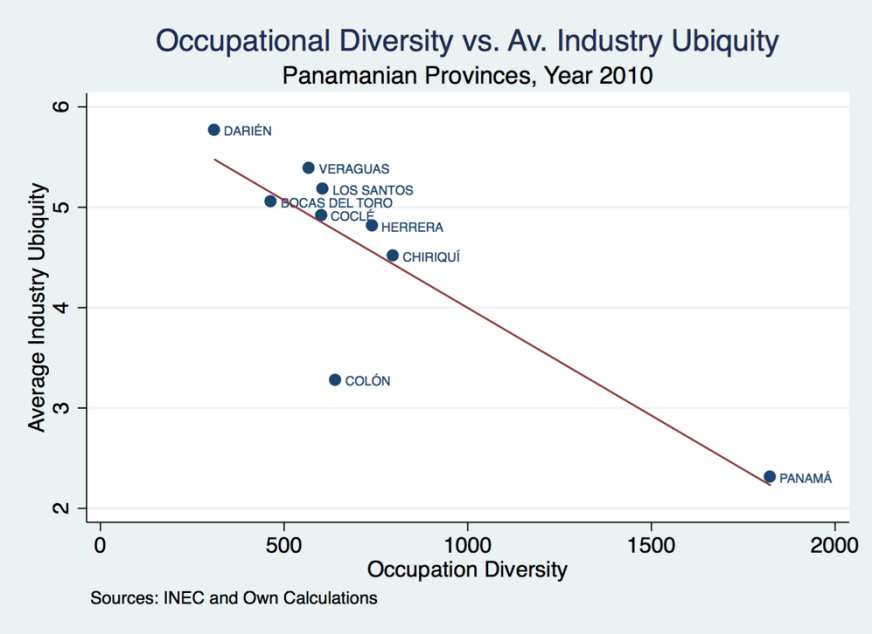

Figure 2. Occupational Diversity vs. Average Industry Ubiquity (Panamanian Provinces, 2010)

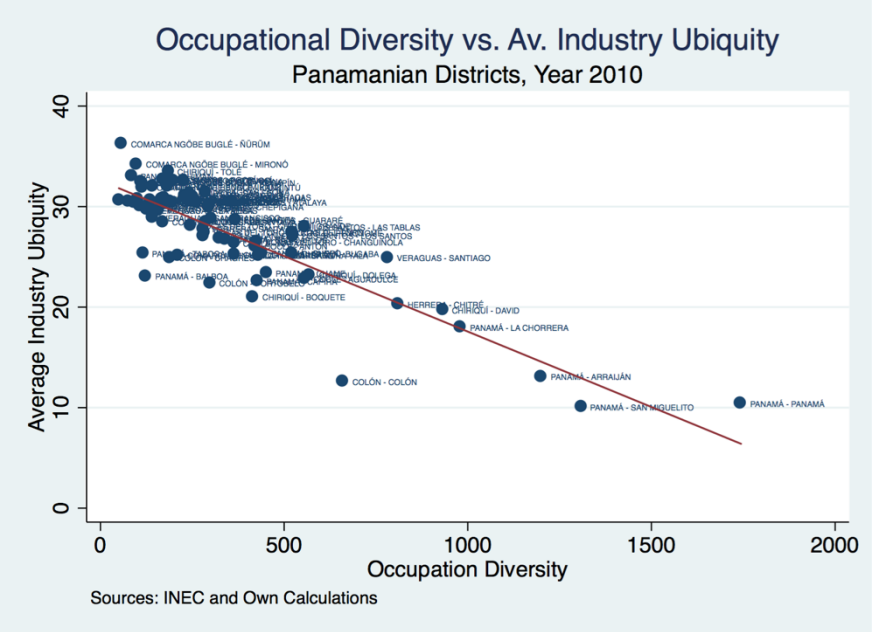

Figure 3. Occupational Diversity vs. Average Industry Ubiquity (Panamanian Districts, 2010)

This correlation counters the usual narrative stemming from economic literature, which argues that societies should specialize in a relatively narrow set of activities where they can amass competitive advantages. Our contention is that the progressive accumulation of productive capacities and know-how are paths to economic development;[8] an "Economic Complexity" perspective based on the following reasoning :

[8] Hausmann and Hidalgo (2009).

- Productive capacities and pieces of tacit know-how, which are not perfectly observable, are combined in the development of different economic sectors.
- Regions that lack many capacities will only be able to assemble a relatively modest number of activities, which will also be feasible in many other regions.
- Regions that accumulate many capacities will be able to assemble a relatively large number of activities, many of which will only be replicable in a very small group of other regions.
- As they expand their stock of productive capacities, developing regions become able to diversify their productive mix into less common activities.

From this perspective, the metrics of productive diversity and average ubiquity of a region's productive mix are indicative of its level of economic development. The Economic Complexity Index (ECI) balances these concepts iteratively to correct for the noise in one with the average values of the other.[9] Figure 4 and Figure 5 show the countries with the lowest and highest levels of economic complexity in 2013-2014, respectively.

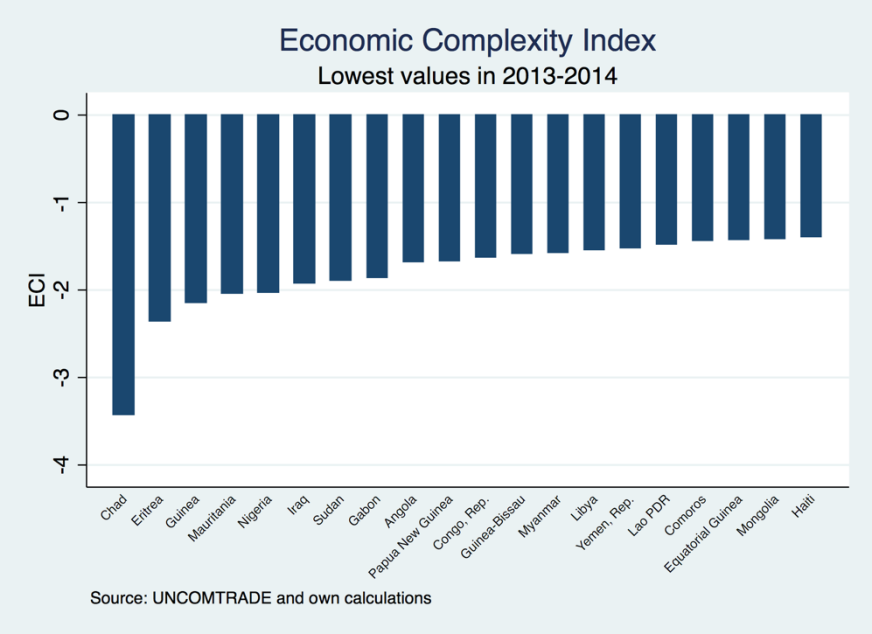

Figure 4. Economic Complexity Index (Lowest values in 2013-2014)

[9] The relationship between ECI, diversity and average ubiquity is not 1-to-1 precisely because deviations in one are corrected for in the other**.** For example, Japan is much less diversified than other countries at the top of the ECI distribution, but since its export basket is shaped by very low ubiquity products, it ends up being the country with the highest ECI value in our distribution.

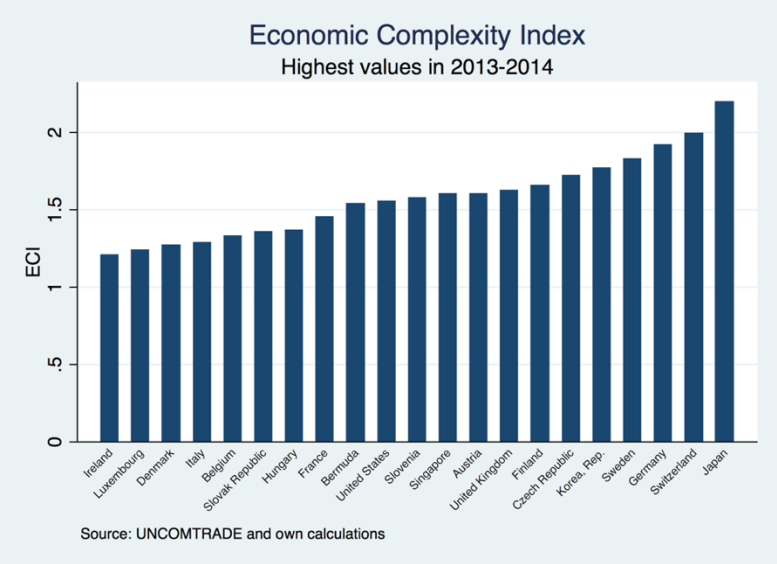

Figure 5. Economic Complexity Index (Highest values in 2013-2014)

In the context of country-level export patterns, ECI values have been found to be excellent predictors of economic activity and future economic growth[10]. Figure 6 shows the strong relationship between ECI between 2013-2014 and GDP per capita in the same period. From this visualization, we can estimate that GDP per capita in Panama is about twice the amount expected, given the complexity of its current export structure of goods.[11]

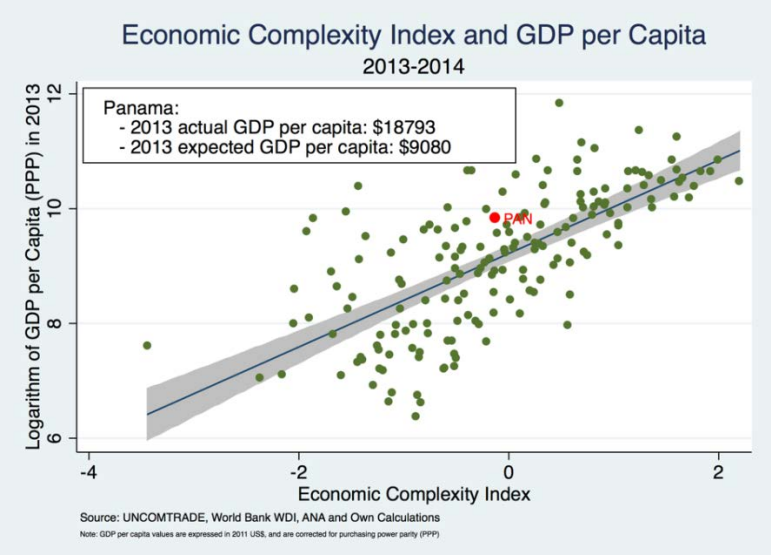

Figure 6. Economic Complexity Index and GDP per Capita (2013-2014)

[10] See http://atlas.cid.harvard.edu/book

[11] This study blends a Panama-specific dataset, which guarantees that only truly Panamanian exports are added, with the standard UNCOMTRADE data of exports per product by country.

ECI values are also strong predictors of subnational income levels in Panama. Figure 7 shows the association between monthly-declared income per capita[12] and the occupation-based ECI[13].

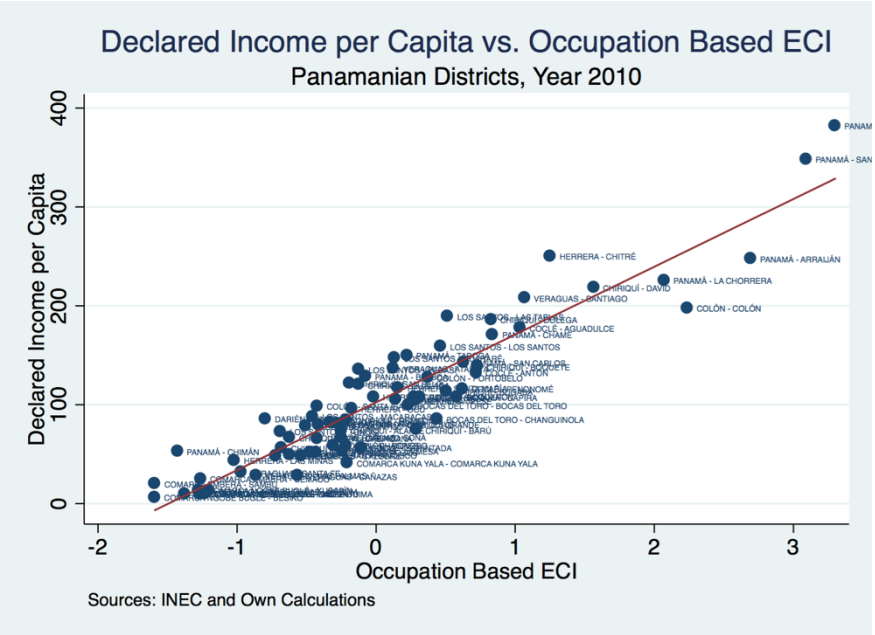

Figure 7. Declared Income per Capita vs. Occupation Based ECI (Panamanian Districts, 2010)

The process of expansion of the productive capacities in a society does not occur at random. Coordination failures prevent individuals from mastering specialized skills that are not demanded by their economies. The incentives for the organic accumulation of productive capacities are endogenous to the capacities that are already available, and depend on how these can be recombined into new, "adjacent possible," economic activities. The degree of "technological proximity" between pairs of products or industries can be estimated in a number of ways.

In an international trade context, these proximities have been estimated as the tendency for the exports of different pairs of goods to co-locate in the same countries of origin.[14] These estimates serve as the basis for the Product Space, a network visualization that shows how closely connected each product is to those other products to which it tends to co-locate to the most. Figure 8 shows this structure, which reveals a clear tendency for aggregate sectors to cluster together.

[12] Monthly incomes might seem surprisingly low. This is because data extracted from the population census is affected by a significant number of individuals who do not report their incomes, therefore lowering per capita observed or reported incomes with regards to standard expectations.

[13] The use of occupation-based complexity metrics for the subnational case will be discussed in section four and in the technical appendix.

[14] See http://atlas.cid.harvard.edu/book

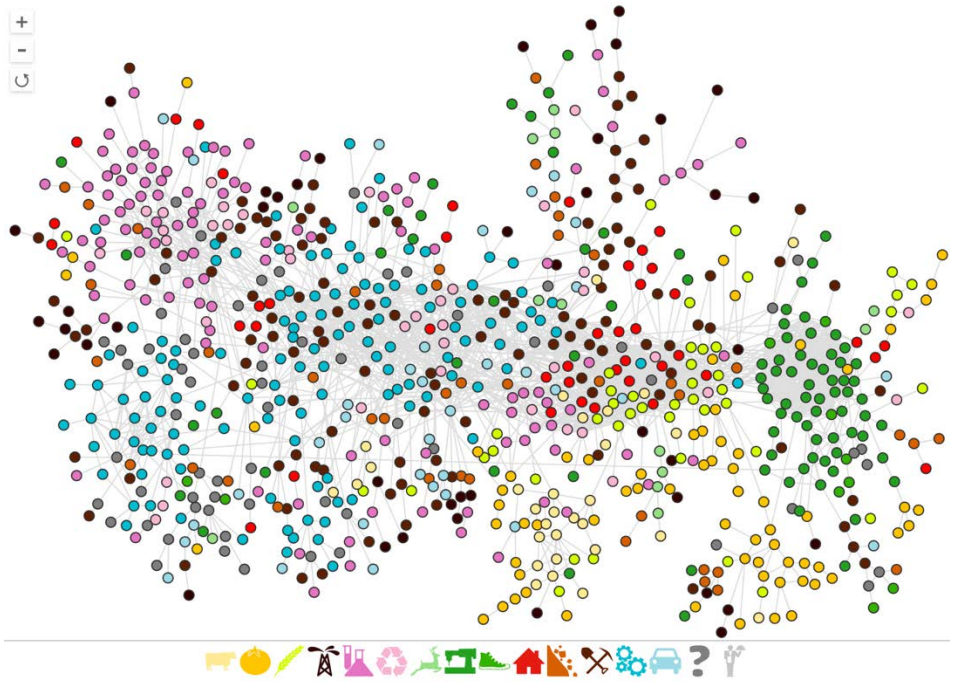

Figure 8 - The International Product Space

Source: atlas.cid.harvard.edu

It has been shown that, over time, countries tend to diversify their exports into products that are absent but relatively proximate from a technology standpoint (from a Product Space perspective) to their current export structure.[15] The "Density" metric of a country's export basket around an absent product associates positively and robustly with the chances of the exports of such product to appear and grow.

This metric is a useful tool for assessing the export diversification opportunities of countries. The sense of *feasibility* has to be balanced with variables that capture a sense of *opportunity* in adding a product to a country's export basket. From an economic complexity perspective, this can be measured by two indices:

- Product Complexity Index (PCI): The analogous version of the ECI as applied to products.
- Complexity Outlook Gain (COG): Measures how the connectivity of the country's export basket in the Product Space improves by diversifying into a product.[16]

[15] See Implied Comparative Advantage by Hausmann, Hidalgo, Yildirim and Stock (2014)

[16] A country-specific measure of how well positioned a country is in the international Product Space, based on its aggregate distance to all missing products in its export basket. More peripheral export structures will have worse COG than more central ones. The mathematics behind these indices are discussed in the Technical Appendix.

The purpose of this paper is to look for evidence from a diverse array of datasets to address the question of what productive diversification opportunities are available for Panama, its 12 provinces and 75 districts. More specifically, the paper addresses the following topics:

1. Measuring Panama's *true* exports of goods without accounting for re-exports.
2. Assessing Panama's position in the Product Space and determining its strategic position for export diversification.
3. Visualizing and discussing export diversification opportunities according to three strategic approaches.
4. Determining the best possible approach to measuring the technological proximity between pairs of industries within Panama, in terms of these approaches' capacity to predict future growth and appearance.
5. Assessing the strategic position for industrial diversification of all provinces and districts within Panama.
6. Illustrating the process of identifying and exploring productive diversification opportunities at the sub-national level, for three Panamanian provinces of different strategic situation.

The paper is structured as follows: **Section 2. Panama's Export Diversification Opportunities**, discusses Panama's current export structure and its diversification opportunities. **Section 3. Measuring technological similarity between economic sectors**, addresses what the best approach is to measuring industrial technological similarity within Panama by examining a number of plausible and measurable alternatives. **Section 4. Regional industrial diversification opportunities**, assesses the measurement of industrial diversification opportunities and presents relevant analysis for three Panamanian provinces. General conclusions and recommendations are presented in **Section 5. Conclusions and policy recommendations**.

2. Panama's Export Diversification Opportunities

2.1. Panama's true exports of goods in 2013 and 2014

Acccording to UNComtrade,[17] the value of goods exports originating in Panama between 2013 and 2014 amount to $12.5 billion, in a rather diversified array. However, after discounting the imports for each product,[18] the sum of positive net exports by product shrinks to about $3.4 billion, and they concentrate around a much more constrained number of products. This drastic difference is explained by the preponderance that re-exporting activities have within the Panamanian economy.[19]

A fair assessment of Panama's exports of goods should only take into account customs registers of transactions that can be linked to a domestic source through a certificate of origin. The National Customs Authority of Panama (ANA, for its Spanish acronym) was kind enough to provide a joint dataset of Panamanian export transactions for 2013-2014, which registers the country of origin of the exported product. Hence, our definition of Panama's true exports of goods for this period is the sum, by product, of all transactions that are registered as originating either in Panama or in especially identified regions within Panama (i.e. Colón Free Zone).

The picture obtained from analyzing this data is quite different from one based on the UNComtrade-reported diversified exports figure mentioned above ($12.5 billion). The total value of exports of goods for 2013-2014 as calculated from ANA's dataset amounts to $1.1 billion. Figure 9, Figure 10 and Figure 11 show how these reduced exports of goods concentrate mostly around agricultural and mining products of low or mid-low complexity.

A further inspection of this data allows us to identify specific products that shape the bulk of the country's exports within each complexity block (Figure 12 to Figure 15).[20] At the low complexity level, bananas and gold dominate exports of goods. At the mid-low complexity level, exports of goods are mostly ethyl alcohols, meats and cheese, and paper-related products. Paper-related products also make up the bulk of the largest exports of mid-high complexity goods, with the addition of flat-rolled iron. Finally, paints, inks and aldehydes account for most exports of high complexity products.

[17] As reported in the Atlas of Economic Complexity – see http://atlas.cid.harvard.edu

[18] This study refers to specific product-to-product categories in the HS classification system, revision 3 (1992) at 4 digits.

[19] Re-exporting activities are defined as the temporary importing of goods for subsequent export after minor domestic value is added.

[20] The following bar graphs only show export products in which Panama show a Relative Comparative Advantage index above the unit. See Balassa (1964) for a justification of this metric for the purpose of assessing a country's comparative advantage.

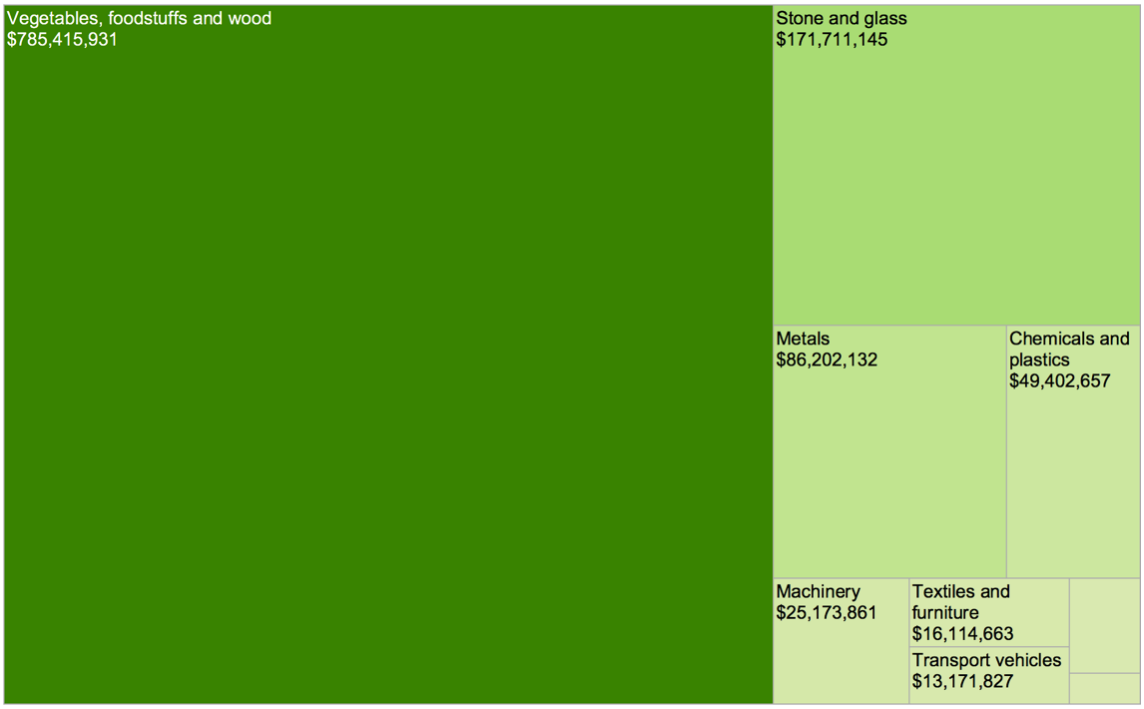

Figure 9. Exports of goods by product section

Source: ANA and own Calculations

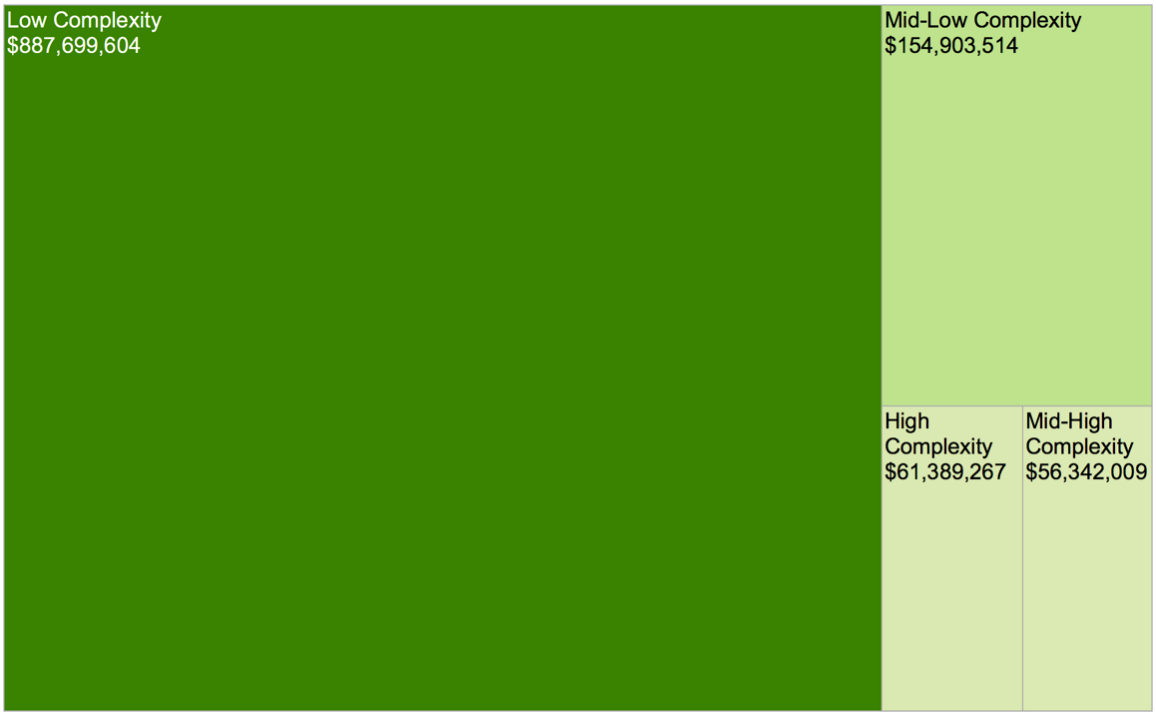

Figure 10. Exports of goods by economic complexity group

Source: ANA and own Calculations

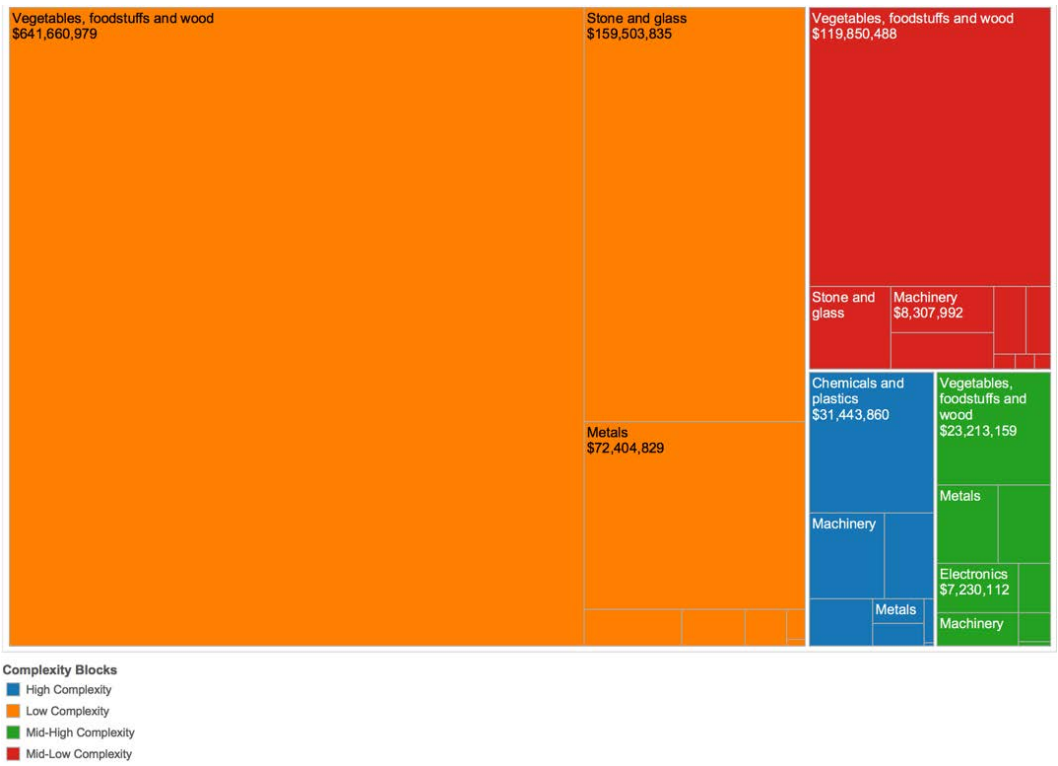

Figure 11. Exports of goods by product section and economic complexity group

Source: ANA and own Calculations

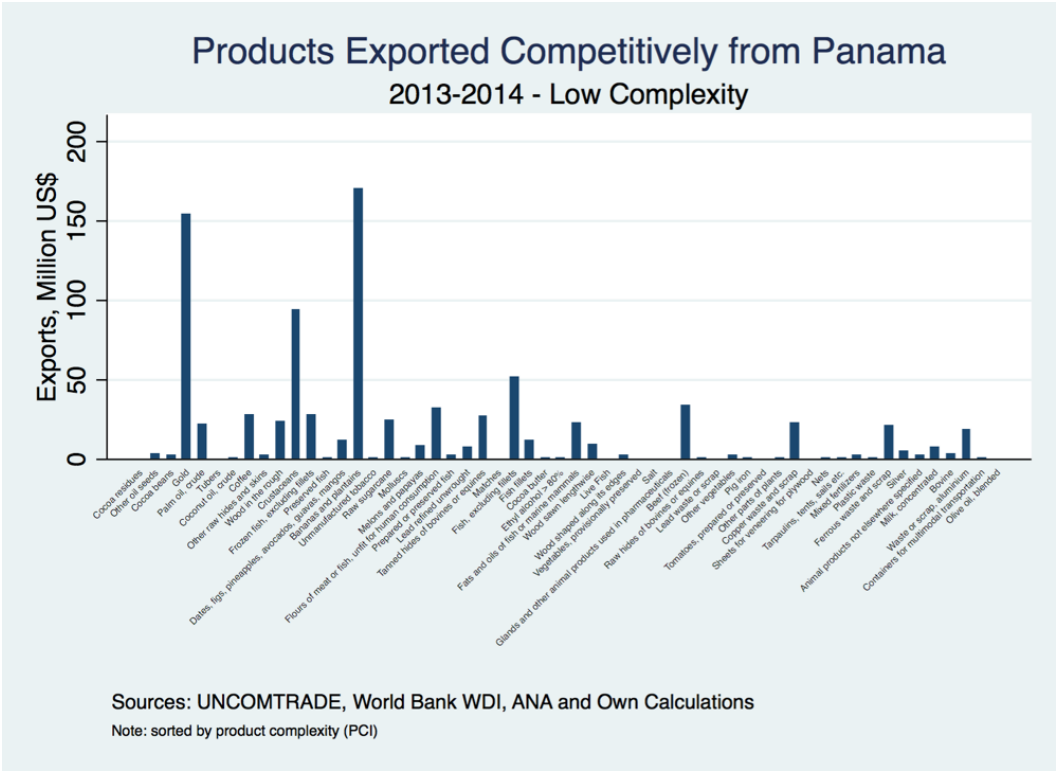

Figure 12. Products Exported Competitively from Panama (2013-2014 - Low Complexity)

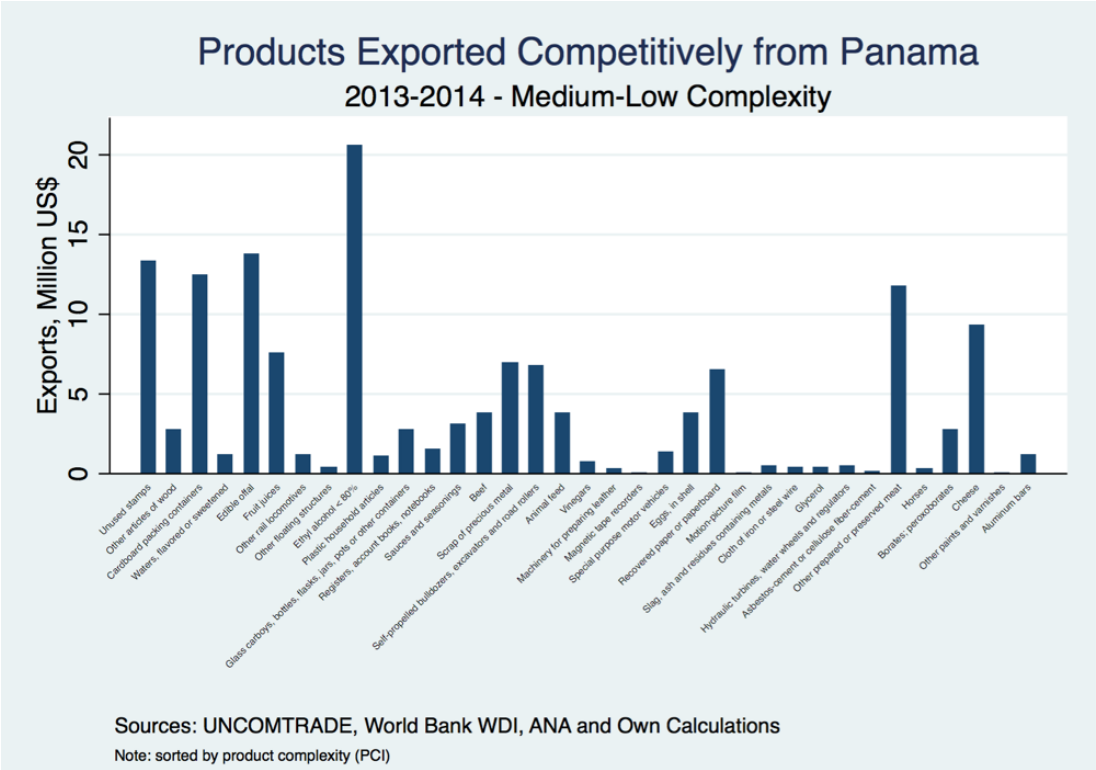

Figure 13. Products Exported Competitively from Panama (2013-2014 - Medium-Low Complexity)

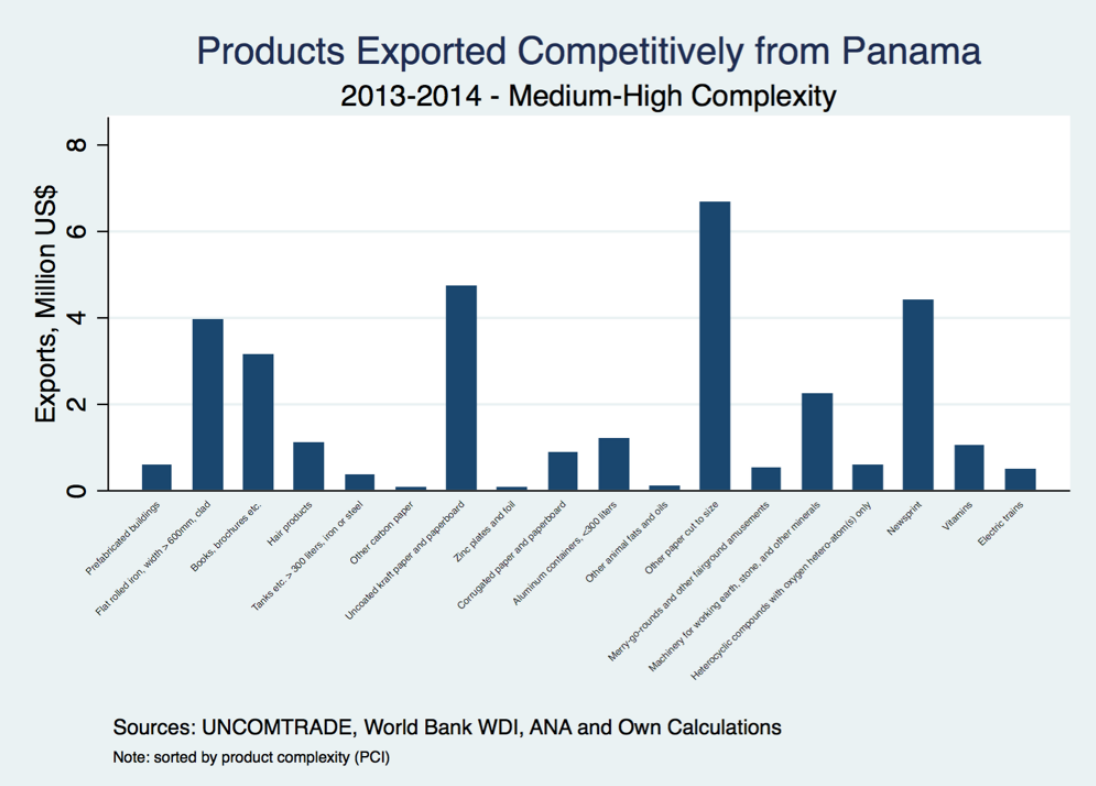

Figure 14. Products Exported Competitively from Panama (2013-2014 - Medium-High Complexity)

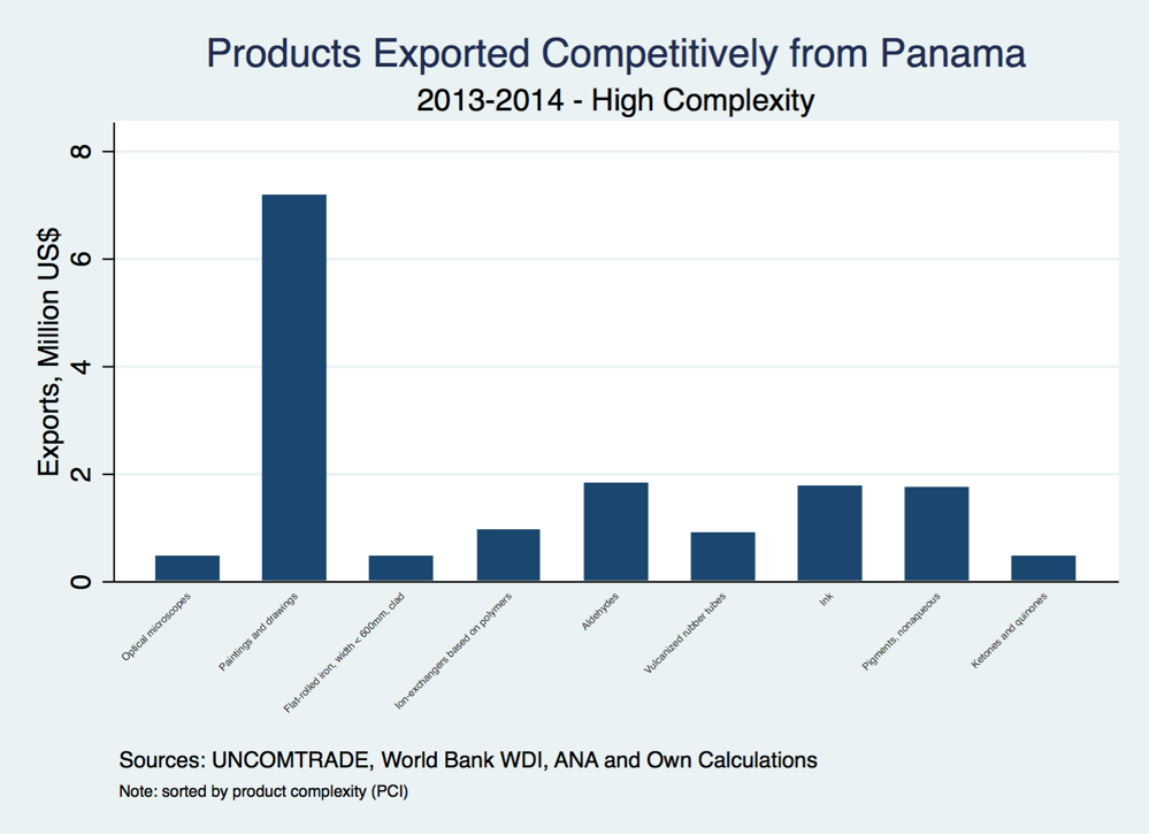

Figure 15. Products Exported Competitively from Panama (2013-2014 - High Complexity)

2.2. Panama's Strategic Approach to Export Diversification

While there is no automatic way of visualizing this data in the Product Space, it is possible to plot the UNComtrade data and impose special constraints to gauge the competitiveness of Panamanian exports. A country is considered to have a comparative advantage in a product if its share within the country's export basket is larger than the share of the product in worldwide exports. This index, known as Relative Comparative Advantage (RCA), would hence need to be larger than the unit. In studying the location of Panamanian exports of goods in the Product Space based on UNComtrade data, we use an RCA threshold of 3. Figure 16 shows how the only area of the Product Space that is robustly populated by Panamanian exports is the agriculture cluster. While this does not mean that Panama is only competitive in these products, it does underscore the point that Panama's export structure is relatively peripheral and concentrated in low-complexity products.

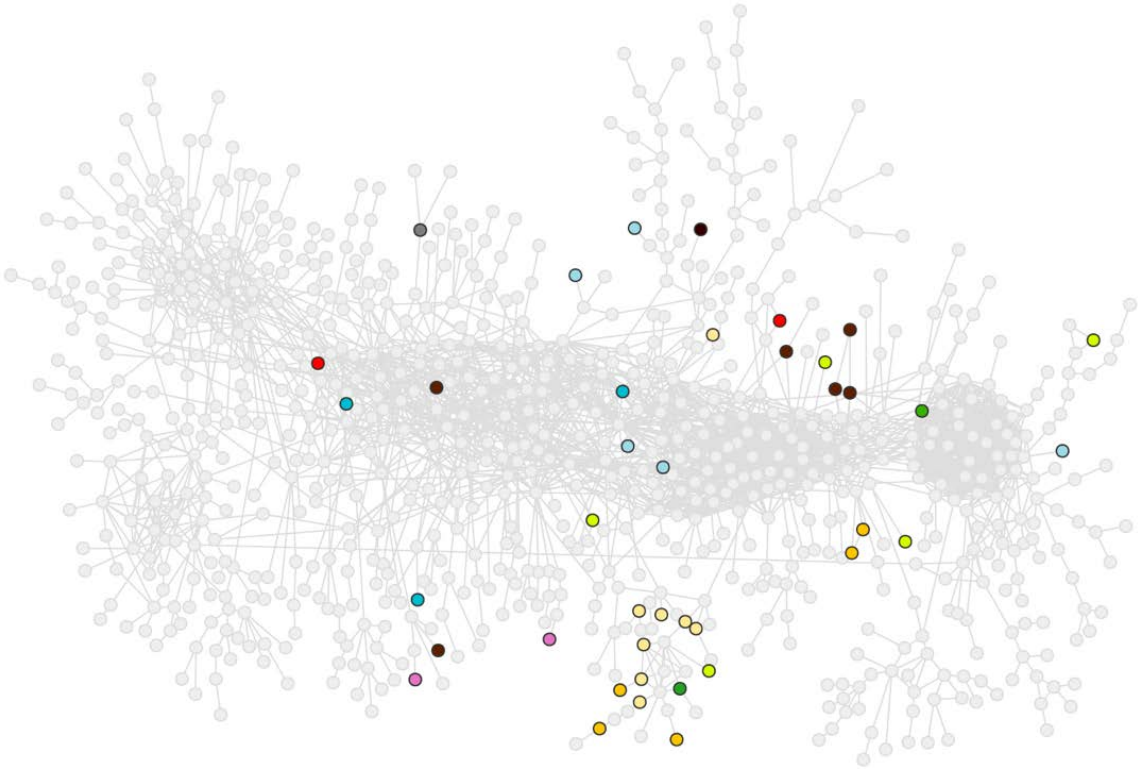

Figure 16. Panama's position in the Product Space (RCA > 3)

Source: atlas.cid.harvard.edu

Using the ANA data, products with RCA below the unit can be visualized according to their distance to Panama's current export structure, their COG and their Complexity Block. Figure 17 shows these three metrics for all "missing products" in Panama (products with a RCA lower than one). The first apparent finding is that the added opportunity of each missing product is, on average, higher for products that are more distant from Panama's current export structure. This is a common feature of countries with relatively peripheral export structures. However, the notable vertical dispersion observed at different distances suggests that significant optimization opportunities arise when assessing which products should be considered.

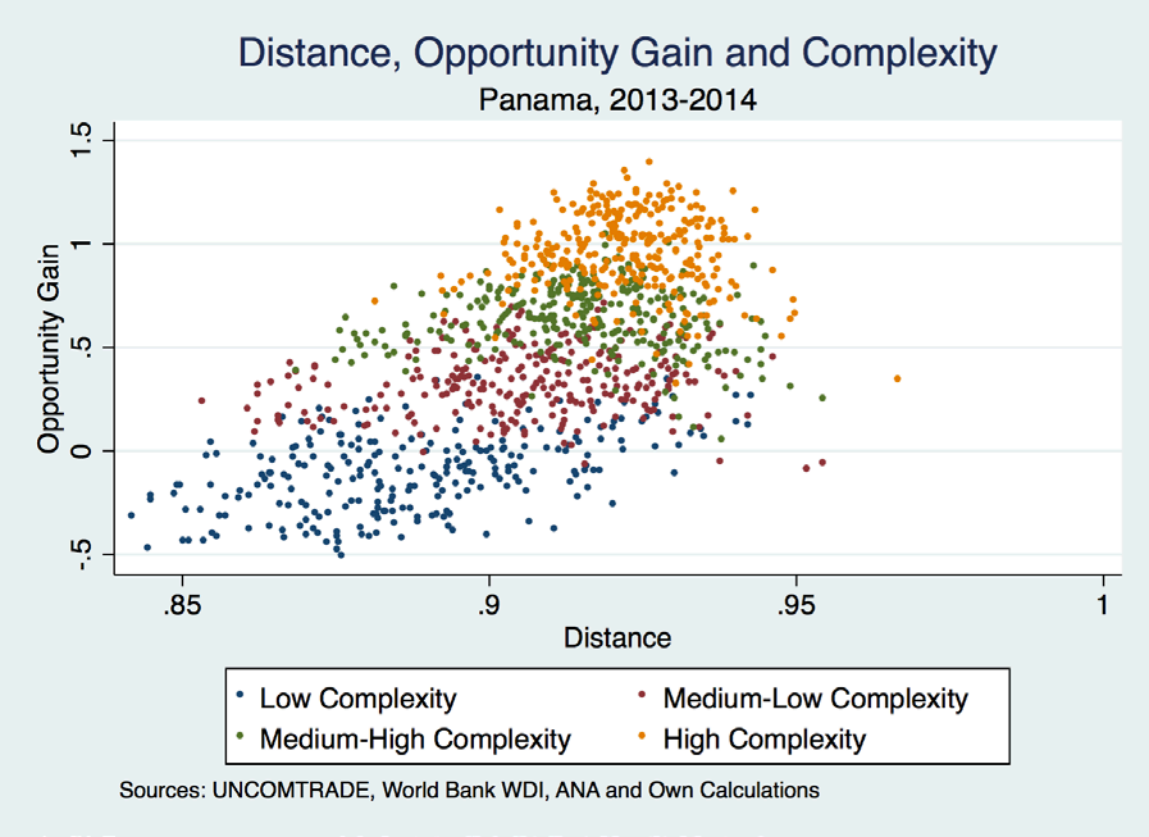

Figure 17. Distance, Opportunity Gain and Complexity (Panama, 2013-2014)

To make sense of all this data, we perform exercises of aggregation and decomposition. Figure 18 and Figure 19 show what product sections and sectors[21] average out missing products in ways that suggest their strategic position.

Figure 18 suggests some optimal paths to diversification. Products in the Vegetables, Foodstuffs and Wood section are closer and more strategic than those in the Minerals section. The same can be observed when comparing Transport Vehicles to Textiles and Furniture; when comparing Chemicals and Plastics to Metals and to Stone and Glass; and when comparing Machinery to Electronics. Figure 19 allows for further precision, pointing to a number of relatively close agricultural products and foodstuffs that outweigh other products with similar distance in both COG and PCI (Edible preparations, Beverages, Oils, Wood, Dairy Products, Cocoa and Meat). At higher distances, we see Chemical Products (Soaps, Dyes, Pharmaceuticals and Plastics) along with Machineries dominating the opportunity scores at their respective distances.

[21] Product sectors are defined as the 2-digit level of detail of the HS classification system, revision 3 (1992). Product sections are aggregates of these 2-digit sectors used by the Center for International Development in the Colombian and Mexican subnational atlases of economic complexity. See http://datlascolombia.com and http://complejidad.datos.gob.mx.

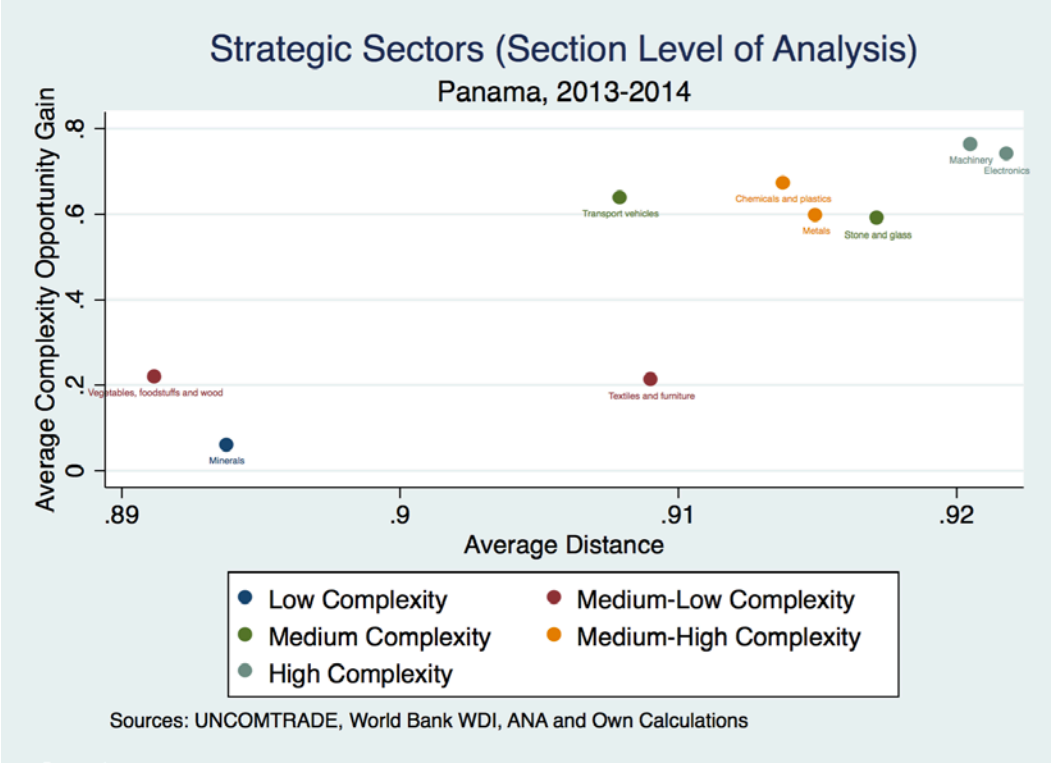

Figure 18. Strategic Sectors (Section Level Analysis, Panama, 2013-2014)

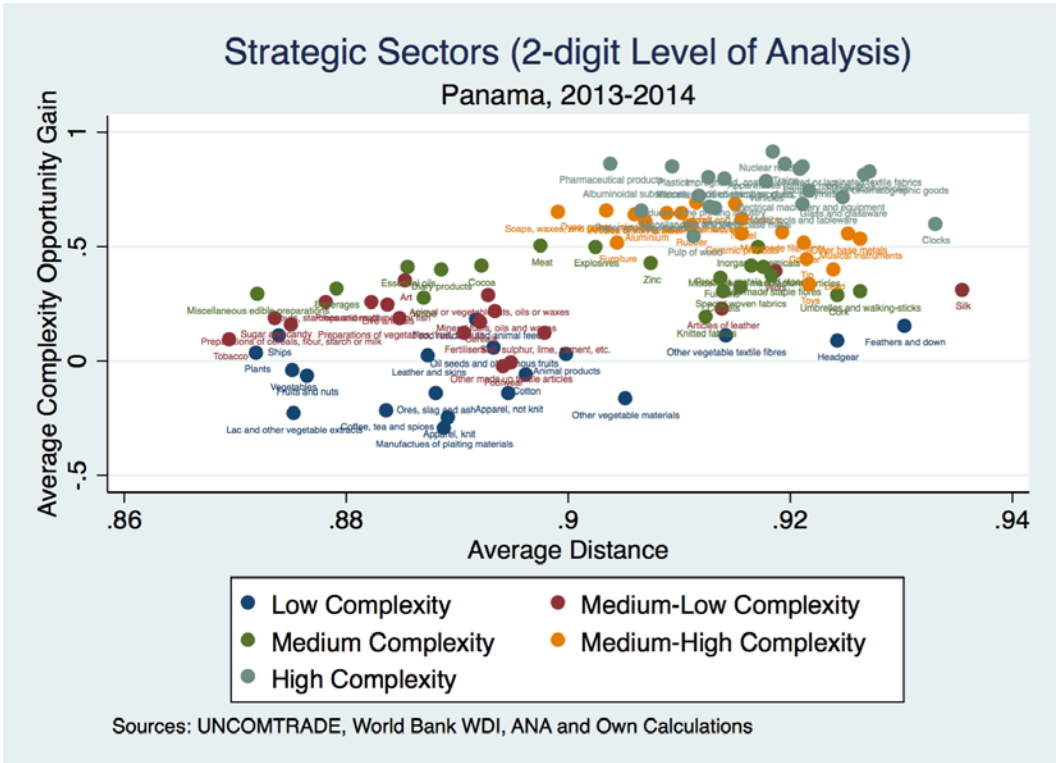

Figure 19. Strategic Sectors (2-digit Level Analysis, Panama, 2013-2014)

Figure 20 to Figure 23 show the same information contained in Figure 17, broken down by complexity block.

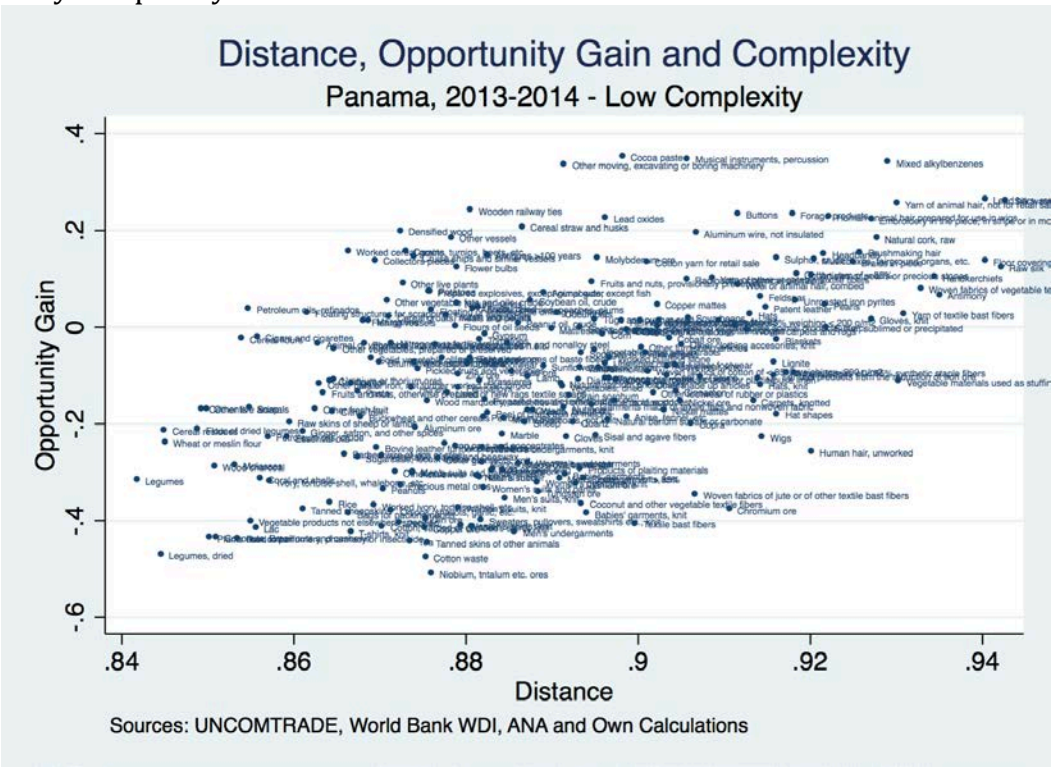

Figure 20. Distance, Opportunity Gain and Complexity (Panama 2013-2014 - Low Complexity)

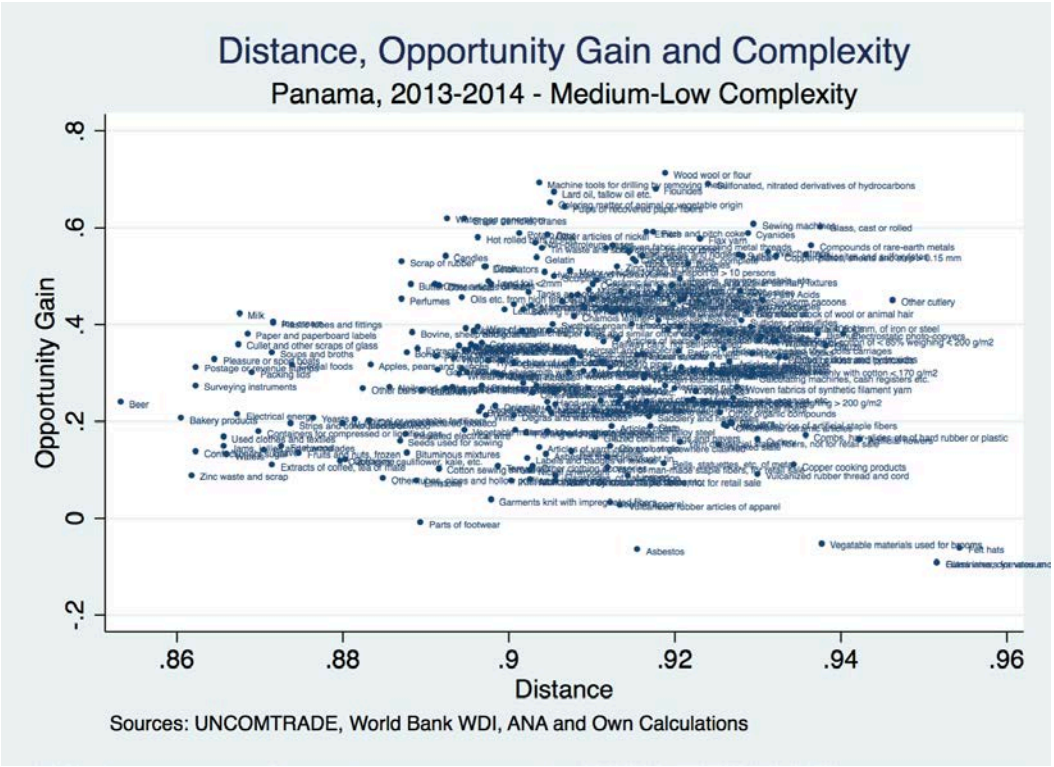

Figure 21. Distance, Opportunity Gain and Complexity (Panama, 2013-2014 - Medium-Low Complexity)

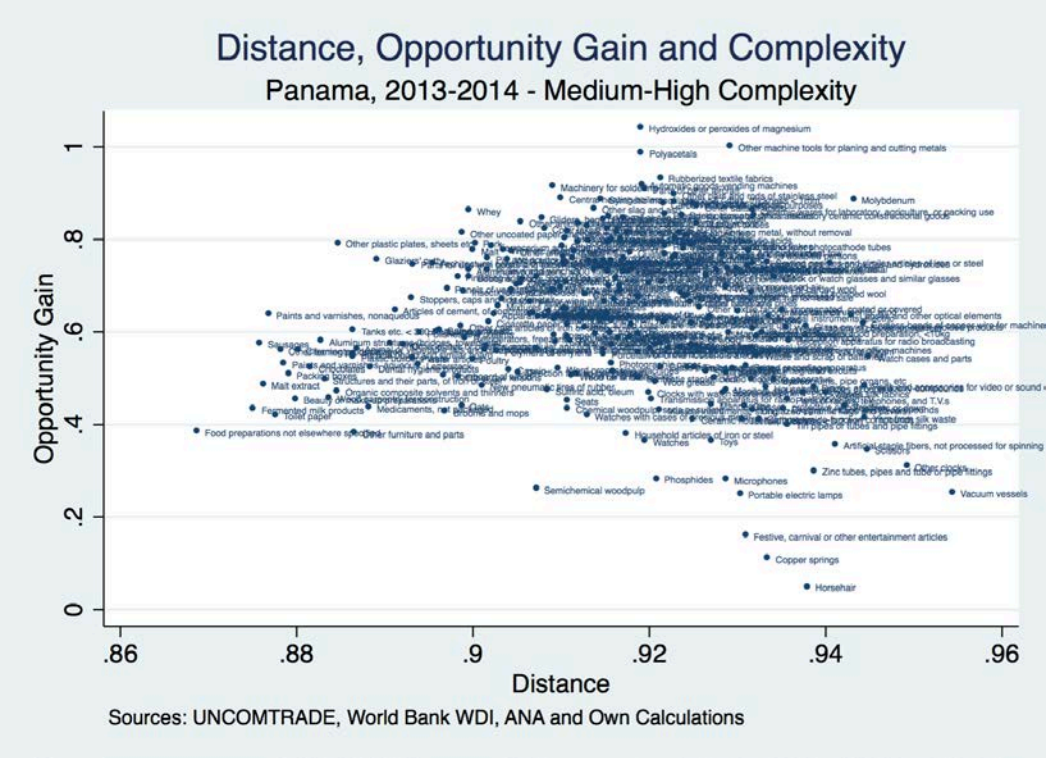

Figure 22. Distance, Opportunity Gain and Complexity (Panama, 2013-2014 - Medium-High Complexity)

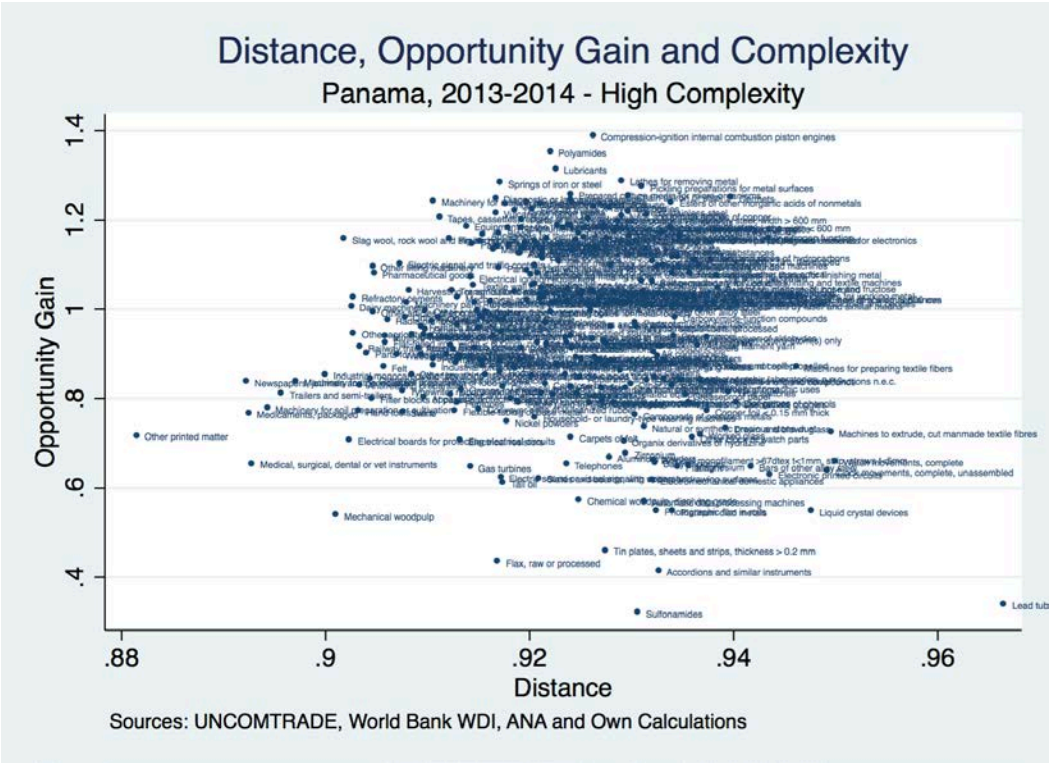

Figure 23. Distance, Opportunity Gain and Complexity (Panama, 2013-2014 - High Complexity)

While we now have a better understanding of the economic activities where opportunities for export diversification may exist, narrowing the analysis to the product level requires reducing the dimensionality of the variables for measuring feasibility and opportunity. This need opens the question of how to reduce this dimensionality.

Countries that are very peripheral and have little opportunities for organic diversification may place a premium on opportunity, while countries that are low in complexity but have good connectivity to increasingly complex products might emphasize proximity. Finally, countries with adequate complexity but difficulty for improving organically, can opt for a more balanced strategy.

These are the principles behind Figure 24, which shows the normalized ECI values for different countries in the world, along with their Complexity Outlook Indices (COI's). The COI of a locality is the sum of the densities for the products in which a location has RCA lower than 1, multiplied by their PCIs[22]. The analysis becomes more intuitive if we proceed clockwise from the bottom-left: Countries in that quadrant of the graph should prioritize "Strategic Bets" for products that enhance their connectivity and complexity, despite being distant from their current and peripheral export structure. Countries in the upper-left quadrant are not very complex, but their good connectivity from a Product Space perspective suggests that they might have some "Ripe Fruits:" nearby products that might enhance their complexity significantly. Countries in the upper-right quadrant are both relatively complex and well connected, which suggests that they are in a good situation and with plenty of room to continue growing organically. Finally, countries in the bottom-right quadrant already show significant levels of export complexity, but lack the connectivity to continue improving organically. For countries on the right-hand side of the chart, a more "Balanced" strategy, equally weighing feasibility and opportunity, is advised.

[22] For the precise definition of Complexity Outlook Index (COI), see the Technical Appendix.

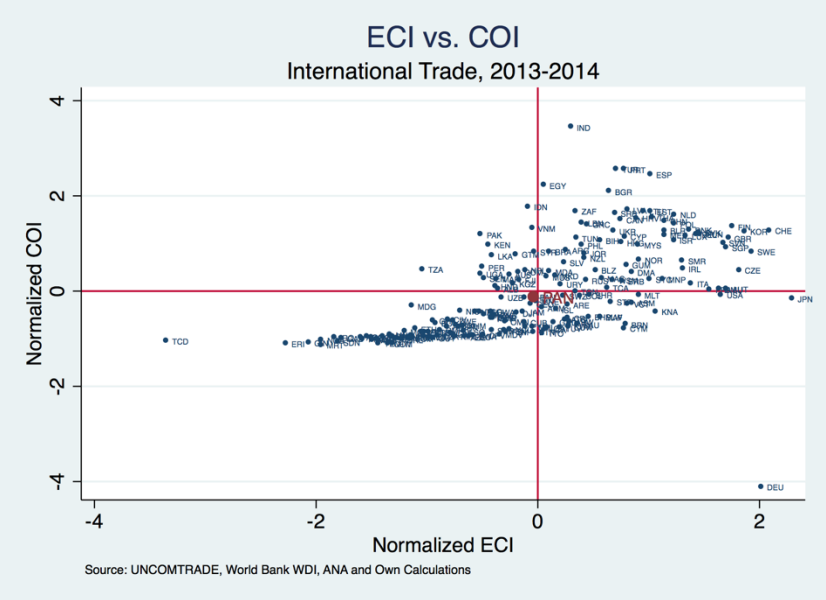

Figure 24. ECI vs. COI (International Trade, 2013-2014)

As we can see, the location of a country within these quadrants can inform the strategic approach to export diversification that should be followed: "Strategic Bets," "Ripe Fruit," or "Balanced." While, strictly speaking, Panama lies on the "Strategic Bets" quadrant, it is noteworthy that its position remains very close to the center of the visualization plane. This implies that there are little grounds to justify any of these specific approaches exclusively.

Therefore, we proceed to identify export diversification opportunities according to each of the three strategic approaches. Definitions and methods for producing the relevant scores for the "Strategic Bets", "Balanced", and "Ripe Fruit" approaches are shown below, along with visualizations and tables displaying aggregate product sections that show highest approach scores, and the top 50 missing products according to each strategy.

2.2.1. Strategic Bets

The Strategic Bets approach prioritizes opportunity over feasibility. Its score is a weighted average of normalized values of each of three dimensions: Density (40%),[23] COG (40%), and PCI (20%). This approach is suggested for the bottom-left quadrant in Figure 24, for countries with low scores in both complexity and connectivity in the Product Space. Figure 25 sorts all product sections according to the average Strategic Bets scores of their missing products in Panama. The figure suggests that special emphasis should be placed on Transport Vehicles, Chemicals and Machinery. Figure 26 and Table 1 rank the top 50 products for export

[23] As the inverse metric of distance, the Density of a product increases the as the product approaches the current export structure of a given country. The mathematical expressions to calculate these metrics for both the export of goods and industries are discussed in the Technical Appendix.

diversification according to their respective Strategic Bets scores, displaying additional information about them.

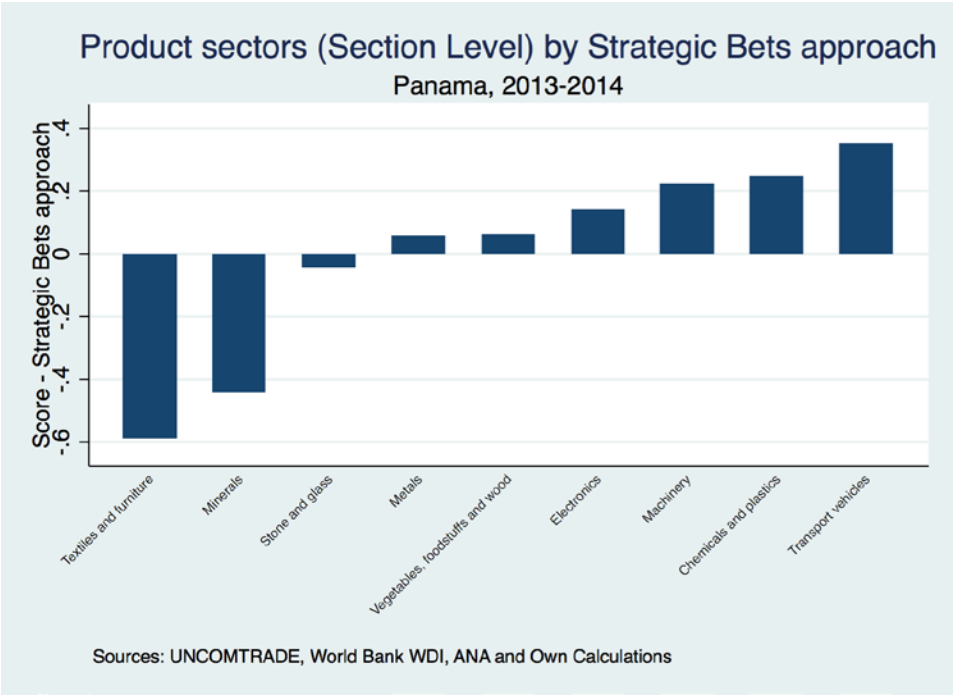

Figure 25. Product sectors (Section Level) by Strategic Bets approach (Panama, 2013-2014)

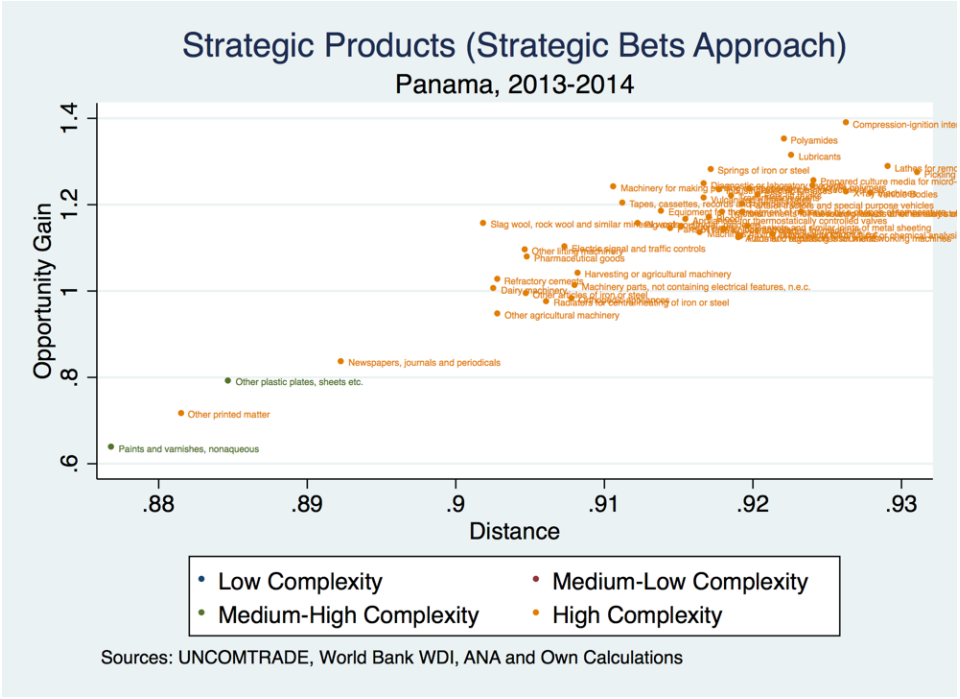

Figure 26. Strategic Products (Strategic Bets Approach, Panama, 2013-2014)

Table 1. Top 50 Products for export diversification according to the Strategic Bets Approach

Rank	Product	Sector	Section	Density	PCI	COG	Exports	Score
1	Slag wool, rock wool and similar mineral wools	Articles of stone, plaster, cement, etc.	Stone and glass	0.0981	2.9279	1.1565	14684	0.957
2	Machinery for making printing components	Miscellaneous Machinery	Machinery	0.0893	3.3457	1.2404	754	0.944
3	Polyamides	Plastics	Chemicals and plastics	0.0779	3.8560	1.3509	6	0.924
4	Tapes, cassettes, records and compact disks	Electrical machinery and equipment	Electronics	0.0888	3.4420	1.2041	101744	0.912
5	Springs of iron or steel	Articles of iron or steel	Metals	0.0828	3.6007	1.2816	481	0.908
6	Diagnostic or laboratory reagents	Miscellaneous chemical products	Chemicals and plastics	0.0833	3.7330	1.2470	0	0.899
7	Compression-ignition internal combustion piston engines	Miscellaneous Machinery	Machinery	0.0737	3.8618	1.3879	167894	0.893
8	Other lifting machinery	Miscellaneous Machinery	Machinery	0.0953	3.0076	1.0942	94842	0.864
9	Equipment for the treatment of materials by a change of temperature	Miscellaneous Machinery	Machinery	0.0861	3.3549	1.1853	176427	0.843
10	Electric signal and traffic controls	Electrical machinery and equipment	Electronics	0.0926	3.0642	1.1007	7000	0.834
11	Industrial electric furnaces	Electrical machinery and equipment	Electronics	0.0823	3.4063	1.2346	0	0.834
12	Instruments for measuring flow or other variables of liquids or gases	Apparatuses (optical, medical, etc.)	Machinery	0.0807	4.0311	1.1812	171668	0.830
13	Prepared culture media for micro-organisms	Miscellaneous chemical products	Chemicals and plastics	0.0759	4.0381	1.2558	0	0.824
14	Transmission shafts	Miscellaneous Machinery	Machinery	0.0814	3.5340	1.2186	316934	0.820
15	Textile articles for technical use	Impregnated, coated, covered or laminated textile fabrics	Textiles and furniture	0.0802	3.5485	1.2371	43	0.819
16	Blood	Pharmaceutical products	Chemicals and plastics	0.0829	3.6872	1.1703	0	0.815
17	Lubricants	Soaps, waxes, and paints	Chemicals and plastics	0.0774	3.1919	1.3134	5678	0.805
18	Other plastic plates, sheets etc.	Plastics	Chemicals and plastics	0.1153	2.1326	0.7915	129473	0.797
19	Vulcanized rubber plates	Rubber	Chemicals and plastics	0.0833	3.0893	1.2140	11439	0.794
20	Pig and poultry fat, rendered	Animal or vegetable fats, oils or waxes	Vegetables, foodstuffs and wood	0.0877	2.9011	1.1562	0	0.790
21	Other printed matter	Products of the printing industry	Vegetables, foodstuffs and wood	0.1185	2.2280	0.7162	142699	0.788
22	Fork-lift trucks	Miscellaneous Machinery	Machinery	0.0797	3.4394	1.2225	75688	0.785
23	Pharmaceutical goods	Pharmaceutical products	Chemicals and plastics	0.0952	2.4443	1.0783	0	0.782
24	Centrifuges	Miscellaneous Machinery	Machinery	0.0848	3.2749	1.1497	338944	0.779
25	Appliances for thermostatically controlled valves	Miscellaneous Machinery	Machinery	0.0845	3.1690	1.1658	29332	0.778
26	Dairy machinery	Miscellaneous Machinery	Machinery	0.0974	2.6846	1.0044	988	0.776
27	Refractory cements	Miscellaneous chemical products	Chemicals and plastics	0.0972	2.5235	1.0255	195	0.774
28	Lathes for removing metal	Miscellaneous Machinery	Machinery	0.0709	4.0134	1.2870	0	0.771
29	Instruments for physical or chemical analysis	Apparatuses (optical, medical, etc.)	Machinery	0.0786	4.2100	1.1309	20867	0.770
30	Machines having individual functions n.e.c.	Miscellaneous Machinery	Machinery	0.0835	3.4933	1.1344	906145	0.769
31	Parts of railway locomotives	Trains	Transport vehicles	0.0855	3.1085	1.1449	0	0.767
32	Tractors	Vehicles	Transport vehicles	0.0820	3.1939	1.1821	505613	0.757
33	X-ray machines	Apparatuses (optical, medical, etc.)	Machinery	0.0737	3.9562	1.2283	179877	0.754
34	Parts of tractors and special purpose vehicles	Vehicles	Transport vehicles	0.0807	3.1866	1.2002	693449	0.751
35	Gaskets and similar joints of metal sheeting	Miscellaneous Machinery	Machinery	0.0803	3.6280	1.1485	0	0.747
36	Acrylic polymers	Plastics	Chemicals and plastics	0.0759	3.4190	1.2422	3688	0.742
37	Other agricultural machinery	Miscellaneous Machinery	Machinery	0.0972	2.8489	0.9459	0	0.736
38	Newspapers, journals and periodicals	Products of the printing industry	Vegetables, foodstuffs and wood	0.1077	2.2800	0.8363	127049	0.735
39	Other articles of iron or steel	Articles of iron or steel	Metals	0.0953	2.6973	0.9935	322323	0.733
40	Parts and accessories for metal working machines	Miscellaneous Machinery	Machinery	0.0808	3.6325	1.1242	42463	0.733
41	Knives and blades for machines	Metal tools and tableware	Metals	0.0819	3.3289	1.1426	3203	0.732
42	Flat-rolled products of other alloy steel, width < 600 mm	Iron and steel	Metals	0.0767	3.6984	1.1818	0	0.729
43	Orthopedic appliances	Apparatuses (optical, medical, etc.)	Machinery	0.0922	3.1187	0.9821	89294	0.722
44	Harvesting or agricultural machinery	Miscellaneous Machinery	Machinery	0.0918	2.6871	1.0412	52688	0.721
45	Vehicle Bodies	Vehicles	Transport vehicles	0.0720	3.8982	1.2260	31823	0.719
46	Paints and varnishes, nonaqueous	Dyes, paints, inks, etc.	Chemicals and plastics	0.1231	1.5972	0.6371	541089	0.716
47	Machinery parts, not containing electrical features, n.e.c.	Miscellaneous Machinery	Machinery	0.0920	2.8498	1.0124	28123	0.716
48	Automatic regulating instruments	Apparatuses (optical, medical, etc.)	Machinery	0.0809	3.4447	1.1239	35051	0.713
49	Radiators for central heating of iron or steel	Articles of iron or steel	Metals	0.0939	2.7965	0.9751	0	0.705
50	Pickling preparations for metal surfaces	Miscellaneous chemical products	Chemicals and plastics	0.0689	3.7660	1.2728	0	0.699

Source: UNCOMTRADE, World Bank WDI, ANA and Own Calculations.

2.2.2. Balanced Approach

The Balanced Approach places equal emphasis on feasibility and opportunity. Its score is a weighted average of the normalized values of Density (50%), COG (25%) and PCI (25%). This approach is suggested for countries in the upper- and lower-right quadrants in Figure 24.

Figure 27 sorts all product sections according to average scores of their missing products in Panama. It suggests that special emphasis should be placed on Vegetables and Foodstuffs, Transport Vehicles and Chemicals. Figure 28 and Table 2 rank the top 50 products according to the Balanced score, with some additional information about each.

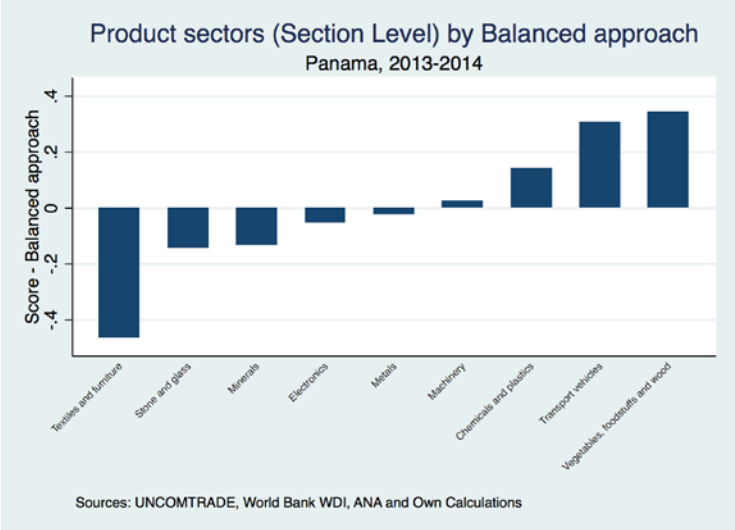

Figure 27. Product sectors (Section Level) by Balanced approach (Panama, 2013-2014)

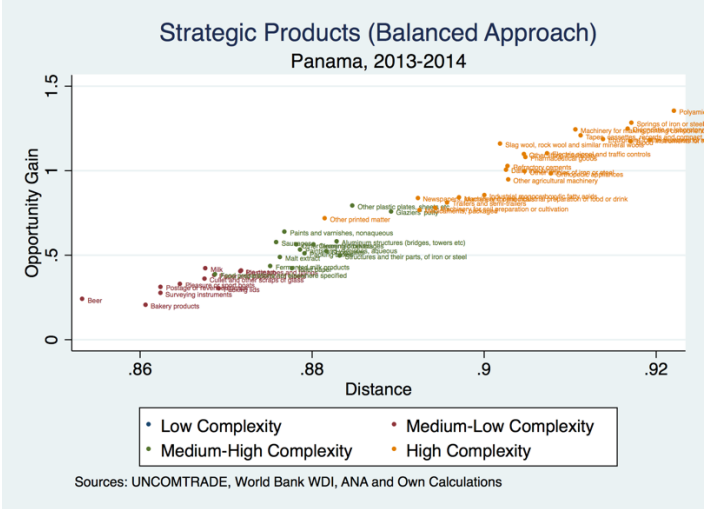

Figure 28. Strategic Products (Balanced Approach, Panama, 2013-2014)

Table 2. Top 50 Products for export diversification according to the Balanced Approach

Rank	Product	Sector	Section	Density	PCI	COG	Exports	Score
1	Other printed matter	Products of the printing industry	Vegetables, foodstuffs and wood	0.1185	2.2280	0.7162	142699	0.8181
2	Beer	Beverages	Vegetables, foodstuffs and wood	0.1466	0.1509	0.2370	8905	0.8010
3	Other plastic plates, sheets etc.	Plastics	Chemicals and plastics	0.1153	2.1326	0.7915	129473	0.7852
4	Paints and varnishes, nonaqueous	Dyes, paints, inks, etc.	Chemicals and plastics	0.1231	1.5972	0.6371	541089	0.7747
5	Slag wool, rock wool and similar mineral wools	Articles of stone, plaster, cement, etc.	Stone and glass	0.0981	2.9279	1.1565	14684	0.7715
6	Milk	Diary products	Vegetables, foodstuffs and wood	0.1323	0.9589	0.4205	61962	0.7397
7	Food preparations not elsewhere specified	Miscellaneous edible preparations	Vegetables, foodstuffs and wood	0.1312	1.1673	0.3832	149921	0.7255
8	Sausages	Preparations of meat or fish	Vegetables, foodstuffs and wood	0.1241	1.3679	0.5742	139276	0.7247
9	Pleasure or sport boats	Ships	Transport vehicles	0.1353	0.7290	0.3261	210380	0.7107
10	Machinery for making printing components	Miscellaneous Machinery	Machinery	0.0893	3.3457	1.2404	754	0.7065
11	Paper and paperboard labels	Paper and paperboard	Vegetables, foodstuffs and wood	0.1314	0.9894	0.3792	5612	0.7005
12	Postage or revenue stamps	Art	Textiles and furniture	0.1375	0.3483	0.3109	0	0.6921
13	Other lifting machinery	Miscellaneous Machinery	Machinery	0.0953	3.0076	1.0942	94842	0.6915
14	Tapes, cassettes, records and compact disks	Electrical machinery and equipment	Electronics	0.0888	3.4420	1.2041	101744	0.6874
15	Newspapers, journals and periodicals	Products of the printing industry	Vegetables, foodstuffs and wood	0.1077	2.2800	0.8363	127049	0.6819
16	Bakery products	Preparations of cereals, flour, starch or milk	Vegetables, foodstuffs and wood	0.1393	0.3768	0.2038	1910670	0.6686
17	Medicaments, packaged	Pharmaceutical products	Chemicals and plastics	0.1075	2.4696	0.7657	18865164	0.6632
18	Plastic tubes and fittings	Plastics	Chemicals and plastics	0.1283	1.0601	0.4010	472384	0.6627
19	Surveying instruments	Apparatuses (optical, medical, etc.)	Machinery	0.1376	0.2613	0.2725	221371	0.6584
20	Other fermented beverages	Beverages	Vegetables, foodstuffs and wood	0.1218	1.2779	0.5595	0	0.6569
21	Electric signal and traffic controls	Electrical machinery and equipment	Electronics	0.0926	3.0642	1.1007	7000	0.6501
22	Diagnostic or laboratory reagents	Miscellaneous chemical products	Chemicals and plastics	0.0833	3.7330	1.2470	0	0.6451
23	Aluminum structures (bridges, towers etc)	Aluminium	Metals	0.1171	1.7396	0.5789	87737	0.6421
24	Cleaning products	Soaps, waxes, and paints	Chemicals and plastics	0.1198	1.4301	0.5589	305352	0.6388
25	Springs of iron or steel	Articles of iron or steel	Metals	0.0828	3.6007	1.2816	481	0.6374
26	Dairy machinery	Miscellaneous Machinery	Machinery	0.0974	2.6846	1.0044	988	0.6343
27	Packing boxes	Wood	Vegetables, foodstuffs and wood	0.1209	1.4490	0.5073	71735	0.6327
28	Ice cream	Miscellaneous edible preparations	Vegetables, foodstuffs and wood	0.1282	0.8355	0.4047	30479	0.6311
29	Glaziers' putty	Dyes, paints, inks, etc.	Chemicals and plastics	0.1108	1.8131	0.7564	158238	0.6309
30	Malt extract	Preparations of cereals, flour, starch or milk	Vegetables, foodstuffs and wood	0.1237	1.1266	0.4858	425466	0.6303
31	Fermented milk products	Diary products	Vegetables, foodstuffs and wood	0.1248	1.1757	0.4329	91	0.6286
32	Refractory cements	Miscellaneous chemical products	Chemicals and plastics	0.0972	2.5235	1.0255	195	0.6195
33	Cullet and other scraps of glass	Glass and glassware	Stone and glass	0.1325	0.3490	0.3583	22316	0.6195
34	Paints and varnishes, aqueous	Dyes, paints, inks, etc.	Chemicals and plastics	0.1214	1.1875	0.5301	106094	0.6188
35	Other agricultural machinery	Miscellaneous Machinery	Machinery	0.0972	2.8489	0.9459	0	0.6186
36	Polyamides	Plastics	Chemicals and plastics	0.0779	3.8560	1.3509	6	0.6170
37	Toilet paper	Paper and paperboard	Vegetables, foodstuffs and wood	0.1223	1.4705	0.4194	1310949	0.6132
38	Equipment for the treatment of materials by a change of temperature	Miscellaneous Machinery	Machinery	0.0861	3.3549	1.1853	176427	0.6121
39	Industrial monocarboxylic fatty acids	Miscellaneous chemical products	Chemicals and plastics	0.0999	2.7281	0.8531	2685510	0.6024
40	Packing lids	Plastics	Chemicals and plastics	0.1308	0.6894	0.2994	1469948	0.6006
41	Pharmaceutical goods	Pharmaceutical products	Chemicals and plastics	0.0952	2.4443	1.0783	0	0.5991
42	Machinery for soil preparation or cultivation	Miscellaneous Machinery	Machinery	0.1056	2.2258	0.7765	68139	0.5991
43	Instruments for measuring flow or other variables of liquids or gases	Apparatuses (optical, medical, etc.)	Machinery	0.0807	4.0311	1.1812	171668	0.5979
44	Trailers and semi trailers	Vehicles	Transport vehicles	0.1042	2.2602	0.8098	315917	0.5954
45	Chocolates	Cocoa	Vegetables, foodstuffs and wood	0.1183	1.4399	0.5219	118805	0.5901
46	Structures and their parts, of iron or steel	Articles of iron or steel	Metals	0.1167	1.7677	0.4957	1846141	0.5894
47	Other articles of iron or steel	Articles of iron or steel	Metals	0.0953	2.6973	0.9935	322323	0.5872
48	Blood	Pharmaceutical products	Chemicals and plastics	0.0829	3.6872	1.1703	0	0.5865
49	Machinery for the industrial preparation of food or drink	Miscellaneous Machinery	Machinery	0.1028	2.2483	0.8376	129029	0.5824
50	Orthopedic appliances	Apparatuses (optical, medical, etc.)	Machinery	0.0922	3.1187	0.9821	89294	0.5793

Source: UNCOMTRADE, World Bank WDI, ANA and Own Calculations.

2.2.3. Ripe Fruit Approach

The Ripe Fruit approach favors feasibility over opportunity. Its score is a weighted average of the normalized values of Density (65%), COG (20%) and PCI (15%) for missing products. A Ripe Fruit approach is suggested for countries with relatively low complexity but relatively high connectivity in the Product Space, located in the upper-left quadrant in Figure 24. Figure 29 sorts all product sections according to the average Ripe Fruit score of their missing products in Panama. Again, it suggests that special emphasis should be placed on Vegetables and Foodstuffs, Transport Vehicles, and Minerals.[24] Figure 30 and Table 3 rank the top 50 products according to their Ripe Fruit score, with additional information.

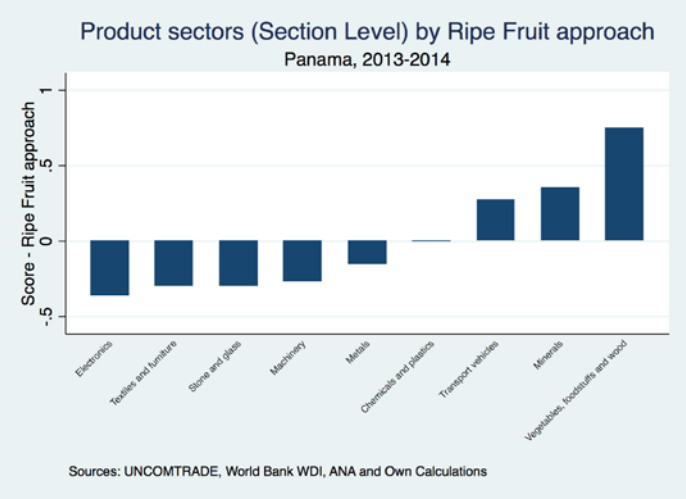

Figure 29. Product sectors (Section Level) by Ripe Fruit approach (Panama, 2013-2014)

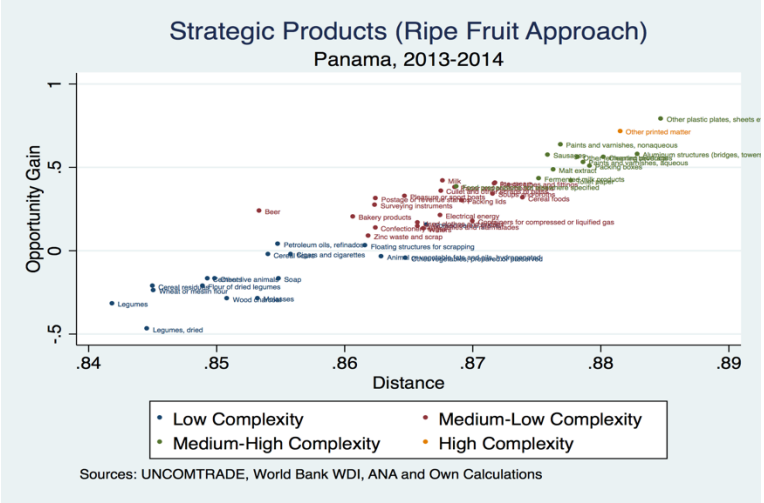

Figure 30. Strategic Products (Ripe Fruit Approach, Panama, 2013-2014)

[24] The Mineral category should be evaluated cautiously, as it as might only be feasible in places with very particular natural endowments that are not replicable.

Table 3. Top 50 Products for export diversification according to the Ripe Fruit Approach

Rank	Product	Sector	Section	Density	PCI	COG	Exports	Score
1	Beer	Beverages	Vegetables, foodstuffs and wood	0.1466	0.1509	0.2370	8905	1.1705
2	Wheat or meslin flour	Flours, starches and malts	Vegetables, foodstuffs and wood	0.1549	-1.3291	-0.2396	8955	1.0341
3	Cements	Salt, sulphur, lime, cement, etc.	Minerals	0.1507	-0.5906	-0.1689	26286	1.0221
4	Legumes	Vegetables	Vegetables, foodstuffs and wood	0.1581	-2.2071	-0.3174	0	1.0059
5	Postage or revenue stamps	Art	Textiles and furniture	0.1375	0.3483	0.3109	0	0.9878
6	Bakery products	Preparations of cereals, flour, starch or milk	Vegetables, foodstuffs and wood	0.1393	0.3768	0.2038	1910670	0.9856
7	Petroleum oils, refinados	Mineral fuels, oils and waxes	Minerals	0.1452	-0.5565	0.0378	2112292	0.9793
8	Pleasure or sport boats	Ships	Transport vehicles	0.1353	0.7290	0.3261	210380	0.9696
9	Cereal residues	Food residues and animal feed	Vegetables, foodstuffs and wood	0.1550	-2.2531	-0.2146	1882	0.9687
10	Surveying instruments	Apparatuses (optical, medical, etc.)	Machinery	0.1376	0.2613	0.2725	221371	0.9638
11	Milk	Diary products	Vegetables, foodstuffs and wood	0.1323	0.9589	0.4205	61962	0.9569
12	Cigars and cigarettes	Tobacco	Vegetables, foodstuffs and wood	0.1442	-0.3477	-0.0213	0	0.9438
13	Cereal flours	Flours, starches and malts	Vegetables, foodstuffs and wood	0.1460	-1.0426	-0.0243	0	0.9292
14	Food preparations not elsewhere specified	Miscellaneous edible preparations	Vegetables, foodstuffs and wood	0.1312	1.1673	0.3832	149921	0.9286
15	Paper and paperboard labels	Paper and paperboard	Vegetables, foodstuffs and wood	0.1314	0.9894	0.3792	5612	0.9150
16	Flour of dried legumes	Flours, starches and malts	Vegetables, foodstuffs and wood	0.1511	-1.8334	-0.2125	0	0.9054
17	Other live animals	Live animals	Vegetables, foodstuffs and wood	0.1501	-1.8105	-0.1690	17126	0.9029
18	Confectionery sugar	Sugar and candy	Vegetables, foodstuffs and wood	0.1376	0.2462	0.1350	164372	0.8977
19	Cullet and other scraps of glass	Glass and glassware	Stone and glass	0.1325	0.3490	0.3583	22316	0.8794
20	Paints and varnishes, nonaqueous	Dyes, paints, inks, etc.	Chemicals and plastics	0.1231	1.5972	0.6371	541089	0.8750
21	Plastic tubes and fittings	Plastics	Chemicals and plastics	0.1283	1.0601	0.4010	472384	0.8525
22	Sausages	Preparations of meat or fish	Vegetables, foodstuffs and wood	0.1241	1.3679	0.5742	139276	0.8518
23	Zinc waste and scrap	Zinc	Metals	0.1381	-0.2338	0.0870	0	0.8483
24	Other printed matter	Products of the printing industry	Vegetables, foodstuffs and wood	0.1185	2.2280	0.7162	142699	0.8463
25	Soap	Soaps, waxes, and paints	Chemicals and plastics	0.1451	-1.0404	-0.1680	0	0.8406
26	Packing lids	Plastics	Chemicals and plastics	0.1308	0.6894	0.2994	1469948	0.8383
27	Ice cream	Miscellaneous edible preparations	Vegetables, foodstuffs and wood	0.1282	0.8355	0.4047	30479	0.8325
28	Legumes, dried	Vegetables	Vegetables, foodstuffs and wood	0.1554	-2.6213	-0.4706	0	0.8286
29	Used clothes and textiles	Other made up textile articles	Textiles and furniture	0.1343	0.0744	0.1653	38311	0.8124
30	Wood charcoal	Wood	Vegetables, foodstuffs and wood	0.1491	-1.9461	-0.2891	19800	0.8101
31	Jams, jellies and marmalades	Preparations of vegetables, fruit, or nuts	Vegetables, foodstuffs and wood	0.1343	0.1267	0.1455	1250	0.8075
32	Other plastic plates, sheets etc.	Plastics	Chemicals and plastics	0.1153	2.1326	0.7915	129473	0.7909
33	Fermented milk products	Diary products	Vegetables, foodstuffs and wood	0.1248	1.1757	0.4329	91	0.7873
34	Soups and broths	Miscellaneous edible preparations	Vegetables, foodstuffs and wood	0.1284	0.5627	0.3410	186601	0.7850
35	Waters	Beverages	Vegetables, foodstuffs and wood	0.1338	0.0771	0.1297	33161	0.7845
36	Molasses	Sugar and candy	Vegetables, foodstuffs and wood	0.1468	-1.5462	-0.2863	0	0.7842
37	Electrical energy	Mineral fuels, oils and waxes	Minerals	0.1325	-0.0069	0.2118	0	0.7821
38	Malt extract	Preparations of cereals, flour, starch or milk	Vegetables, foodstuffs and wood	0.1237	1.1266	0.4858	425466	0.7790
39	Floating structures for scrapping	Ships	Transport vehicles	0.1384	-0.8123	0.0287	0	0.7783
40	Other fermented beverages	Beverages	Vegetables, foodstuffs and wood	0.1218	1.2779	0.5595	0	0.7769
41	Paints and varnishes, aqueous	Dyes, paints, inks, etc.	Chemicals and plastics	0.1214	1.1875	0.5301	106094	0.7449
42	Packing boxes	Wood	Vegetables, foodstuffs and wood	0.1209	1.4490	0.5073	71735	0.7437
43	Toilet paper	Paper and paperboard	Vegetables, foodstuffs and wood	0.1223	1.4705	0.4194	1310949	0.7419
44	Cleaning products	Soaps, waxes, and paints	Chemicals and plastics	0.1198	1.4301	0.5589	305352	0.7384
45	Worked cereal grains	Flours, starches and malts	Vegetables, foodstuffs and wood	0.1336	-0.5510	0.1559	0	0.7366
46	Containers for compressed or liquified gas	Articles of iron or steel	Metals	0.1300	0.3201	0.1760	132264	0.7278
47	Cereal foods	Preparations of cereals, flour, starch or milk	Vegetables, foodstuffs and wood	0.1261	0.7384	0.3156	270538	0.7277
48	Animal or vegetable fats and oils, hydrogenated	Animal or vegetable fats, oils or waxes	Vegetables, foodstuffs and wood	0.1371	-0.8154	-0.0356	132432	0.7150
49	Aluminum structures (bridges, towers etc)	Aluminium	Metals	0.1171	1.7396	0.5789	87737	0.7066
50	Other vegetables, prepared or preserved	Preparations of vegetables, fruit, or nuts	Vegetables, foodstuffs and wood	0.1352	-0.5122	-0.0447	114707	0.6878

Source: UNCOMTRADE, World Bank WDI, ANA and Own Calculations.

Throughout the previous figures and tables, certain sections and products remain common to all three approaches in the list of potential products for export diversification. This is consistent with the fact that Panama lies at the very center of the COG vs. ECI plot (Figure 24), making it hard to pin down a single strategy for identifying potential sectors.

Among the potential products that made all three lists is the Vegetables and Foodstuffs category. It is noteworthy that when we look at the strategy that favors proximity, 31 of the 50 products ranked, or 63%, belong to Vegetables and Foodstuffs. That is one of the alternatives of productive diversification: To add capabilities and begin expanding products downstream from the low complexity products that Panama is nowadays able to export competitively. Within this area, and following the ranking of the 50 most attractive products for each strategy, the most salient opportunities appear to be related to the paper industry, such as printing industry inputs (supply materials for newspaper, journals and magazines); and paper and paperboard products (paperboard labels, toilet paper). Beverages were also well ranked (water, beer, other fermented beverages); as well as preparations of cereals, flour, and starch (bakery products, malt, cereals).

The second section that shows up consistently in the rankings is Chemicals and Plastics. Products belonging to this category were most pervasive in strategy rankings other than Ripe Fruits (24% of all Strategic Bets products and 28% of all Balanced strategy products). This clearly indicates that the Chemicals and Plastics sector entails more risk, i.e. jumping longer distances over the Product Space forest. The sectors which display the most potential within our analysis are dyes, paints and inks (mostly paints and varnishes); plastics (polyamides, plastic sheets, plastic tubes and fittings, packing lids); and soaps, waxes and paints (lubricants, cleaning products, soap).

The analysis provided above should be considered as a roadmap for identifying strategic sectors that could potentially help Panama in diversifying its productive capabilities and competitive exports. Our analysis is only meant to suggest that these sectors demand some capabilities that Panama may already have in place. Those interested in determining what these sectors are intensive on, which capabilities are already on the ground, which are still missing, and how these can be attracted, should perform an industry-detailed analysis based on this roadmap.

3. Measuring technological similarity across sectors

The previous discussion about export diversification opportunities in Panama was based on a measure of technological similarity between tradable products. The values in the "proximity matrix" used for this exercise measured the tendency of different pairs of products to co-originate from the same countries, or more specifically, the minimum conditional probabilities for a country to be competitive in one product, given that it is competitive in another.

The theoretical principle behind this metric is that different activities require different capabilities, but some activities overlap in a large portion of their required capability inputs. If two products require a similar set of capabilities (for example, male shirts and female shirts), the fact that one of them is feasible in a country suggests the presence of many of the required capabilities of the other, and hence a higher likelihood for competitiveness in the other.

While the capabilities required for different sectors are unobservable, their tendency to co-originate in an international trade setting is perfectly measurable as a proxy for the similarity of required capacities. Building on this proximity matrix, Hausmann et al. (2014) find evidence that the presence of technologically similar activities (as measured by the Density metric) has a positive correlation to the future growth and appearance of economic sectors in different countries.

However, this metric cannot be used in assessing industrial diversification opportunities for provinces and districts within Panama, since this exercise requires information about non-tradable activities, which are the largest economic sectors in Panama today. Hence, a different approach to measuring technological similarity between industry pairs is in order for this purpose.

An initial approach could be to capture the tendency for economic activities to co-locate among different provinces or districts within Panama, using the same conditional probability method previously applied to exports, but with employment by sector-region within Panama instead. While plausible, this approach could lead to biases, since economic activities might tend to co-locate not due to technological similarities, but to urban scaling issues instead. For instance, Theater and Central Government activities may appear to be very close technologically when they tend to co-locate because employment for both concentrates in large cities.

Other approaches take advantage of more granular data about empirically evident capabilities being used by different sectors in order to estimate the similarity in all industry pairs. One option would be to leverage on administrative or statistical datasets that measure cross-sector labor flows. This alternative tracks the relative frequency of labor flows between industry pairs as a measure of the tendency for such sectors to use the same human talent. This is the principle behind the skill-relatedness metric derived for a Swedish context (see Neffke and Henning, 2013; Neffke, Otto and Weyh, 2016), as well the Colombian[25] and Mexican[26] Atlases of Economic Complexity. Sadly, the authors were not able to obtain access to the relevant data so as to advance this exercise in Panama through its Social Security Agency (CSS, for its Spanish acronym). However, the Swedish labor-flow matrix was expressed in an industry classification system that can be converted back into an

[25] http://datlascolombia.com
[26] http://datos.complejidad.gob.mx

adapted version of the Panamanian edition of the International Standardized Industry Classification (ISIC) in its third revision.

Finally, a separate approach to measure the overlapping capacities being used by different economic activities takes advantage of statistical sources that capture the occupations or tasks of the labor force in each of the economic sectors. This approach suggests that sectors that overlap in an important part of their occupation vectors will tend to require relatively similar talents if they are to be developed effectively. In the Panamanian case, the Population Census captures relevant information for both the economic activity and occupation of each surveyed individual who identifies as part of the work force. The same conditional probability approach in the co-location case can now be applied to an industry-occupation dataset for assessing the technological similarities between industry pairs. That is, measuring the minimum conditional probabilities that an occupation is relatively important for one sector, given that it is relatively important for the other. The Brazilian subnational economic complexity tool "DataViva" follows this approach[27].

In order to address what the right methodological approach is to the question of predicting future growth and appearance of economic activities for Panamanian provinces and districts, we replicate the empirical approach followed by Hausmann et al. (2014) to predict the growth rate (intensive margin) and the probability of appearance and disappearance (extensive margin) of different industries (in terms of employment) between 2000 and 2010. We measure the size of each activity per province and district from the Population Censuses for both years.

The specification of the empirical model for the intensive margin follows:

$$\log(E_{ir}^{t+10}/E_{ir}^{t}) = \beta_0 + \beta_1 \log(E_{ir}^{t}) + \beta_2 \log(D_{ir}^{t}) + \theta_i + \theta_r + \varepsilon_{ir}$$

where:

- "i" means industry,
- "r" means region (province or district, depending on the regression),
- "t" is the year 2000, and t+10 is the year 2010,
- "E_{ir}^{t}" means employment in industry "i" and region "r" in the year 2000,
- "D_{ir}^{t}" means the Density in industry "i" and region "r" in the year 2000,
- "θ_i" means industry fixed effects,
- "θ_r" means region fixed effects,
- "ε_{ir}" means statistical error.

This regression was executed with the densities computed from

1. the co-location proximities ("coloc"),
2. the Swedish labor-flow proximities ("swe") and
3. the occupation vector proximities ("occ").

[27] http://dataviva.info

Clustering of standard errors at the industry or region levels was added to check for robustness. In the case of district-level regressions, specifications with region-fixed effects and clustering of standard errors at the province level were also considered. Table 4 shows the regression results at the province level, while Table 5 and Table 6 show the regression results at the district level.

Table 4. Intensive margin regression specifications at the province level

VARIABLES	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]
log[E(t)]	-0.0360***	-0.0360***	-0.0360***	-0.0389***	-0.0389***	-0.0389***	-0.0369***	-0.0369***	-0.0369***	-0.0391***	-0.0391***	-0.0391***
	(0.00187)	(0.00297)	(0.00619)	(0.00187)	(0.00276)	(0.00566)	(0.00174)	(0.00272)	(0.00602)	(0.00204)	(0.00303)	(0.00689)
log[D_coloc(t)]	-0.00399	-0.00399	-0.00399							-0.000938	-0.000938	-0.000938
	(0.00460)	(0.00569)	(0.00853)							(0.00465)	(0.00622)	(0.00995)
log[D_swe(t)]				-0.000452	-0.000452	-0.000452				-0.000723	-0.000723	-0.000723
				(0.000551)	(0.000642)	(0.000554)				(0.000555)	(0.000630)	(0.000517)
log[D_occ(t)]							0.0215***	0.0215*	0.0215	0.0270***	0.0270**	0.0270**
							(0.00803)	(0.0110)	(0.0147)	(0.00992)	(0.0130)	(0.00957)
Constant	0.0416*	0.0416	0.0416	0.0746***	0.0746***	0.0746***	0.153***	0.153***	0.153**	0.186***	0.186***	0.186**
	(0.0220)	(0.0270)	(0.0405)	(0.00830)	(0.00869)	(0.00777)	(0.0349)	(0.0483)	(0.0651)	(0.0448)	(0.0571)	(0.0735)
Observations	3,528	3,528	3,528	2,376	2,376	2,376	3,528	3,528	3,528	2,376	2,376	2,376
R-squared	0.711	0.711	0.711	0.577	0.577	0.577	0.712	0.712	0.712	0.578	0.578	0.578
FE	Province & Ind	Province & Ind	Province & Ind	Province & Ind	Province & Ind	Province & Ind	Province & Ind	Province & Ind	Province & Ind	Province & Ind	Province & Ind	Province & Ind
Cluster	None	Industry	Province	None	Industry	Province	None	Industry	Province	None	Industry	Province

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5. Intensive margin regression specifications at the district level (I)

VARIABLES	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]
log[E(t)]	-0.0356***	-0.0356***	-0.0356***	-0.0356***	-0.0270***	-0.0352***	-0.0352***	-0.0352***	-0.0352***	-0.0166***
	(0.000809)	(0.00266)	(0.00213)	(0.00352)	(0.00352)	(0.000871)	(0.00227)	(0.00148)	(0.00198)	(0.00405)
log[D_coloc(t)]	0.00181	0.00181	0.00181	0.00181	0.0222***					
	(0.00195)	(0.00479)	(0.00210)	(0.00233)	(0.00263)					
log[D_swe(t)]						-0.000171	-0.000171	-0.000171	-0.000171	0.00151***
						(0.000161)	(0.000221)	(0.000185)	(0.000207)	(0.000301)
log[D_occ(t)]										
Constant	0.0276***	0.0276	0.0276***	0.0276***	0.119***	0.0302***	0.0302***	0.0302***	0.0302***	0.0393***
	(0.00803)	(0.0181)	(0.00748)	(0.00857)	(0.0119)	(0.00438)	(0.00468)	(0.00152)	(0.00187)	(0.00256)
Observations	22,050	22,050	22,050	22,050	22,050	14,850	14,850	14,850	14,850	14,850
R-squared	0.610	0.610	0.610	0.610	0.583	0.440	0.440	0.440	0.440	0.354
FE	District & Ind	District & Ind	District & Ind	District & Ind	Province & Ind	District & Ind	District & Ind	District & Ind	District & Ind	Province & Ind
Cluster	None	Industry	District	Province	Province	None	Industry	District	Province	Province

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6. Intensive margin regression specifications at the district level (II)

VARIABLES	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]	log[E(t+10)/E(t)]
log[E(t)]	-0.0356***	-0.0356***	-0.0356***	-0.0356***	-0.0257***	-0.0349***	-0.0349***	-0.0349***	-0.0349***	-0.0233***
	(0.000808)	(0.00258)	(0.00215)	(0.00353)	(0.00333)	(0.000873)	(0.00230)	(0.00147)	(0.00200)	(0.00269)
log[D_coloc(t)]						-0.00476**	-0.00476	-0.00476*	-0.00476**	0.0110**
						(0.00200)	(0.00426)	(0.00258)	(0.00206)	(0.00382)
log[D_swe(t)]						-0.000224	-0.000224	-0.000224	-0.000224	-1.03e-05
						(0.000161)	(0.000222)	(0.000186)	(0.000214)	(0.000199)
log[D_occ(t)]	0.00677***	0.00677**	0.00677**	0.00677***	0.0209***	0.00729***	0.00729**	0.00729***	0.00729***	0.0156*
	(0.00135)	(0.00298)	(0.00257)	(0.00155)	(0.00589)	(0.00188)	(0.00357)	(0.00239)	(0.00135)	(0.00859)
Constant	0.0444***	0.0444***	0.0444***	0.0444***	0.116***	0.0376***	0.0376*	0.0376***	0.0376***	0.149***
	(0.00583)	(0.0113)	(0.00871)	(0.00561)	(0.0277)	(0.0103)	(0.0209)	(0.0123)	(0.00692)	(0.0248)
Observations	22,050	22,050	22,050	22,050	22,050	14,850	14,850	14,850	14,850	14,850
R-squared	0.610	0.610	0.610	0.610	0.583	0.441	0.441	0.441	0.441	0.382
FE	District & Ind	District & Ind	District & Ind	District & Ind	Province & Ind	District & Ind	District & Ind	District & Ind	District & Ind	Province & Ind
Cluster	None	Industry	District	Province	Province	None	Industry	District	Province	Province

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The most important finding to be gleaned from the intensive margin regressions is that, among the three alternative approaches followed to estimate the technological similarity between pairs of sectors at both the province and district levels, the lagged Density metric based on occupation proximity shows the most robust positive association with future employment growth at the industry/region level of analysis. The robust negative coefficients in the lagged value of employment are expected, since larger industry/region cells will tend to grow at a slower rate (this mean-reversion term is ubiquitous in the literature).

At the province level, we find no evidence of a statistically significant association between the co-location and Swedish densities, while the occupation proximity density has a positive and significant effect. Although the association becomes insignificant after clustering the standard errors at the province level, we see that in regression specifications that simultaneously control for all three alternative densities, only the occupation proximity density shows a positive and significant coefficient, which is also robust to the clustering of standard errors at the industry or province levels.

At the district level, we find positive and significant coefficients for the co-location and Swedish densities, but only in the specification that includes fixed effects and clustering of standard errors at the province level. However, the occupation proximity density shows positive and significant coefficients for all its specifications. In the joint densities regressions, co-location and Swedish densities show either negative or insignificant associations with employment growth, while the occupation proximity density shows robust positive and significant coefficients. On average, between the province specifications and the district specifications that control for fixed effects at the province level, an increase of 1% in the occupation proximity density correlates with a 0.021% increase in the employment in an industry-region cell.

Another interesting inquiry we can tackle using this methodology is whether higher (lower) values of these density metrics could help predict the chances of appearance (disappearance) of missing (present) industries. To address this hypothesis, Hausmann et al. (2014) outline an extensive margin specification in two stages:

- First stage: A Probit model is executed to test whether Density values associate positively with the presence of a sector.
- Second stage: If a positive association is found, then the differences between predicted probabilities and the binary variable that determines presence are calculated. These “residuals” of the first stage are then used as independent variables in a second Probit predicting a binary variable for initially absent sectors, which determines whether they appeared (1) or not (0). For sectors that were initially absent, the inverse applies, meaning the second Probit runs on a binary variable that shows whether the sector disappeared (1) or not (0).

In the second stage, the expected coefficient for the "appearance" regression is negative, since all residuals for absent sectors should be negative, and higher absolute values hypothetically associate with sectors that should have been present, but were not. The inverse is true for the "disappearance" regression: since all residuals should be positive for initially present sectors, and higher residuals hypothetically associate with sectors that shouldn't have been present but were, we expect there to be a positive coefficient between the residual and the chance of disappearance.

Another important feature of these specifications is that the definition of "*presence*" is determined as a location quotient higher than 0.25, and the definition of "*absence*" is determined as a location quotient lower than 0.05[28]. The goal of defining absence and presence in this discontinuous manner is to be even more restrictive on the events of appearance and disappearance, therefore avoiding that small changes in employment may be interpreted as an appearance. Based on this definition, for the variable of appearance to take the value of one, that sector-location cell should have displayed, at the least, a five-fold increase of its location quotient. Inversely, for the variable of disappearance to take the value of one, that sector-location cell should have displayed a shrinking of its location quotient equal to at least 1/5 of its original value.

Table 7 and Table 8 show the results of the first stage and second stages of the extensive margin regressions at the province and district levels respectively.

[28] The location quotient of a region-industry cell is the analogous to the RCA metric in the international trade context. That is, the location quotient is the product fraction of the employment of an industry in a given location as a share of the full employment of the location, divided by the fraction of the employment of that industry in all of Panama by the full size of the Panamanian work force.

Table 7. Extensive margin regression specifications at the province level

VARIABLES	First Stage			Second Stage - Residuals on Appearance			Second Stage - Residuals on Disappearance		
	Presence	Presence	Presence	Appearance	Appearance	Appearance	Disappearance	Disappearance	Disappearance
log[D_coloc(t)]	0.916***			-0.461***			0.372***		
	(0.0274)			(0.166)			(0.141)		
log[D_swe(t)]		0.111***			-0.619**			0.258	
		(0.00642)			(0.250)			(0.357)	
log[D_occ(t)]			0.880***			-0.450***			0.478***
			(0.0314)			(0.171)			(0.168)
Constant	2.032***	0.444***	1.775***	-0.921***	-0.924***	-0.934***	-1.117***	-1.662***	-1.177***
	(0.0648)	(0.0358)	(0.0662)	(0.0572)	(0.113)	(0.0625)	(0.0592)	(0.169)	(0.0740)
Observations									

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 8. Extensive margin regression specifications at the district level

VARIABLES	First Stage			Second Stage - Residuals on Appearance			Second Stage - Residuals on Disappearance		
	Presence	Presence	Presence	Appearance	Appearance	Appearance	Disappearance	Disappearance	Disappearance
log[D_coloc(t)]	0.887***			-0.989***			0.662***		
	(0.0139)			(0.0648)			(0.0672)		
log[D_swe(t)]		0.0703***			-0.798***			1.681***	
		(0.00251)			(0.142)			(0.188)	
log[D_occ(t)]			0.718***			-0.927***			0.885***
			(0.0176)			(0.0775)			(0.0801)
Constant	1.623***	-0.0229	1.236***	-1.154***	-1.064***	-1.169***	-1.089***	-2.092***	-1.254***
	(0.0303)	(0.0153)	(0.0381)	(0.0210)	(0.0517)	(0.0255)	(0.0353)	(0.117)	(0.0458)
Observations									

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Except for the coefficient of the second stage regression on disappearances for the Swedish density residuals (which shows statistically insignificant results), all other regressions for both provinces and districts show coefficients with the expected sign and with statistically significant values. All coefficients in the first stage show positive and significant coefficients, suggesting that higher density values for all three approaches associate with a higher probability of a sector to be considered present. The negative coefficients in the appearance regressions suggest that originally absent sectors with higher original density values are more likely to appear than sectors with lower original density values. The positive coefficients in the disappearance regressions suggest the inverse: initially present sectors with lower original density values have a higher chance to disappear.

While the results of these extensive margin regressions are encouraging for all three density approaches, the fact that outputs for the Occupation proximity densities in the intensive margin specifications are largely superior to those of the Co-location and Swedish densities, suggests that the analysis of industrial diversification opportunities for provinces and districts should be developed considering the occupation similarity proximity matrix. We now go on to analyze industrial diversification opportunities.

4. Regional industrial diversification opportunities

After reaching a conclusion on using occupation proximity-based metrics of Density (and its inverse, distance) to assess the feasibility of missing sectors in different provinces or districts within Panama, the question of how to measure complexity for locations and for industries remains open.

In the international trade context, the ECI and the PCI are estimated with an iterative correction process between diversity and ubiquity. Estimating these metrics is trickier in a subnational and industrial context, and even more so for a country the size of Panama, where the number of economic activities and locations is much smaller. Since we cannot import these metrics externally, one option is to use the occupational diversity of the occupation vector of each sector as our measure of industrial complexity; and a measure of regional complexity similar to ECI, but based on the iterative correction of a region's occupational diversity and an occupation's regional ubiquity.

The principles behind these alternatives are justified in the economic development paradigm we have discussed thus far: Increasing the productive capabilities in a society as the formula for economic development. According to this view, the process of specialization of work at the individual level leads to the industrial diversification of regions into increasingly complex activities. As used in the Brazilian Atlas of Economic Complexity "DataViva," occupational diversity in a sector is an indicator of the number of specific skills that must be assembled for the

successful development of a given economic activity: the more occupations, the more complex the sector becomes.

Similarly, regions capable of assembling a very diverse array of relatively unique productive occupations will be better suited to recombine them successfully in the development of relatively complex economic activities. The advantage of being able to explicitly observe capabilities by capturing the occupations of censed individuals in the workforce is also complemented by the fact that the Panamanian occupation system breaks down at a more granular level than ISIC´s decomposition of economic activities[29].

Strategic approaches to industrial diversification for Panamanian provinces and districts can be determined based on these occupation-based core metrics of economic complexity: technological proximity between industries and complexity of locations and industries. As was the case with Figure 24 for Panama as a whole, Figure 31 and Figure 32 plot the relative position of provinces and districts in terms of complexity and in terms of technological connectivity to missing industries. These figures show that Panama's interoceanic region is the most complex in the country, but that it also has limitations in its capacity to diversify organically due to relatively poor connectivity. It also shows that western Panama, while not relatively complex, accounts for the regions with best connectivity to central and complex sectors. Lastly, the figures demonstrate the relative peripheral and non-complex nature of economic activities in Eastern Panama.

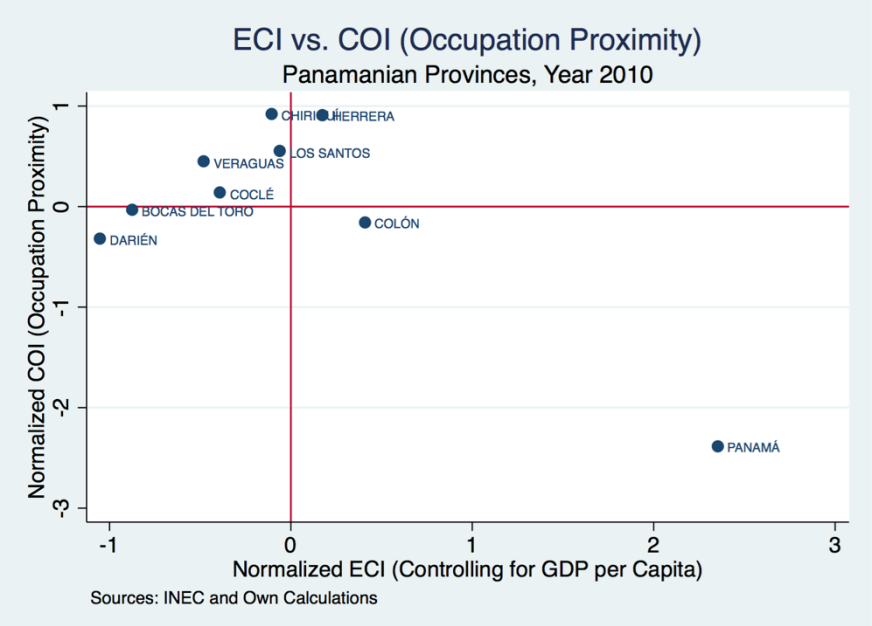

Figure 31. ECI vs. COI (Occupation Proximity, Panamanian Provinces, Year 2010)

[29] The occupation classification system used for the Population Census of 2000 accounts for 1644 occupations. The corrected version of the ISIC Rev 3 classification that allows full concordance between the 2000 and the 2010 editions accounts only for 325 economic activities.

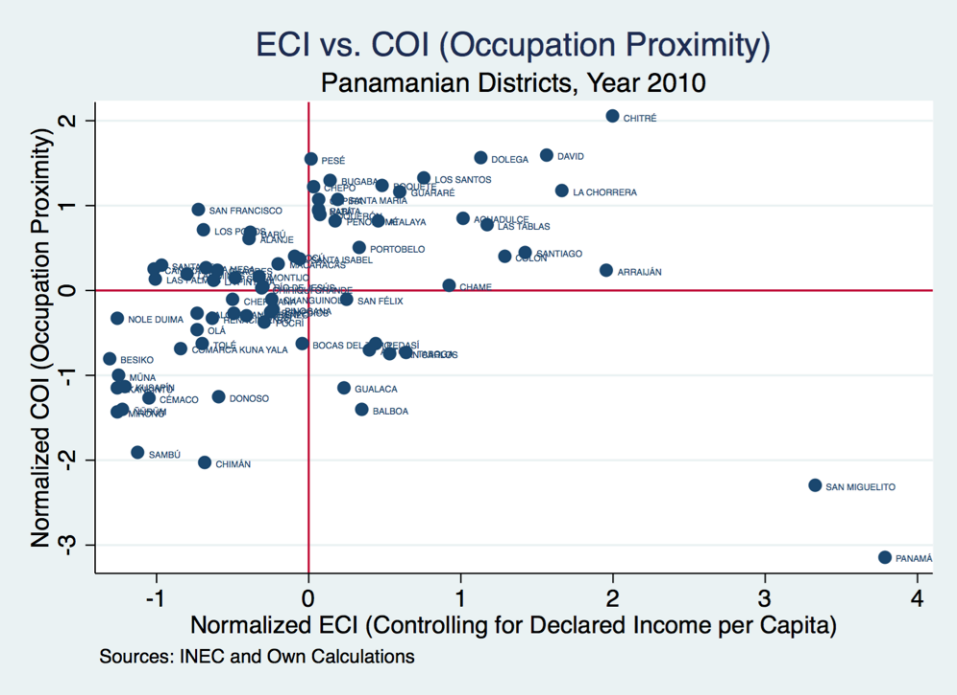

Figure 32 - ECI vs. COI (Occupation Proximity, Panamanian Districts, Year 2010)

For illustrative purposes, this study will discuss the industrial diversification strategy for one Eastern province (in the Strategic Bets approach quadrant), one interoceanic province (in the Balanced approach column) and one Western province (in the Ripe Fruit quadrant). The visualization appendix attached to this study displays all the relevant visualizations for all strategic approaches for all provinces and districts within Panama (including the Panama-wide export diversification visualizations discussed above).

4.1. Interoceanic region: The case of Colón

Figure 33 features missing sectors for Colón grouped together and plotted by distance, COG and economic complexity block. As expected for a relatively developed region in terms of its domestic counterparts, we find that relatively few sectors are missing, and that high-complexity and COG industries tend to be relatively close to other activities.

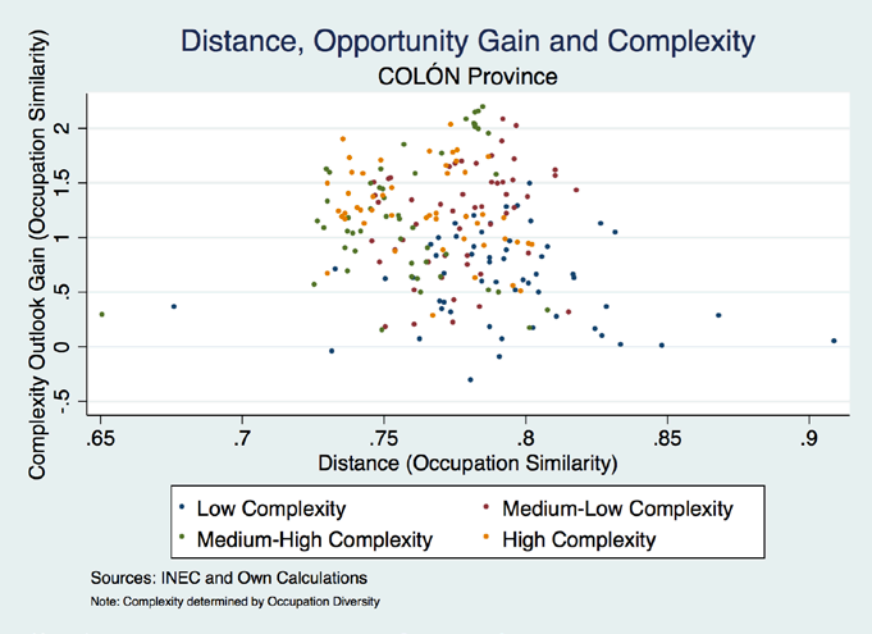

Figure 33. Distance, Opportunity Gain and Complexity (Colón)

Figure 34 shows these numbers aggregated by economic sectors, and displays average metrics of the industries that are missing in Colón and form part of the respective sector. While Agriculture offers the nearest opportunities, the sector displays very low complexity. The Logistics and Commerce sectors, by contrast, are both closer and more strategic than most other economic sectors. And although the Utilities, Real Estate and Financial Activities sectors appear more distant and with relatively lower complexity levels than Logistics and Commerce, they reveal the highest potential for connectivity improvement for Colón out of all sectors in the economy.

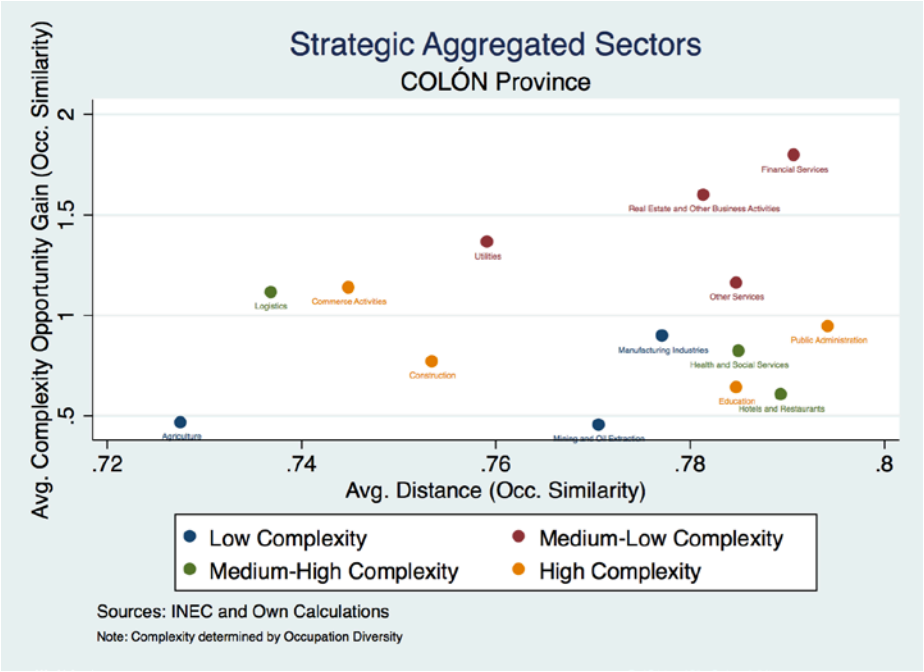

Figure 34. Strategic Aggregated Sectors (Colón)

Figure 35 through Figure 38 display the same metrics as Figure 34, identifying sectors by name and separating them by complexity block.

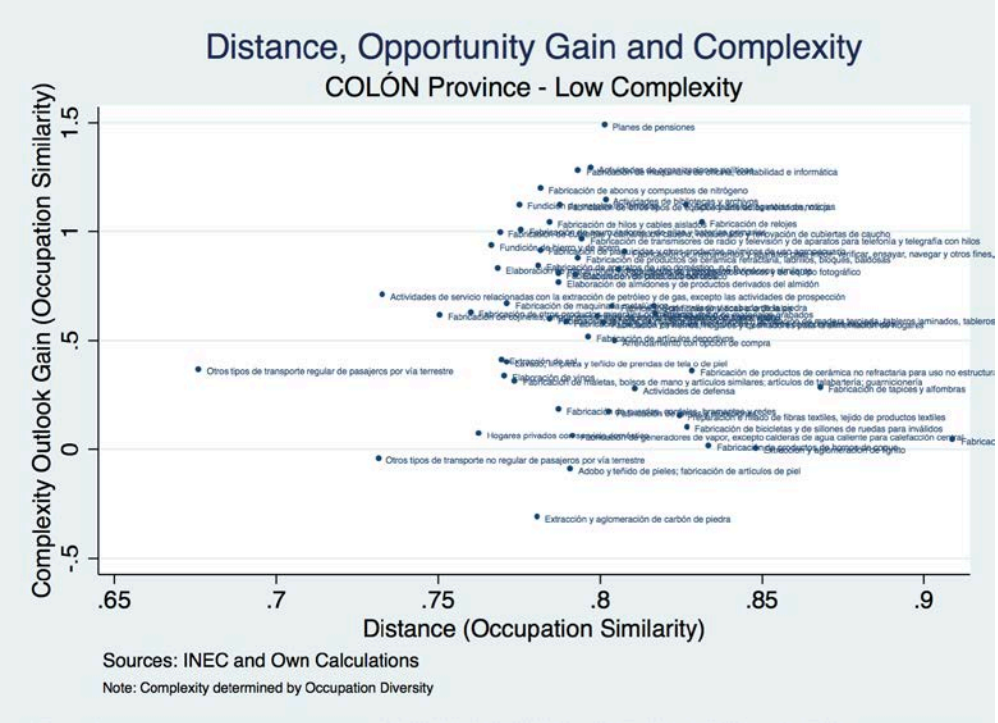

Figure 35. Distance, Opportunity Gain and Complexity (Colón - Low Complexity)

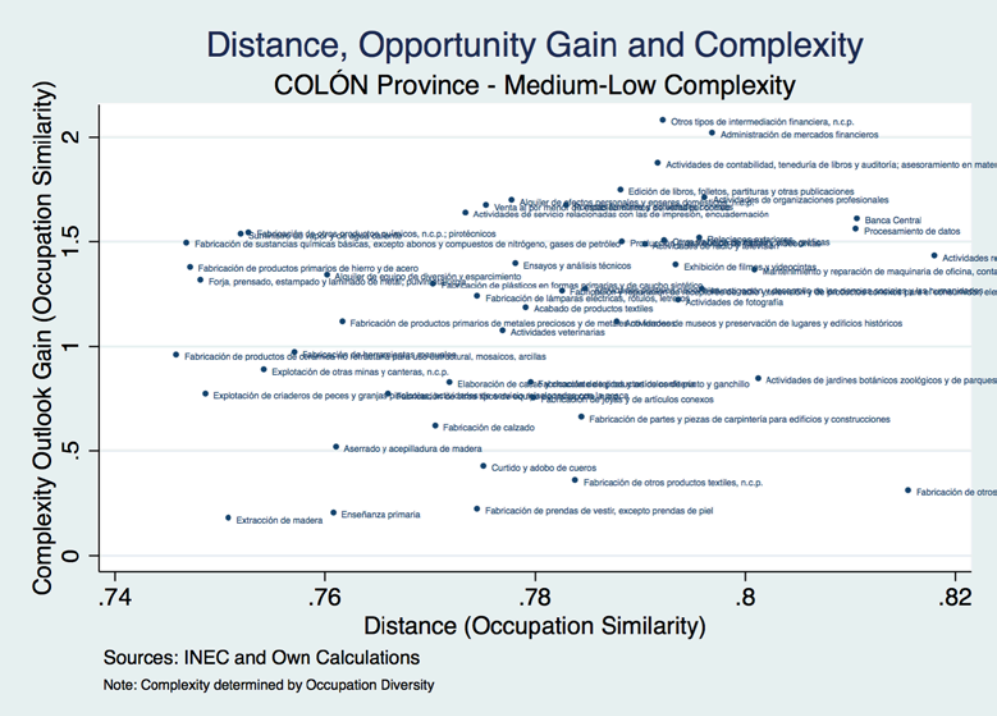

Figure 36. Distance, Opportunity Gain and Complexity (Colón - Medium-Low Complexity)

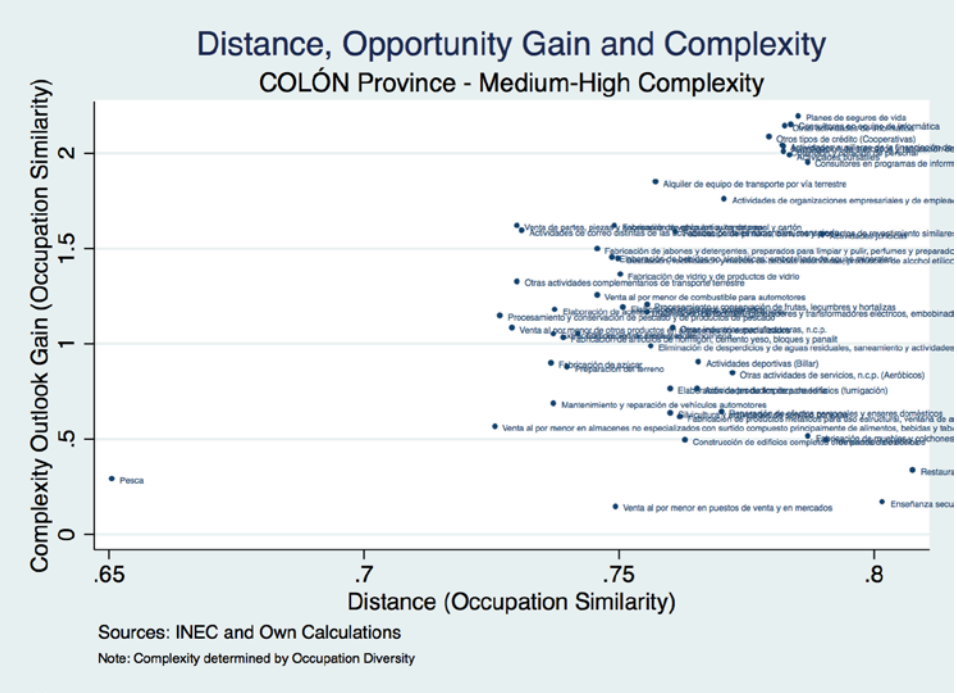

Figure 37. Distance, Opportunity Gain and Complexity (Colón Province - Medium-High Complexity)

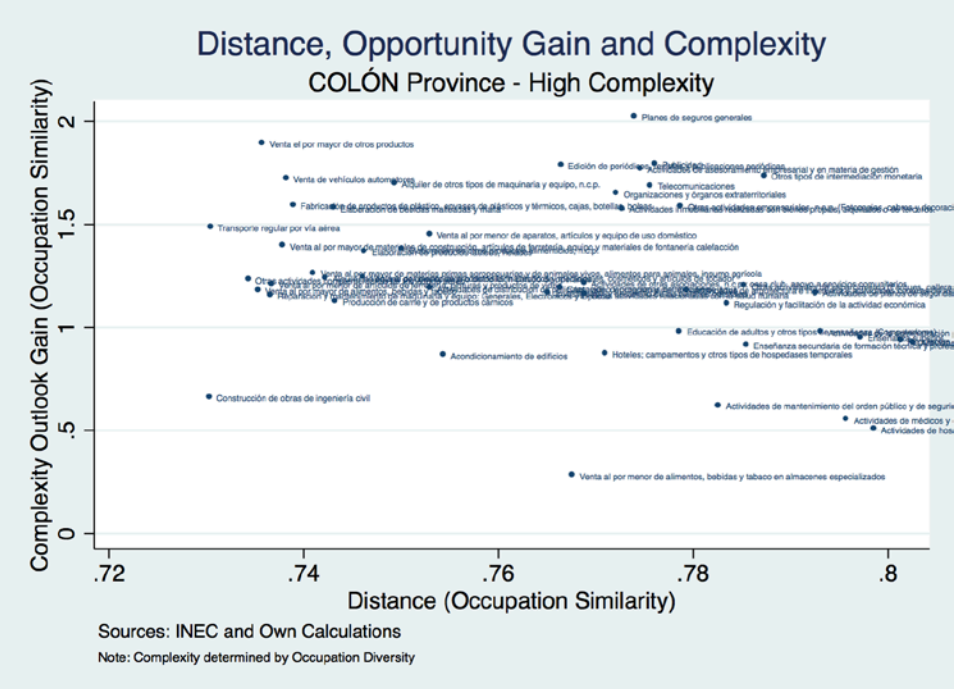

Figure 38. Distance, Opportunity Gain and Complexity (Colón Province - High Complexity)

As previously mentioned, Panama's interoceanic region falls within the Balanced approach quadrant for industrial diversification. The same criteria as the one discussed in the international trade section was applied for reducing the dimensionality of the feasibility and opportunity metrics of missing products. Figure 39 shows the average balanced approach scores of missing industries in each of the

economic sectors. This graph serves to underscore that, given Colón's strategic stance, its most interesting opportunities will likely arise in Commerce and Logistics activities, followed by Construction, Utilities and Agriculture sectors.

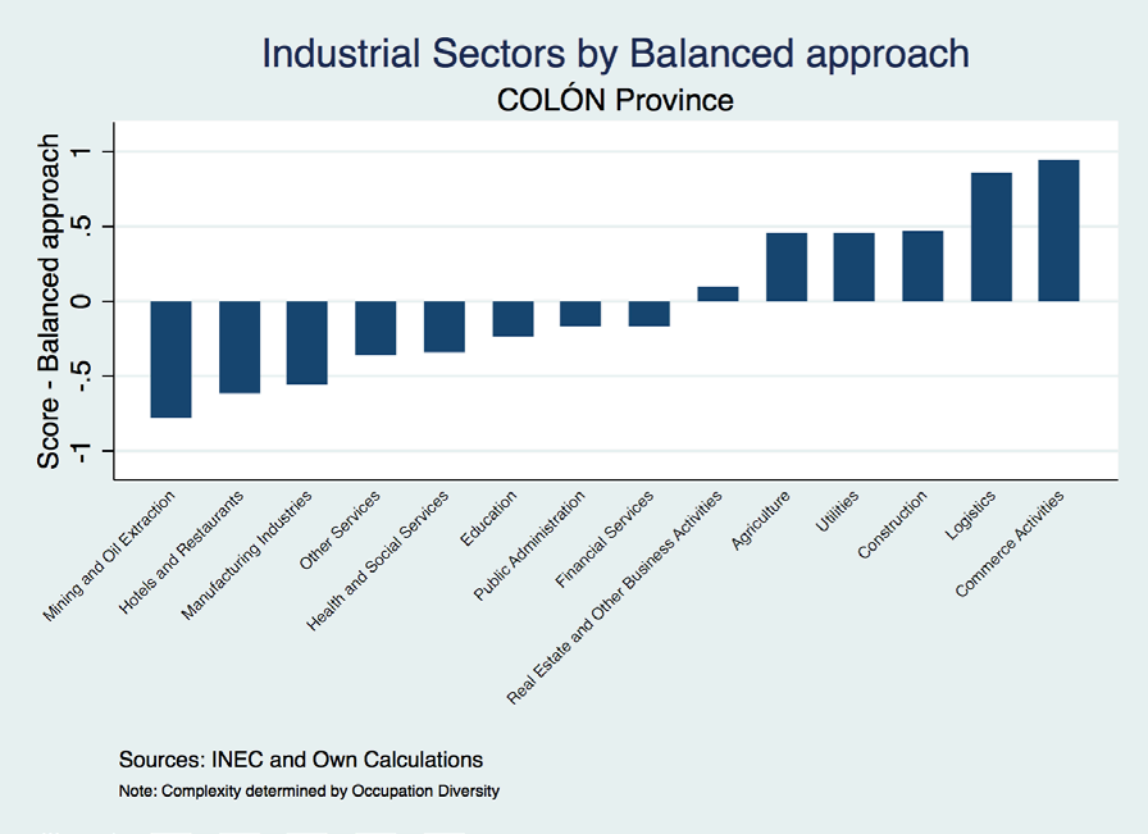

Figure 39. Industrial Sectors by Balanced approach (Colón Province)

In visualizing the most interesting opportunities for Colón at the specific industry level, Figure 40 and Table 9 rank the top 50 industries in terms of their Balanced approach scores, displaying their relevant economic complexity metrics as well. Interestingly, in addition to the expected findings in Logistics and Commerce; we find relevant Manufacturing sectors that overlap with the ones we had already identified as having potential, when analyzing export diversification opportunities for goods in Panama. It should be noted that Manufacturing did not appear in Figure 39 as having a high average score, due to the fact that these schedules are based on sub-sector averages, and other products within the Manufacturing sector pulled the sector average downwards. [30] This should not prevent us from observing the list of manufactured products that made the top 50 industries according to their score on the Balanced approach.

Plastics (plates, sheets, vases, containers), Foodstuffs (beer, fermented beverages, preparations of meat and fish), and Paper (newspapers, journal, periodicals,

[30] It should be noted that the Manufacturing sector accounts for the most individual industries among the ones reported.

cartons), are a few of the manufacturing items that ranked among the top 50 missing industries for Colón, that also showed up in our analysis at the product level. The preponderance of the Commerce and Logistics industries in this strategic list, however, also points to the possibility of redeploying existing capabilities towards opportunities for export diversification in the logistic and air hub around the Panama Canal and Colón Free Zone.

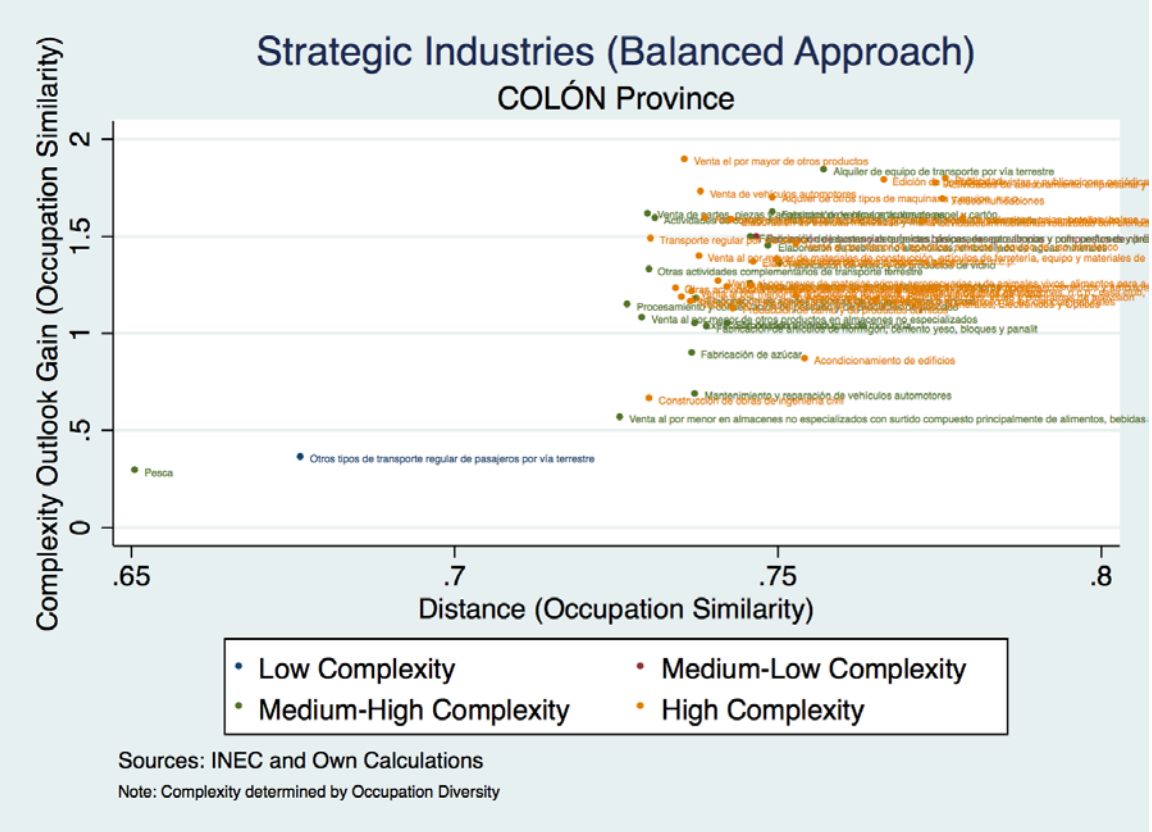

Figure 40. Strategic Industries (Balanced Approach, Colón)

Table 9. Top 50 missing activities for industrial diversification for Colón (Balanced)

Rank	Industry	Section	Density	Complexity	COG	Employment	Score
1	Pesca	Agriculture	0.3492	129	0.2869	306	1.7817
2	Actividades de distribución de películas, video y	Commerce Activities	0.2470	525	1.1895	821	1.3993
3	Venta de vehículos automotores	Commerce Activities	0.2618	284	1.7231	284	1.2632
4	Venta al por mayor de alimentos, bebidas y tabaco	Commerce Activities	0.2647	331	1.1784	577	1.2134
5	Venta el por mayor de otros productos	Commerce Activities	0.2642	217	1.8924	84	1.2057
6	Venta al por mayor de materiales de construcción,	Commerce Activities	0.2621	308	1.3955	204	1.1993
7	Otras actividades complementarias de transporte aé	Logistics	0.2657	306	1.2303	46	1.1892
8	Construcción de obras de ingeniería civil	Construction	0.2696	370	0.6588	1215	1.1890
9	Otros tipos de transporte regular de pasajeros por	Logistics	0.3236	35	0.3613	825	1.1519
10	Reparación y mantenimiento de maquinaria y equipo:	Manufacturing Industries	0.2634	310	1.1569	81	1.1320
11	Transporte regular por vía aérea	Logistics	0.2695	210	1.4854	37	1.1179
12	Venta de partes, piezas y accesorios de vehículos	Commerce Activities	0.2699	174	1.6154	216	1.0862
13	Venta al por menor de aparatos, artículos y equipo	Commerce Activities	0.2470	340	1.4509	542	1.0476
14	Fabricación de productos de plástico, envases de p	Manufacturing Industries	0.2610	216	1.5910	36	1.0319
15	Actividades de correo distintas de las actividades	Logistics	0.2689	160	1.5868	140	1.0241
16	Venta al por mayor de materias primas agropecuaria	Commerce Activities	0.2590	258	1.2637	22	0.9721
17	Venta al por menor de artículos de ferretería, pin	Commerce Activities	0.2633	237	1.2084	667	0.9707
18	Elaboración de bebidas malteadas y malta	Manufacturing Industries	0.2569	221	1.5787	98	0.9707
19	Otras actividades complementarios de transporte te	Logistics	0.2698	174	1.3232	90	0.9705
20	Elaboración de productos lácteos, helados	Manufacturing Industries	0.2537	264	1.3689	89	0.9394
21	Procesamiento y conservación de pescado y de produ	Manufacturing Industries	0.2731	164	1.1425	3	0.9299
22	Alquiler de otros tipos de maquinaria y equipo, n.	Real Estate and Other Business Activities	0.2506	219	1.6983	97	0.9073
23	Venta al por menor de otros productos en almacenes	Commerce Activities	0.2708	168	1.0761	644	0.8753
24	Alquiler de equipo de construcción o demolición do	Construction	0.2577	211	1.2380	67	0.8261
25	Producción de carne y de productos cárnicos	Manufacturing Industries	0.2567	236	1.1250	36	0.8258
26	Fabricación de otros artículos de papel y cartón	Manufacturing Industries	0.2507	188	1.6166	39	0.8009
27	Elaboración de otros productos alimenticios, n.c.p	Manufacturing Industries	0.2499	221	1.3773	21	0.7746
28	Telecomunicaciones	Logistics	0.2243	344	1.6887	428	0.7709
29	Venta al por menor de productos farmacéuticos y me	Commerce Activities	0.2539	205	1.2426	267	0.7483
30	Edición de periódicos, revistas y publicaciones pe	Manufacturing Industries	0.2336	255	1.7862	68	0.7447
31	Fabricación de azúcar	Manufacturing Industries	0.2632	191	0.8946	2	0.7334
32	Elaboración de aceites y grasas de origen vegetal	Manufacturing Industries	0.2624	152	1.1709	11	0.7322
33	Otras actividades empresariales, n.c.p. (Fotocopia	Real Estate and Other Business Activities	0.2212	365	1.5871	114	0.7305
34	Venta al por menor en almacenes no especializados	Commerce Activities	0.2742	165	0.5617	2947	0.7237
35	Actividades de otras asociaciones, n.c.p.; casa cl	Other Services	0.2312	347	1.2150	67	0.7069
36	Fabricación de jabones y detergentes, preparados p	Manufacturing Industries	0.2541	144	1.4912	12	0.7009
37	Extracción de piedra, arena y arcilla	Mining and Oil Extraction	0.2626	151	1.0455	66	0.6853
38	Fabricación de vidrio y de productos de vidrio	Manufacturing Industries	0.2496	190	1.3571	45	0.6847
39	Investigación y desarrollo de las ciencias natural	Real Estate and Other Business Activities	0.2348	320	1.1676	65	0.6832
40	Fabricación de artículos de hormigón, cemento yeso	Manufacturing Industries	0.2608	163	1.0278	134	0.6767
41	Elaboración de productos de molinería	Manufacturing Industries	0.2578	171	1.0476	16	0.6545
42	Elaboración de bebidas no alcohólicas; embotellado	Manufacturing Industries	0.2512	149	1.4487	11	0.6478
43	Alquiler de equipo de transporte por vía terrestre	Real Estate and Other Business Activities	0.2427	137	1.8412	20	0.6286
44	Actividades de asesoramiento empresarial y en mate	Real Estate and Other Business Activities	0.2254	259	1.7704	457	0.6122
45	Fabricación de sustancias químicas básicas, except	Manufacturing Industries	0.2531	115	1.4921	2	0.6118
46	Venta al por menor de combustible para automotores	Commerce Activities	0.2541	141	1.2482	247	0.5981
47	Acondicionamiento de edificios	Construction	0.2456	258	0.8646	861	0.5926
48	Actividades inmobiliarias realizadas con bienes pr	Real Estate and Other Business Activities	0.2272	262	1.5762	825	0.5739
49	Publicidad	Real Estate and Other Business Activities	0.2239	249	1.7917	59	0.5703
50	Mantenimiento y reparación de vehículos automotore	Commerce Activities	0.2626	162	0.6836	1405	0.5700

4.2. Eastern Panama: The case of Darién

As was discussed above, Eastern Panama seems to have the least complex and connected industrial structure in the country. In contrast to what Figure 33 showed for Colón, Figure 41 shows that the most interesting sectors from an opportunity standpoint have low feasibility given Darién's industrial structure.

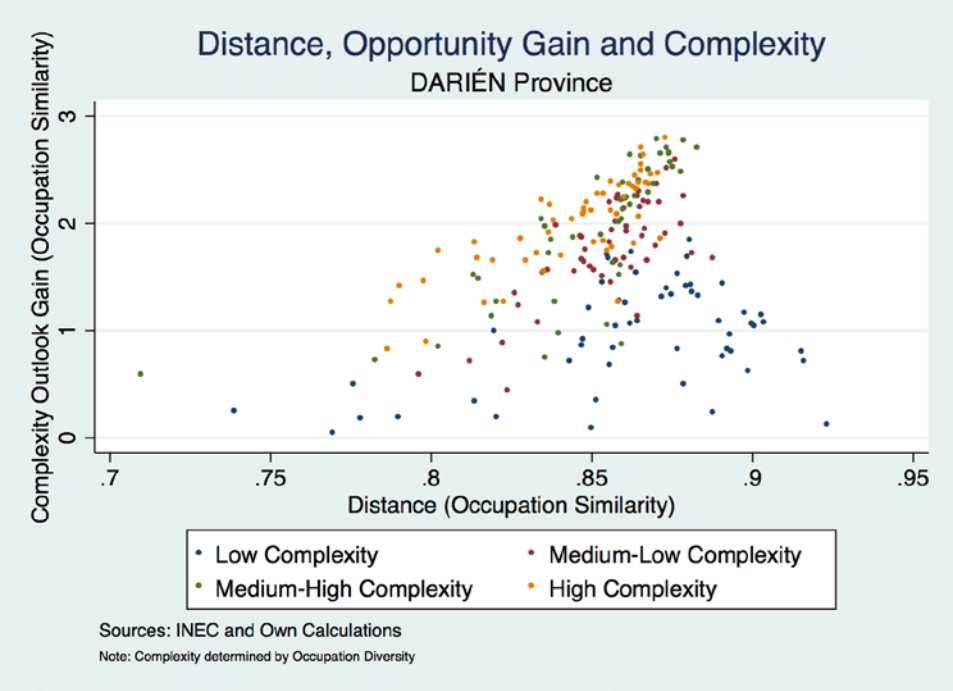

Figure 41. Distance, Opportunity Gain and Complexity (Darién Province)

Figure 42 plots aggregate sectors and average metrics of missing industries in Darién. Education services show up at a feasible distance, high level of complexity, and above-average COG. Logistics associated with transport services and Hotels and Restaurants sectors show relatively high connectivity and complexity opportunities at a medium feasibility level. Finally, the Real Estate and Commercial Activities sectors remain the highest complexity and connectivity opportunities, and relatively distant to Darién's current industrial structure.

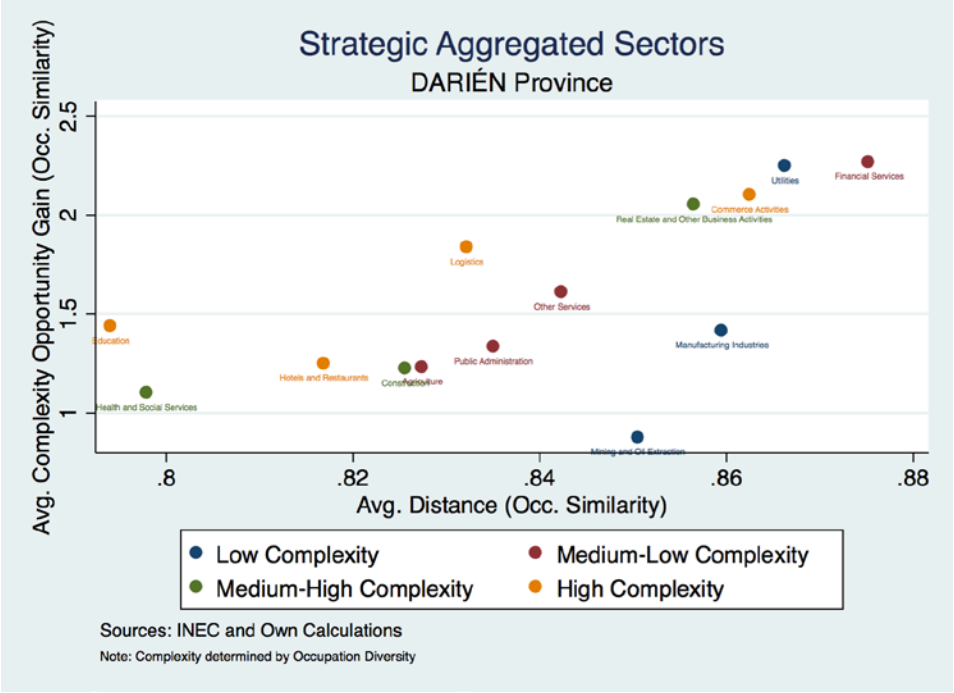

Figure 42. Strategic Aggregated Sectors (Darién Province)

Figure 43 to Figure 46 show specific missing industries by complexity block.

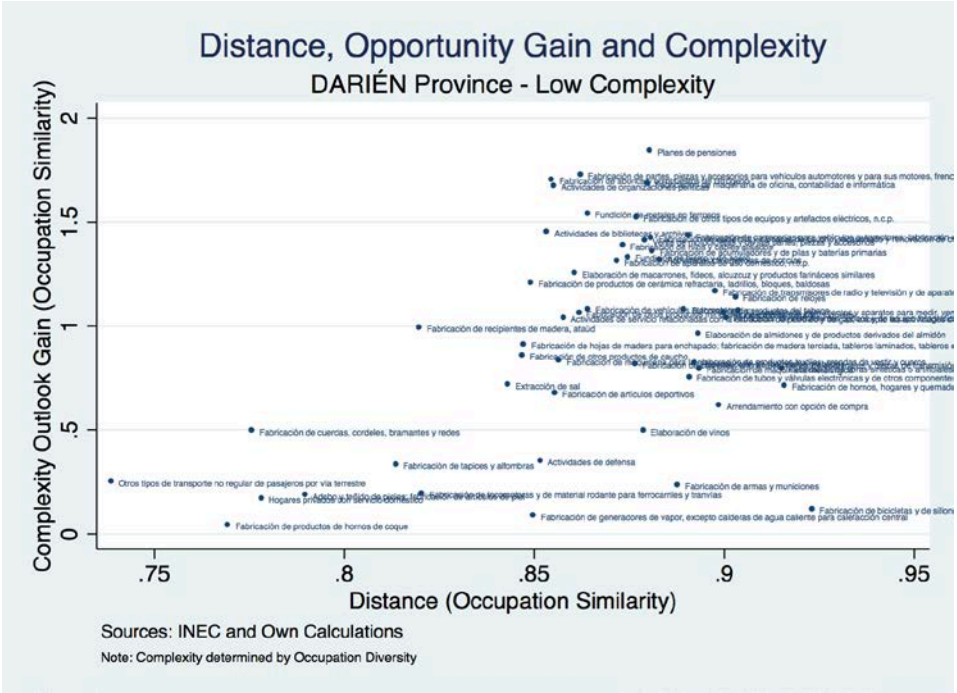

Figure 43. Distance, Opportunity Gain and Complexity (Darién - Low Complexity)

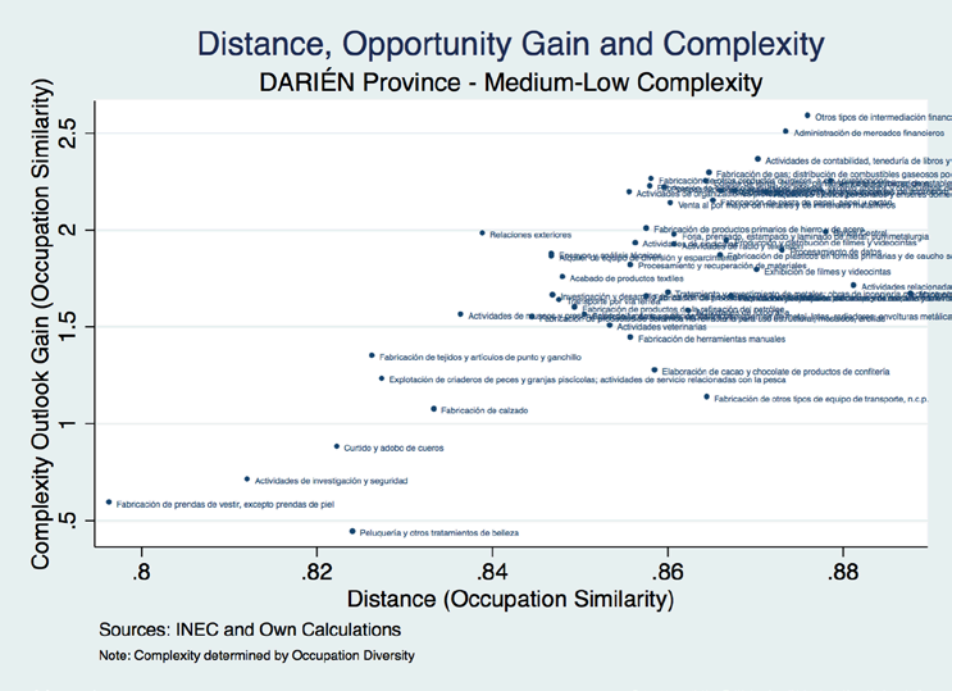

Figure 44. Distance, Opportunity Gain and Complexity (Darién - Medium-Low Complexity)

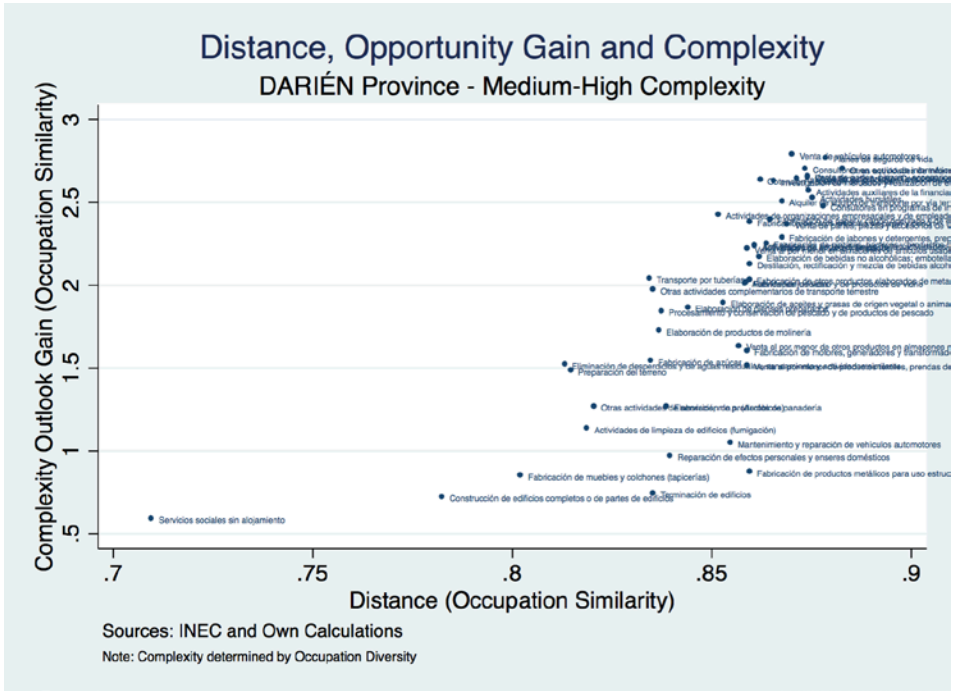

Figure 45. Distance, Opportunity Gain and Complexity (Darién - Medium-High Complexity)

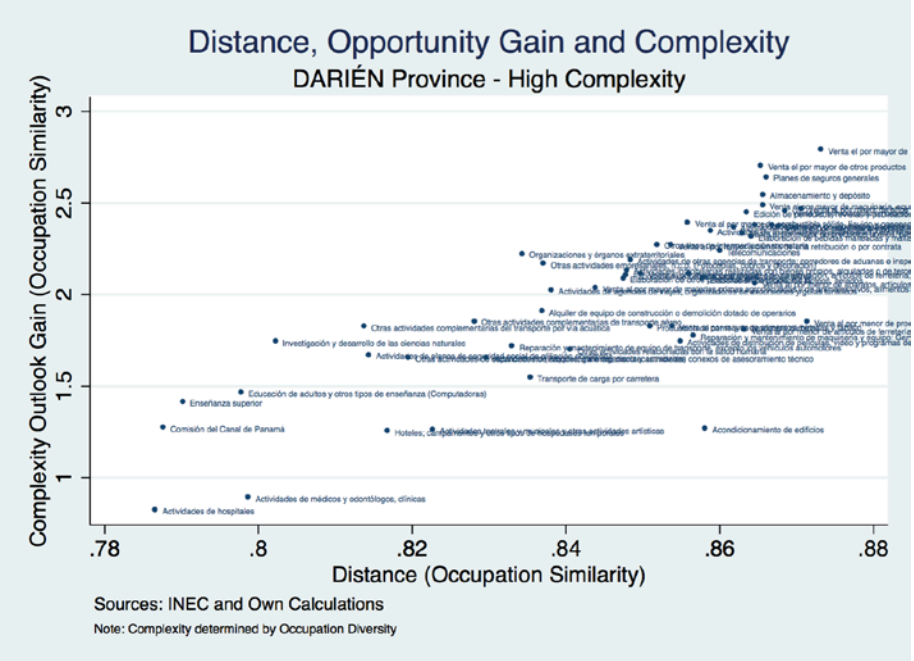

Figure 46. Distance, Opportunity Gain and Complexity (Darién - High Complexity)

Given Darién's disadvantaged position, deep in the Strategic Bets quadrant, industrial diversification measures for this region should prioritize opportunity over feasibility. Figure 47 shows which aggregate sectors fare best when averaging the Strategic Bets scores of Darién's missing industries. Education services account for the highest scores, while the Health and Social Services (mid-high complexity), Logistics (high complexity and mid opportunity gain) and Hotels and Restaurants (high complexity) sectors concentrate the areas of opportunity.

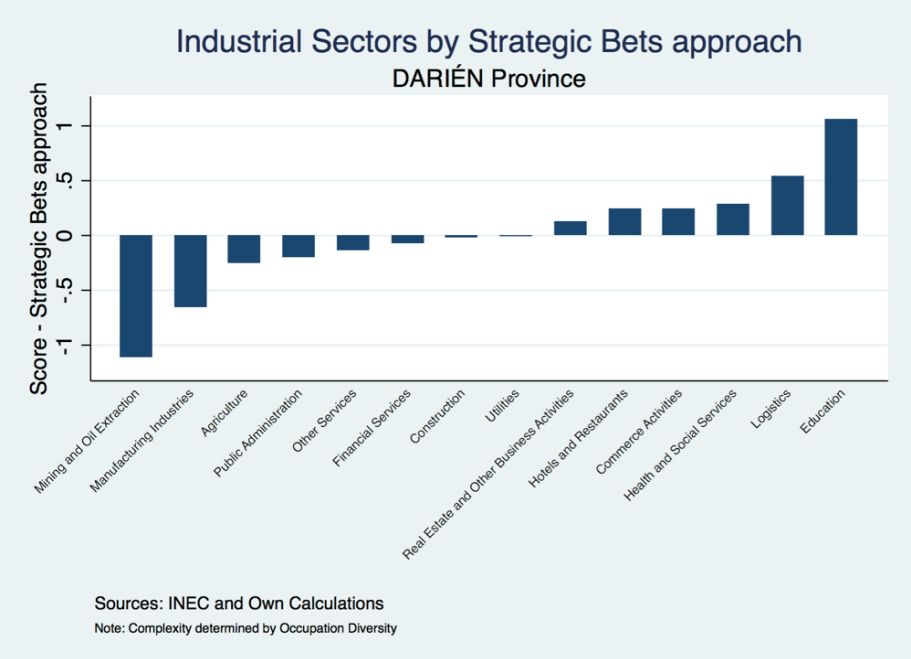

Figure 47. Industrial Sectors by Strategic Bets approach (Darién)

Finally, Figure 48 and Table 10 rank the top 50 missing industries in Darién, according to their Strategic Bets scores. While some manufacturing activities do make the cut (newsprint, paper, dairies and other edibles, cement, repair of transport equipment and plastics), even as Strategic Bets (more weight on COG and ECI) they are to be found at the bottom of the list. Sections such as Education and Health services probably reflect the relative insufficiencies of the State's footprint in Darién, the poorest province in Panama. Other than these (more a public good than an industry), it seems evident that sectors associated with the tourism industry (ecotourism) and logistic service associated to transport of goods are the most feasible opportunities.

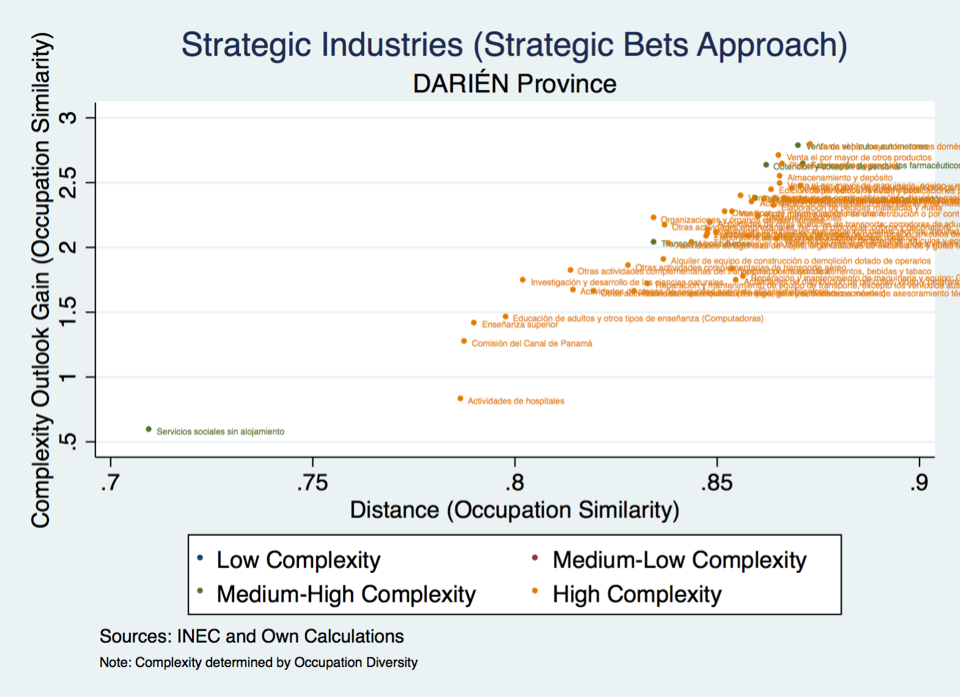

Figure 48. Strategic Industries (Strategic Bets Approach, Darién)

Table 10. Top 50 missing activities for industrial diversification for Darién (Strategic Bets)[31]

Rank	Industry	Section	Density	Complexity	COG	Employment	Score
1	Comisión del Canal de Panamá	Logistics	0.2123	439	1.2678	5	0.9858
2	Enseñanza superior	Education	0.2098	405	1.4116	48	0.9650
3	Otras actividades complementarias del transporte p	Logistics	0.1861	394	1.8213	11	0.9504
4	Otras actividades empresariales, n.c.p. (Fotocopia	Real Estate and Other Business Activities	0.1628	365	2.1640	5	0.8726
5	Actividades de distribución de películas, video y	Commerce Activities	0.1451	525	1.7418	102	0.8630
6	Investigación y desarrollo de las ciencias natural	Real Estate and Other Business Activities	0.1977	320	1.7392	4	0.8549
7	Venta al por mayor de maquinaria, equipo y materia	Commerce Activities	0.1343	348	2.4850	8	0.7698
8	Venta al por mayor a cambio de una retribución o p	Commerce Activities	0.1462	317	2.2658	44	0.6995
9	Telecomunicaciones	Logistics	0.1399	344	2.2348	33	0.6908
10	Otras actividades complementarias de transporte aé	Logistics	0.1718	306	1.8514	6	0.6834
11	Educación de adultos y otros tipos de enseñanza (C	Education	0.2021	271	1.4610	12	0.6665
12	Actividades de otras agencias de transporte, corre	Logistics	0.1515	298	2.1872	1	0.6664
13	Actividades de planos de seguridad social de afili	Public Administration	0.1855	282	1.6676	7	0.6564
14	Otras actividades de esparcimiento (Parques, galle	Other Services	0.1804	300	1.6533	35	0.6468
15	Venta el por mayor de enseres domésticos	Commerce Activities	0.1267	245	2.7873	2	0.6464
16	Venta al por mayor de materiales de construcción,	Commerce Activities	0.1501	308	2.1107	14	0.6411
17	Servicios sociales sin alojamiento	Health and Social Services	0.2902	120	0.5863	22	0.6377
18	Venta al por mayor de combustible sólido, líquido	Commerce Activities	0.1440	256	2.3891	2	0.6186
19	Venta el por mayor de otros productos	Commerce Activities	0.1345	217	2.7000	8	0.6106
20	Venta de vehículos automotores	Commerce Activities	0.1314	284	2.4511	4	0.6066
21	Otros tipos de intermediación monetaria	Financial Services	0.1480	257	2.2709	64	0.5973
22	Organizaciones y órganos extraterritoriales	Other Services	0.1656	199	2.2200	5	0.5925
23	Actividades de arquitectura e ingeniería y activid	Real Estate and Other Business Activities	0.1702	308	1.6534	11	0.5858
24	Edición de periódicos, revistas y publicaciones pe	Manufacturing Industries	0.1364	255	2.4444	5	0.5842
25	Actividades de asesoramiento empresarial y en mate	Real Estate and Other Business Activities	0.1411	259	2.3460	0	0.5833
26	Actividades inmobiliarias realizadas con bienes pr	Real Estate and Other Business Activities	0.1520	262	2.1312	6	0.5742
27	Venta al por menor de aparatos, artículos y equipo	Commerce Activities	0.1353	340	2.0587	14	0.5690
28	Venta al por mayor de materias primas agropecuaria	Commerce Activities	0.1560	258	2.0346	15	0.5528
29	Almacenamiento y depósito	Logistics	0.1343	223	2.5435	1	0.5501
30	Planes de seguros generales	Financial Services	0.1338	197	2.6391	4	0.5387
31	Publicidad	Real Estate and Other Business Activities	0.1354	249	2.3754	2	0.5336
32	Venta al por mayor de alimentos, bebidas y tabaco	Commerce Activities	0.1461	331	1.8245	46	0.5271
33	Actividades de agencias de viajes, organizadores d	Logistics	0.1618	215	2.0221	14	0.5060
34	Actividades de hospitales	Health and Social Services	0.2133	290	0.8217	208	0.4994
35	Alquiler de otros tipos de maquinaria y equipo, n.	Real Estate and Other Business Activities	0.1381	219	2.3633	9	0.4897
36	Venta al por mayor de otros efectos personales y p	Commerce Activities	0.1293	226	2.4674	2	0.4840
37	Elaboración de productos lácteos, helados	Manufacturing Industries	0.1421	264	2.0806	9	0.4808
38	Fabricación de cemento, cal y yeso	Manufacturing Industries	0.1521	219	2.1027	1	0.4775
39	Elaboración de otros productos alimenticios, n.c.p	Manufacturing Industries	0.1525	221	2.0843	4	0.4759
40	Reparación y mantenimiento de equipo de transporte	Manufacturing Industries	0.1669	248	1.7138	14	0.4701
41	Venta al por mayor de otros productos intermedios,	Commerce Activities	0.1323	230	2.3664	9	0.4688
42	Transporte por tuberías	Logistics	0.1655	176	2.0374	0	0.4641
43	Fabricación de productos farmacéuticos, sustancias	Manufacturing Industries	0.1285	175	2.6410	1	0.4560
44	Elaboración de bebidas malteadas y malta	Manufacturing Industries	0.1358	221	2.3143	4	0.4545
45	Alquiler de equipo de construcción o demolición do	Construction	0.1630	211	1.9033	5	0.4539
46	Fabricación de productos de plástico, envases de p	Manufacturing Industries	0.1331	216	2.3772	0	0.4521
47	Fabricación de otros artículos de papel y cartón	Manufacturing Industries	0.1403	188	2.3776	3	0.4516
48	Reparación y mantenimiento de maquinaria y equipo:	Manufacturing Industries	0.1433	310	1.7701	4	0.4402
49	Venta de vehículos automotores	Commerce Activities	0.1297	129	2.7843	0	0.4396
50	Obtención y dotación de personal	Real Estate and Other Business Activities	0.1378	131	2.6323	0	0.4356

4.3. Western Panama: The case of Chiriquí

The Western Panama region falls between the interoceanic region and Eastern Panama in terms of economic complexity. The case of Chiriquí is representative, as its scatterplot of missing industries (Figure 49) is somewhere between that of Colón and that of Darién. The relationship between opportunity and distance is still positive, but visibly less steep than that of Darién. Several medium-high and high-complexity sectors with interesting COG levels appear at a medium distance, suggesting that interesting sectors are attainable– as expected from Chiriquí's strategic position (Figure 31).

[31] Our hands-off statistical approach yields Logistics: Commission of the Panama Canal as the most feasible industry, which is clearly not a transferable economic activity.

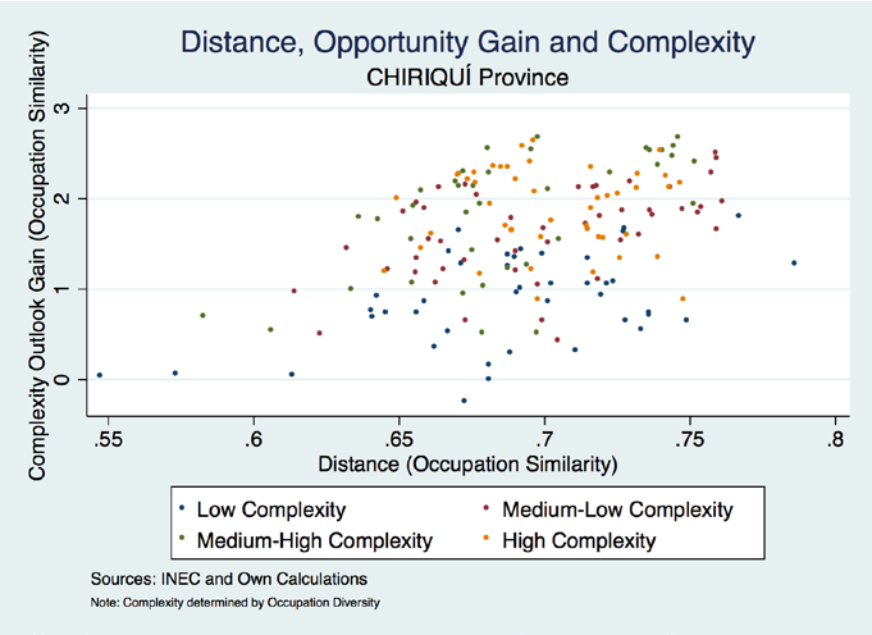

Figure 49. Distance, Opportunity Gain and Complexity (Chiriquí Province)

The aggregation of these metrics by sector confirms our initial intuition, as depicted in Figure 50. Mid-high complexity industries in Construction; and Hotels and Restaurants sectors are relatively close. Moreover, tradable opportunities in Agriculture and Manufacturing seem to balance feasibility and connectivity in interesting ways. Lastly, commercial activities that account for the highest levels of complexity and COG appear only at a medium distance.

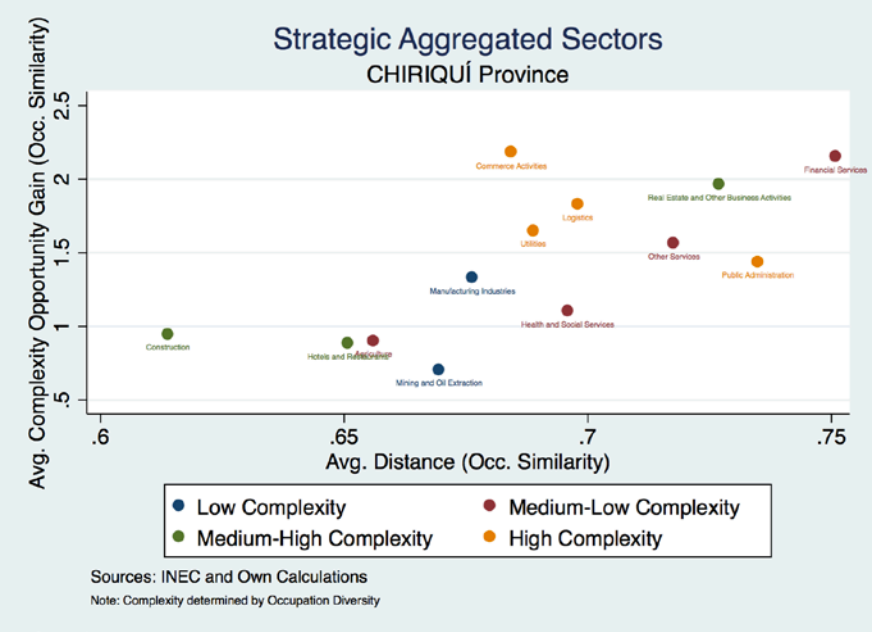

Figure 50. Strategic Aggregated Sectors (Chiriquí)

Again, Figure 51 to Figure 54 show specific industries by complexity blocks.

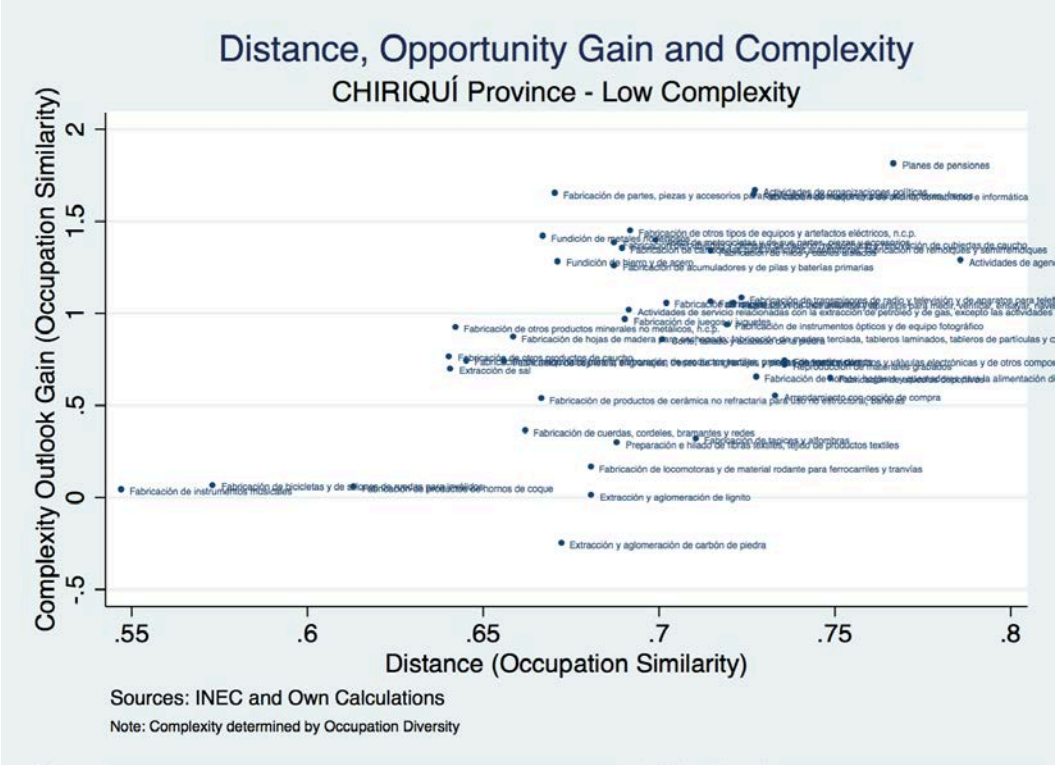

Figure 51. Distance, Opportunity Gain and Complexity (Chiriquí - Low Complexity)

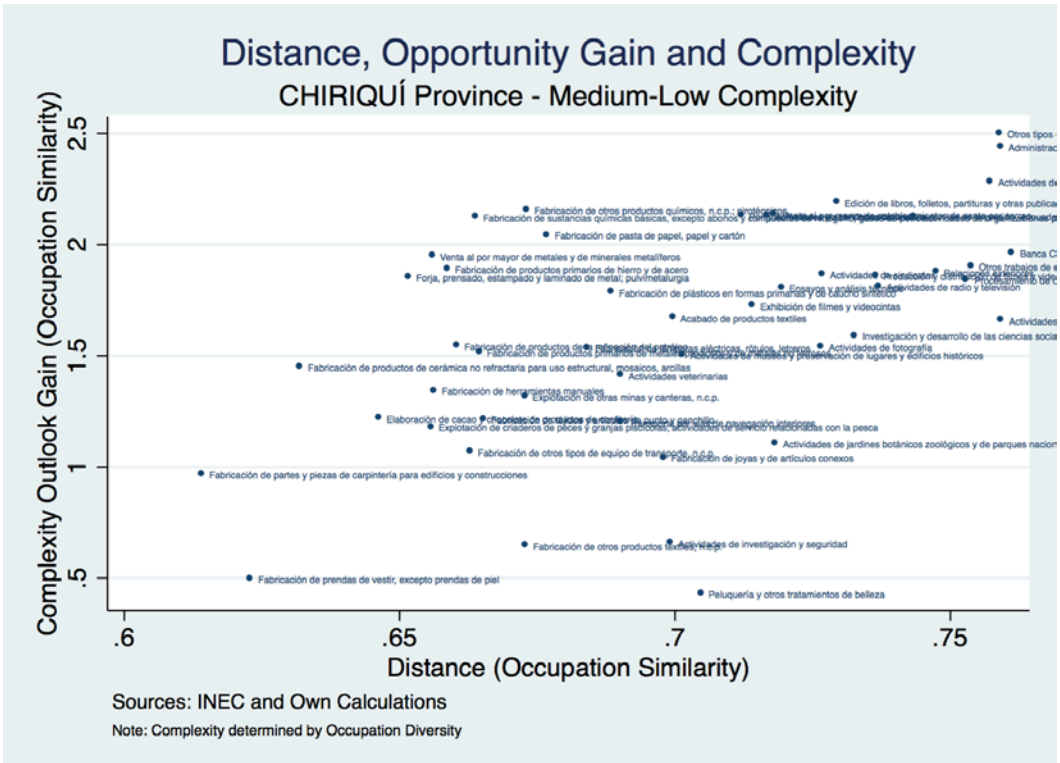

Figure 52. Distance, Opportunity Gain and Complexity (Chiriquí - Medium-Low Complexity)

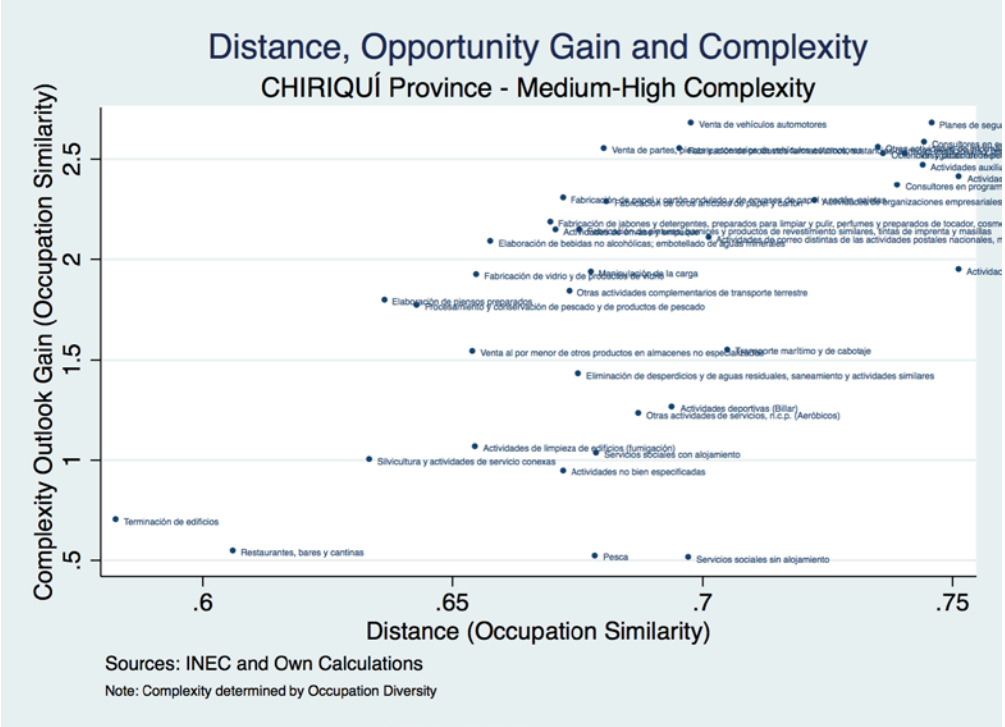

Figure 53. Distance, Opportunity Gain and Complexity (Chiriquí - Medium-High Complexity)

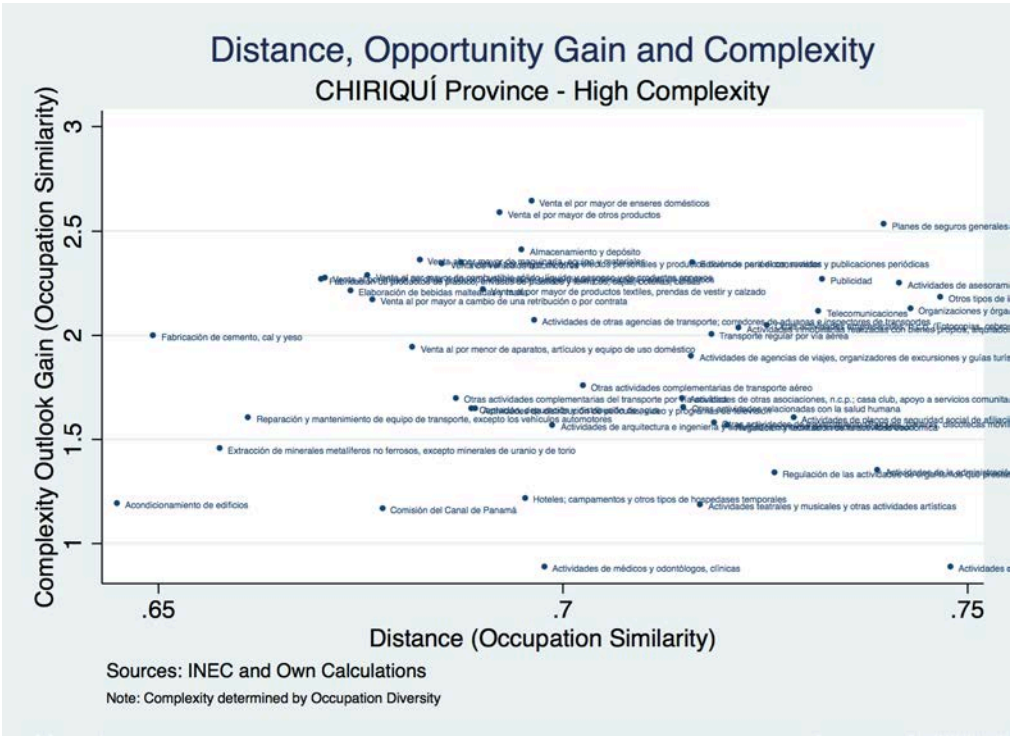

Figure 54 - Distance, Opportunity Gain and Complexity (Chiriquí - High Complexity)

Chiriquí is among the best-positioned provinces in the Ripe Fruit quadrant of Figure 31. Figure 55 shows aggregated industrial sector scores according to the average

score of their corresponding sections. Commercial Activities, Logistics, Construction and Utilities seem to be the sectors offering the most interesting diversification opportunities for Chiriquí.

Figure 56 and Table 11 describe the characteristics of the top 50 industries in terms of their Ripe Fruit score. The diverse manufacturing industries that make the list suggest interesting opportunities for tradable development in Chiriquí, a fact that was not apparent from the low aggregate scores obtained by Manufacturing and Agriculture in Figure 55. Again, this is due to other manufacturing sector products pulling the sector average downwards due to high distances to Chiriquí's export structure. Nevertheless, it's worth remarking that the upper half of top 50 list of potential industries is populated by manufacturing, mostly related to minerals (metal press, forged metal, primary products derived from iron, coke ovens), construction materials (cement, lime, cast), and goods derived from wood (carpentry, musical instruments). The presence of several activities in Wholesale commerce and transport logistics suggests that it could also leverage its position as bordering province to the rest of Central America to develop the sectors that are already relatively close to its productive structure.

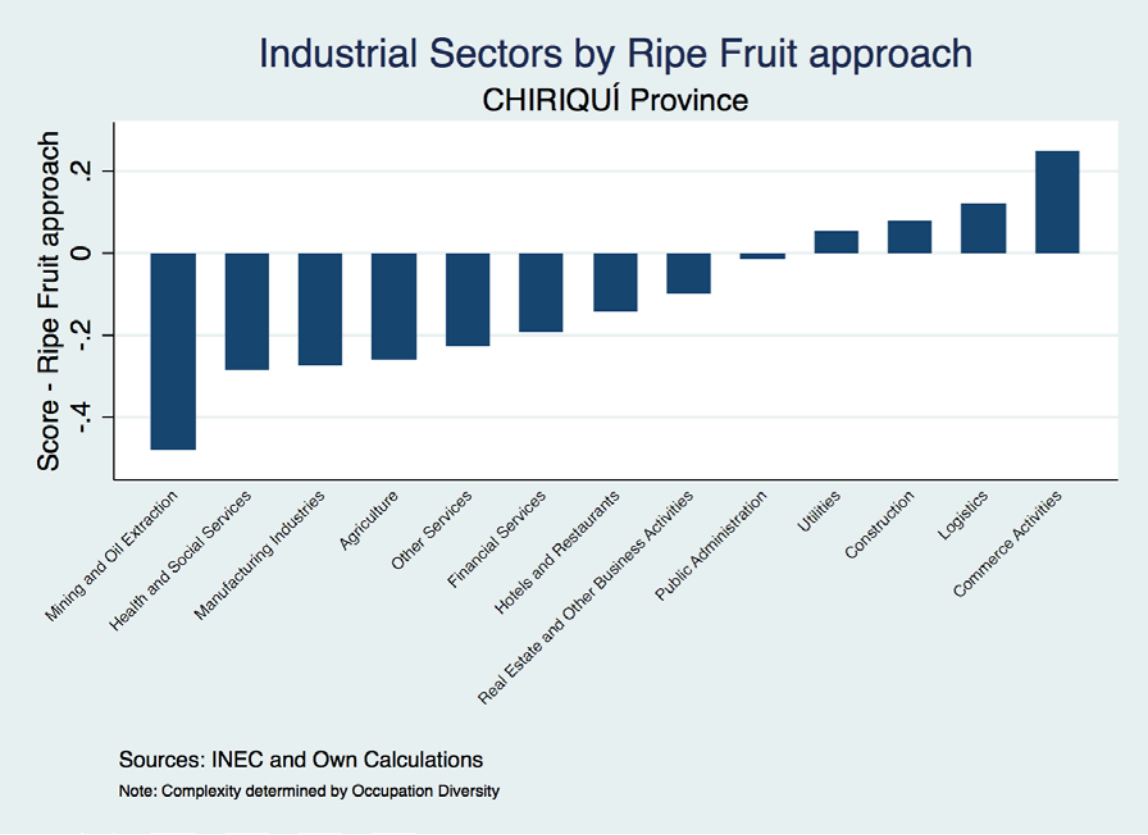

Figure 55. Industrial Sectors by Ripe Fruit approach (Chiriquí)

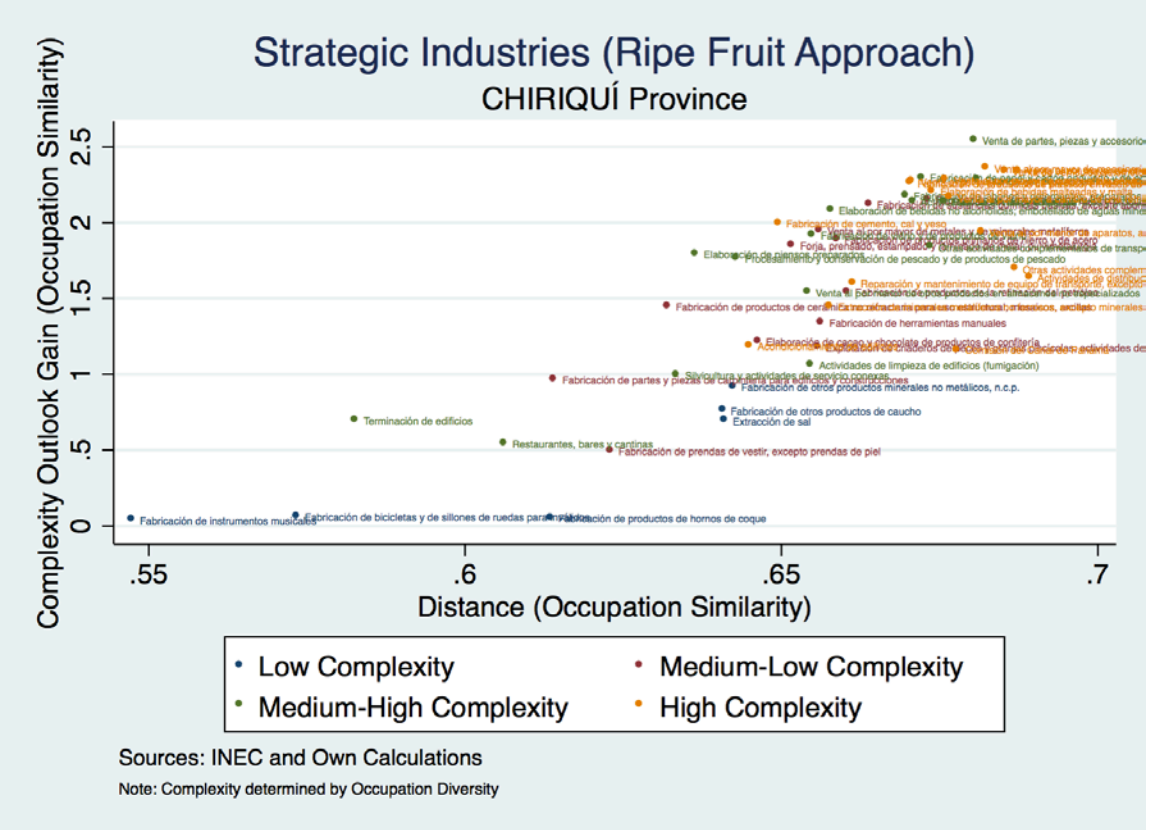

Figure 56. Strategic Industries (Ripe Fruit Approach, Chiriquí)

Table 11. Top 50 missing activities for industrial diversification for Chiriquí (Ripe Fruit)

Rank	Industry	Section	Density	Complexity	COG	Employment	Score
1	Fabricación de instrumentos musicales	Manufacturing Industries	0.4527	9	0.0399	0	1.661
2	Terminación de edificios	Construction	0.4173	175	0.6985	685	1.518
3	Fabricación de bicicletas y de sillones de ruedas	Manufacturing Industries	0.4266	2	0.0627	0	1.263
4	Restaurantes, bares y cantinas	Hotels and Restaurants	0.3938	131	0.5438	4555	1.066
5	Fabricación de partes y piezas de carpintería para	Manufacturing Industries	0.3859	74	0.9679	70	0.955
6	Elaboración de piensos preparados	Manufacturing Industries	0.3635	132	1.7951	52	0.886
7	Fabricación de cemento, cal y yeso	Manufacturing Industries	0.3505	219	1.9969	53	0.862
8	Fabricación de productos de cerámica no refractari	Manufacturing Industries	0.3679	108	1.4490	21	0.841
9	Procesamiento y conservación de pescado y de produ	Manufacturing Industries	0.3570	164	1.7674	49	0.828
10	Acondicionamiento de edificios	Construction	0.3550	258	1.1884	1204	0.810
11	Silvicultura y actividades de servicio conexas	Agriculture	0.3665	127	0.9980	191	0.748
12	Fabricación de prendas de vestir, excepto prendas	Manufacturing Industries	0.3770	92	0.4969	704	0.745
13	Fabricación de vidrio y de productos de vidrio	Manufacturing Industries	0.3450	190	1.9207	60	0.720
14	Fabricación de productos de hornos de coque	Manufacturing Industries	0.3865	4	0.0524	0	0.661
15	Elaboración de bebidas no alcohólicas; embotellado	Manufacturing Industries	0.3422	149	2.0827	84	0.652
16	Reparación y mantenimiento de equipo de transporte	Manufacturing Industries	0.3387	248	1.6027	68	0.641
17	Actividades de distribución de películas, video y	Commerce Activities	0.3108	525	1.6421	2089	0.637
18	Venta al por mayor de maquinaria, equipo y materia	Commerce Activities	0.3176	348	2.3581	176	0.636
19	Venta al por mayor a cambio de una retribución o p	Commerce Activities	0.3234	317	2.1673	319	0.636
20	Forja, prensado, estampado y laminado de metal; pu	Manufacturing Industries	0.3483	108	1.8530	10	0.634
21	Venta al por mayor de otros productos intermedios,	Commerce Activities	0.3293	230	2.2725	327	0.620
22	Venta al por menor de otros productos en almacenes	Commerce Activities	0.3458	168	1.5417	1275	0.617
23	Fabricación de productos de plástico, envases de p	Manufacturing Industries	0.3298	216	2.2626	151	0.603
24	Venta al por mayor de metales y de minerales metal	Commerce Activities	0.3440	106	1.9486	15	0.587
25	Extracción de minerales metalíferos no ferrosos, e	Mining and Oil Extraction	0.3423	196	1.4511	8	0.585
26	Venta al por mayor de combustible sólido, líquido	Commerce Activities	0.3240	256	2.2820	177	0.580
27	Comisión del Canal de Panamá	Logistics	0.3222	439	1.1639	44	0.578
28	Elaboración de bebidas malteadas y malta	Manufacturing Industries	0.3261	221	2.2116	116	0.545
29	Venta al por menor de aparatos, artículos y equipo	Commerce Activities	0.3184	340	1.9380	652	0.545
30	Fabricación de sustancias químicas básicas, except	Manufacturing Industries	0.3362	115	2.1238	12	0.521
31	Fabricación de productos primarios de hierro y de	Manufacturing Industries	0.3413	96	1.8914	27	0.519
32	Elaboración de cacao y chocolate de productos de c	Manufacturing Industries	0.3537	55	1.2179	9	0.498
33	Venta de vehículos automotores	Commerce Activities	0.3148	284	2.3396	643	0.495
34	Fabricación de papel y cartón ondulado y de envase	Manufacturing Industries	0.3278	156	2.2989	13	0.493
35	Otras actividades complementarias del transporte p	Logistics	0.3131	394	1.6956	113	0.491
36	Fabricación de jabones y detergentes, preparados p	Manufacturing Industries	0.3304	144	2.1822	21	0.489
37	Fabricación de otros productos minerales no metáli	Manufacturing Industries	0.3576	31	0.9198	0	0.456
38	Actividades de envase y empaque	Real Estate and Other Business Activities	0.3293	132	2.1407	26	0.446
39	Fabricación de otros productos de caucho	Manufacturing Industries	0.3593	30	0.7624	3	0.445
40	Actividades de limpieza de edificios (fumigación)	Real Estate and Other Business Activities	0.3453	118	1.0649	455	0.430
41	Extracción de sal	Mining and Oil Extraction	0.3589	28	0.6927	0	0.421
42	Explotación de criaderos de peces y granjas piscíc	Agriculture	0.3443	105	1.1799	50	0.421
43	Fabricación de otros artículos de papel y cartón	Manufacturing Industries	0.3190	188	2.2824	45	0.405
44	Otras actividades complementarios de transporte te	Logistics	0.3265	174	1.8399	108	0.399
45	Fabricación de productos de la refinación del petr	Manufacturing Industries	0.3396	82	1.5444	6	0.396
46	Fabricación de herramientas manuales	Manufacturing Industries	0.3437	65	1.3431	21	0.389
47	Venta al por mayor de otros efectos personales y p	Commerce Activities	0.3125	226	2.3473	29	0.377
48	Fabricación de otros productos químicos, n.c.p.; p	Manufacturing Industries	0.3269	108	2.1544	19	0.377
49	Fabricación de pinturas, barnices y productos de r	Manufacturing Industries	0.3244	134	2.1418	31	0.375
50	Venta de partes, piezas y accesorios de vehículos	Commerce Activities	0.3195	122	2.5479	42	0.373

5. Conclusions and Policy Recommendations

The process of productive diversification poses a chicken-and-egg dilemma: Some desirable industries are not present, because places lack the skills and know-how required, but there are little incentives to acquire those skills for industries that do not exist. Hidalgo and Hausmann (2009) have provided a hint on how societies overcome this dilemma. Countries and regions do not diversify at random, but rather spread towards economic activities that demand similar capabilities and know-how than the ones they already have. Through this process, productive capacities, skills and know-how can be recombined and redeployed into technologically "adjacent" economic activities.
Based on these findings, we set out to find export diversification opportunities for Panama. Once we corrected Panama's reported exports by subtracting imports which are later re-exported, we were left with exports representing less than 1% of GDP. These exports are highly concentrated around agricultural and mining products with poor connectivity to other products and very low complexity. It is therefore not surprising that the most adjacent exportable goods we have detected are mostly concentrated around vegetables and foodstuffs, paper, and some preparations of cereals, flour and starch.

The approach based on co-origination of goods that Hidalgo and Hausmann (2009) have suggested clearly fails to take into account the fact that Panama's less ubiquitous capabilities and know-how are to be found in its modern services sector. In order to address this shortcoming, we devised proximity measures for Panamanian industries (comprising goods and services) using three different approaches. First, we built a co-location matrix of proximities between pairs of goods, based on the same co-location criteria proposed by Hausmann and Hidalgo (2009), but applied to relative intensities of employment (as opposed to relative intensities of exports). Secondly, we used a proximity matrix based on labor flows. Since we were unable to obtain data on labor flows from Panama's Social Security office, we use the proximity matrix for Sweden derived by Neffke and Hartog (2014). Under the reasonable assumption that technological proximities should not be country-specific, we converted the Swedish industry classification system into its corresponding Panamanian equivalent, and used the Sweden-based proximity matrix based on labor flows. Finally, we built a proximity matrix based on occupation-similarity. This approach suggests that sectors that overlap in an important part of their occupation vectors will tend to require relatively similar talents if they are to be developed effectively.

In order to decide which among these three proximity matrices is most relevant to the Panamanian case, we tested their ability to predict the observed employment growth by sector (intensive margin) and the appearance and disappearance of industries (extensive margin). The most important finding to be gleaned from both the intensive and extensive margin regressions is that the Density metric resulting from the proximities based on occupation-similarity displays the most robust

positive association with future employment growth at the industry/region level of analysis, and appearance and disappearance of industries.

These results are robust to the inclusion of the three alternative density metrics and to the clustering of standard errors at the industry or province levels. We also found that our results with the three Density metrics remained consistent at both the district and province level. This is a fortunate feature, as it would have been hard to explain why some significant positive associations at the province level break down at the district level (possibly attributable to agglomeration effects), or vice versa.

Of all the three approaches, the Density metric computed based on Swedish-based labor flows exhibits the weakest links to both the intensive and the extensive margins. An interesting extension of our analysis would involve computing a proximity matrix based on Panamanian labor flows as derived from social security data, and testing its power to predict employment growth and appearance or disappearance of sectors at the sub-national level. This might lead to the uncomfortable result that technological proximities as measured by labor flows are not the same across countries.

Finally, we have used our Density metric based on occupation-similarity to identify potential diversification opportunities at the province level, in both goods and services. We take into account that the knowledge embedded in the service industries does reveal a set of richer and more complex export diversification opportunities, which we would not have observed by only considering the exports of goods. In Colón, where trade services are preponderant, logistics shows up as a significant opportunity in services; but so do goods such as plastics (plates, sheets, vases, containers). In Chiriquí, one of the Panamanian provinces with higher potential, diversification opportunities are concentrated around fishing, mineral-related manufacturing (metal press, forged metal, primary products derived from iron, coke ovens), and construction materials (cement, lime, cast). The presence of several activities in the wholesale commerce and transport logistics categories suggests that Chiriquí could also leverage its position as bordering province to develop service sectors that are already relatively close to its current productive structure.

We illustrated the case of three provinces that display significant differences with respect to the stock of skills and knowledge they possess at the beginning (2010). We have suggested a framework to define the nature of industrial policy in each case, depending on whether provinces have low hanging fruits (due to a large set of knowledge and capabilities at the onset) and therefore require a more parsimonious "do not fix it, it's not broken" approach; or whether they have scant capabilities and are only able to produce goods and services of low complexity, and therefore require a more adventurous policy framework which entails pursuing strategic bets.

In contrast to the different Density metrics we estimated based on alternate ways of measuring technological proximity, here we have no way of gauging the goodness of

the framework proposed. We have only intended to stress the differences between places that are able to manufacture multiple products and provide a wide range of services, and those that are just able to produce a few goods and services that on average many others are able to make. Igniting the flame of productive diversification would entail totally different industrial policy approaches, and would involve different types and levels of risk in either case.

Our results are not meant to be considered as a mandate, nor as the result of a process aimed at picking winners in the lottery of industrial policy. We only provide a roadmap to guide the search for strategic sectors that could potentially help Panama in diversifying its competitive exports of goods and services. These lists only point to potential sectors demanding capabilities that, to a varying extent, are already on site for each of the provinces. A more in-depth industry analysis should ensue, in order to establish market potential, missing capabilities, and what can be done to ease their supply in an efficient way.

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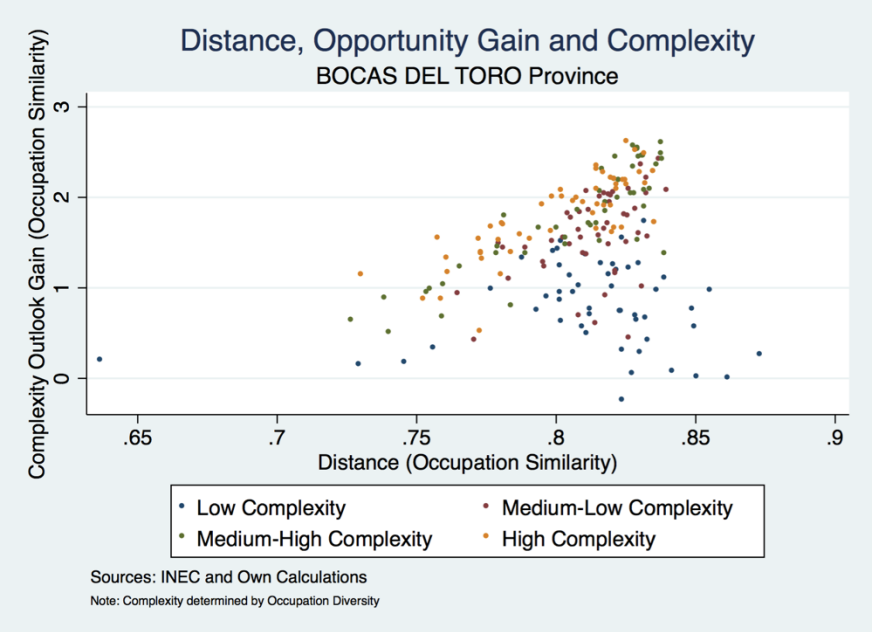
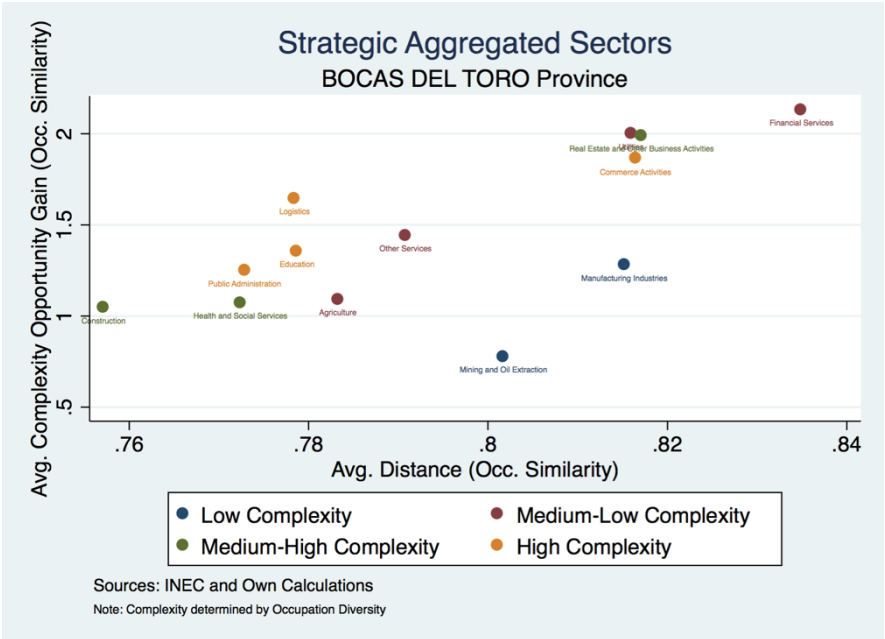
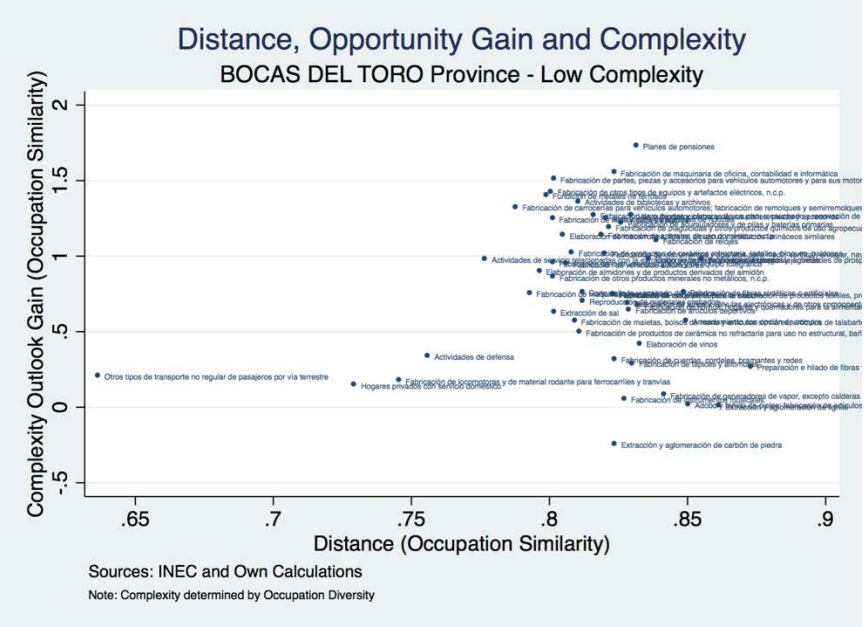
Appendix I

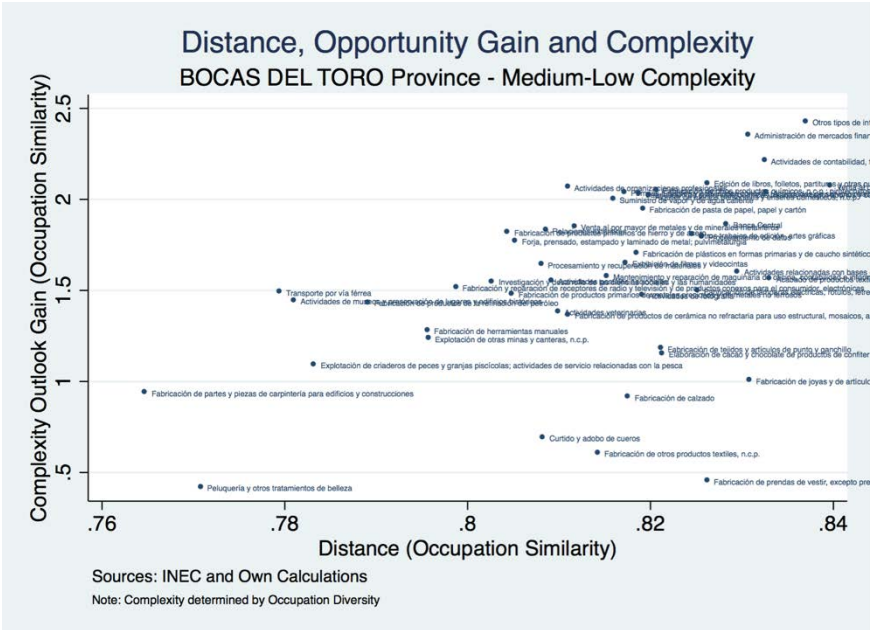


Appendix 1 - Distance, Opportunity Gain and Complexity (Bocas del Toro Province)

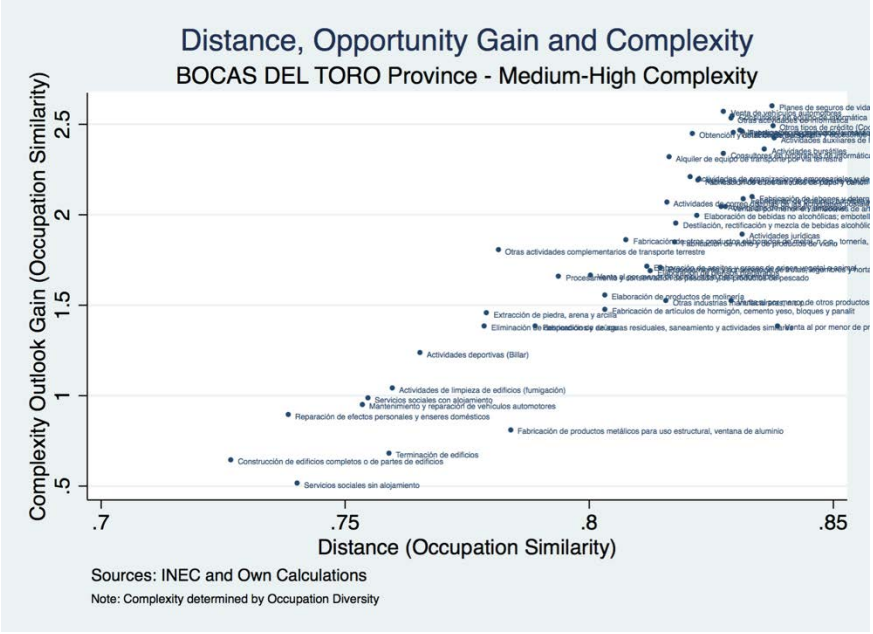




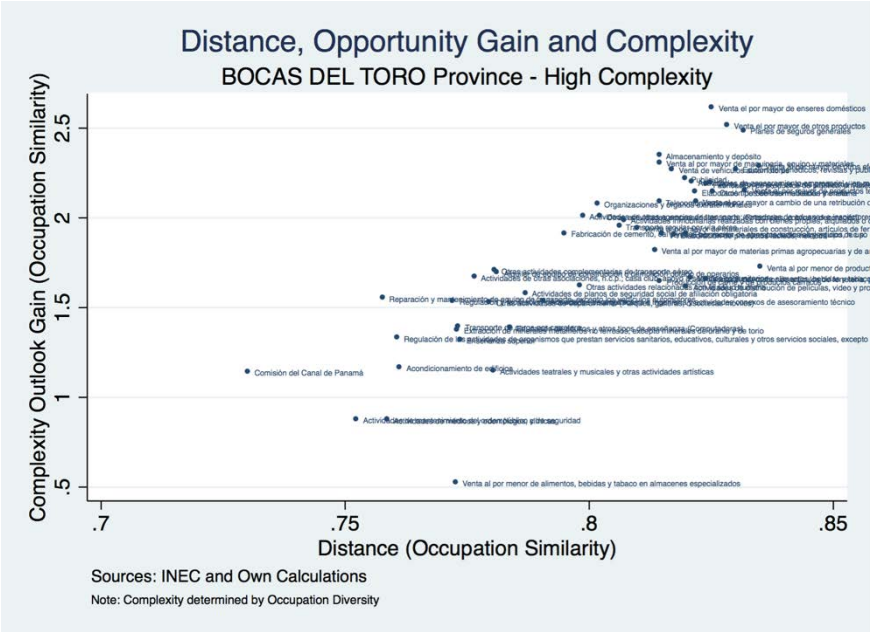
Appendix 2 - Distance, Opportunity Gain and Complexity (Bocas del Toro Province - Low Complexity)



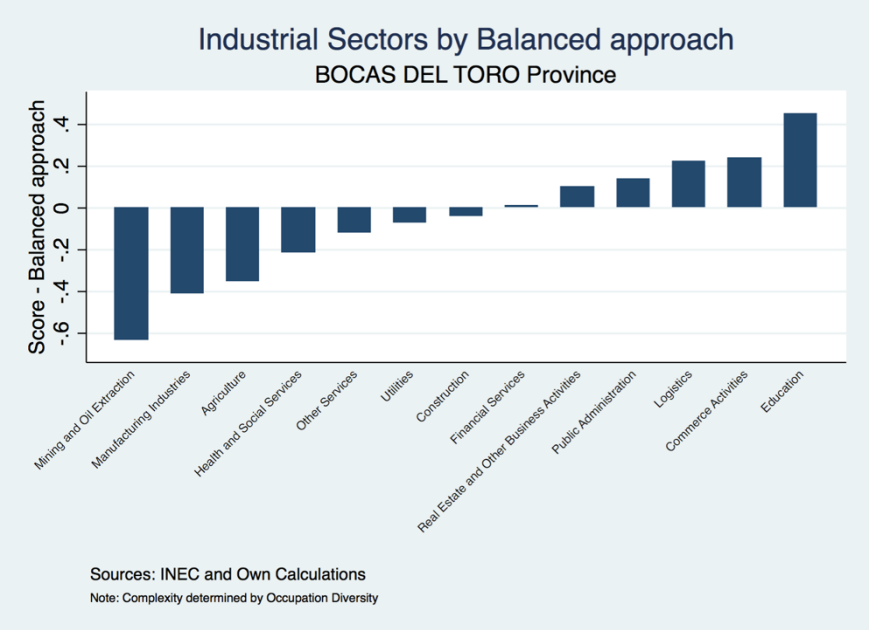
Appendix 3 - Distance, Opportunity Gain and Complexity (Bocas del Toro Province - Medium-Low Complexity)



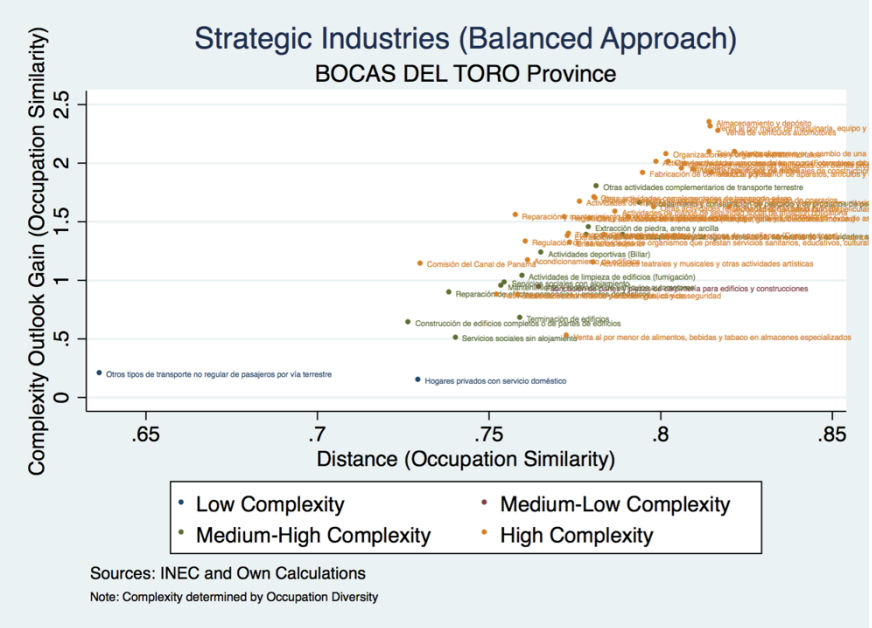
Appendix 4 - Distance, Opportunity Gain and Complexity (Bocas del Toro Province - Medium-High Complexity)



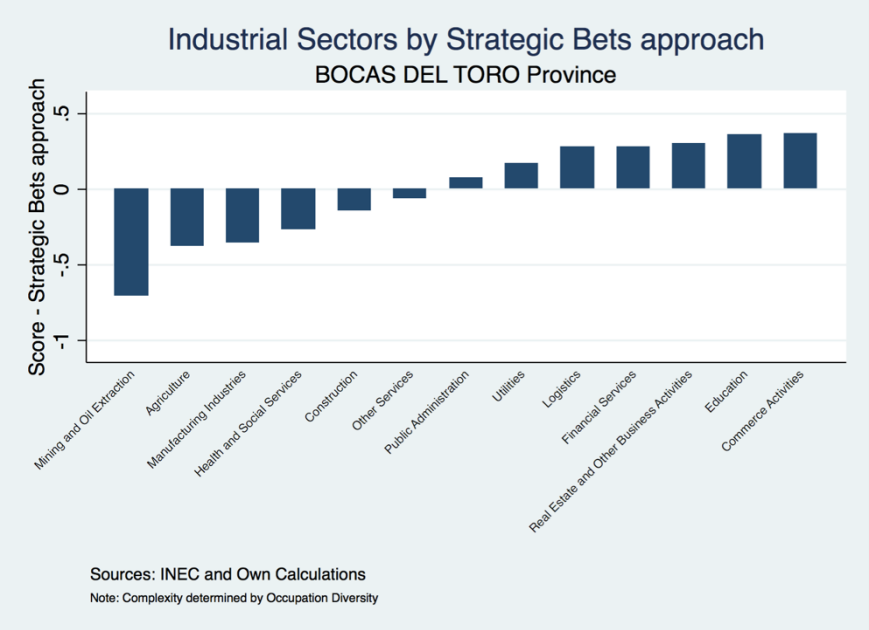
Appendix 5 - Distance, Opportunity Gain and Complexity (Bocas del Toro Province - High Complexity)



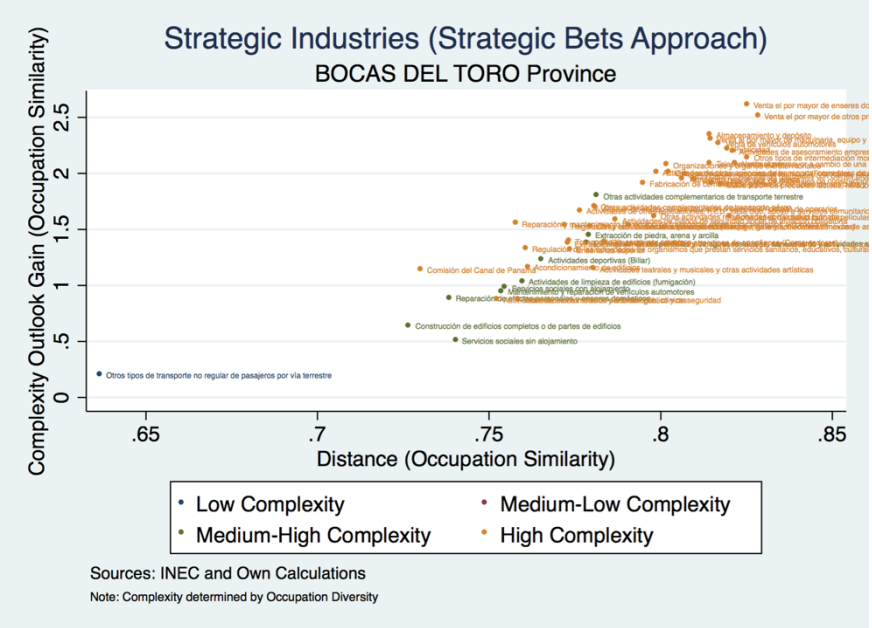
Appendix 6 - Industrial Sectors by Balanced approach (Bocas del Toro Province)



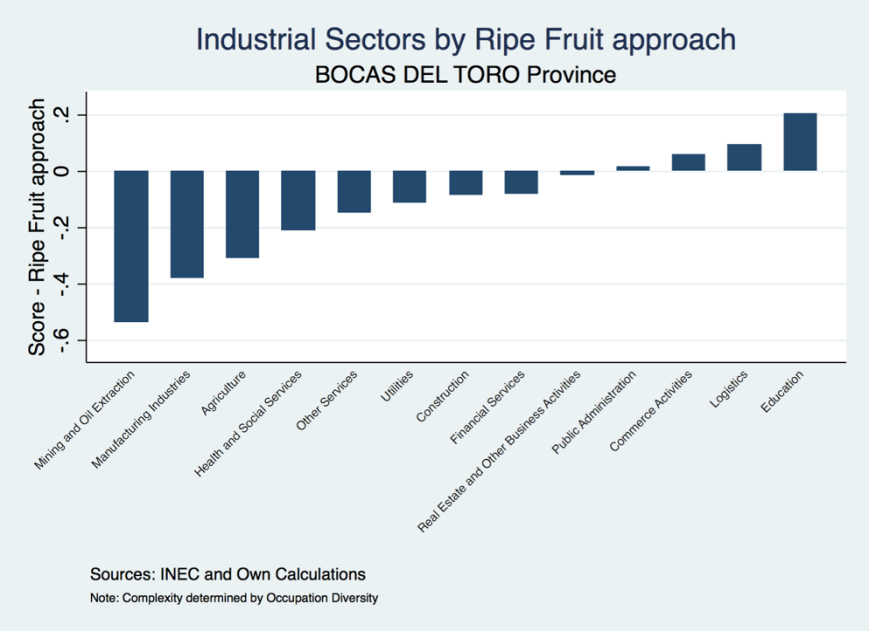
Appendix 7 - Strategic Industries (Balanced Approach, Bocas del Toro Province)



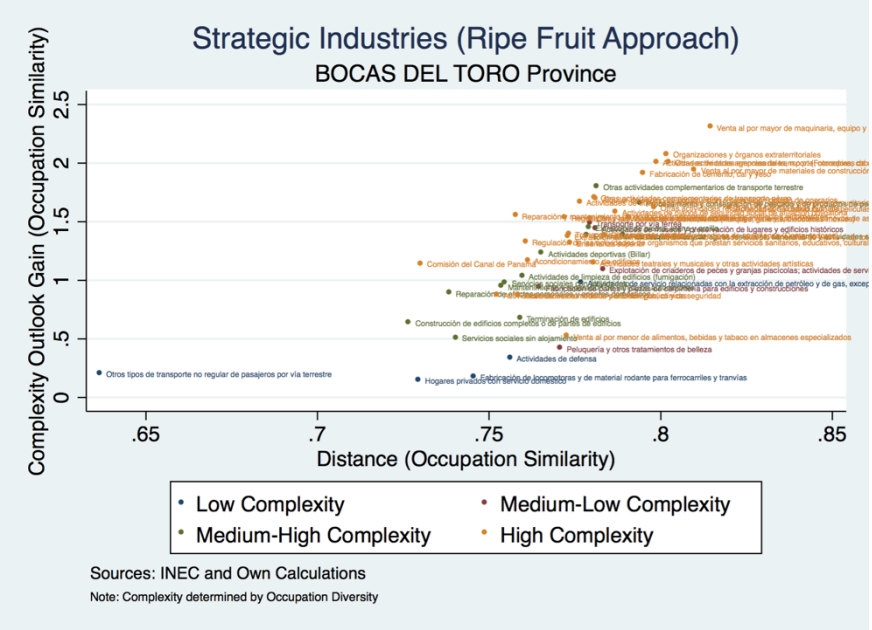
Appendix 8 - Industrial Sectors by Strategic Bets approach (Bocas del Toro Province)



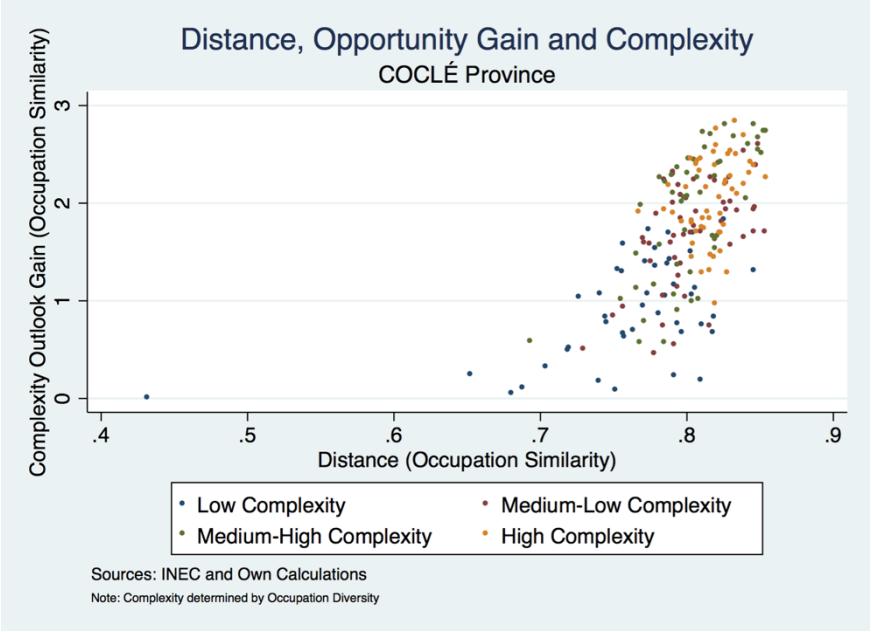
Appendix 9 - Strategic Industries (Strategic Bets Approach, Bocas del Toro Province)



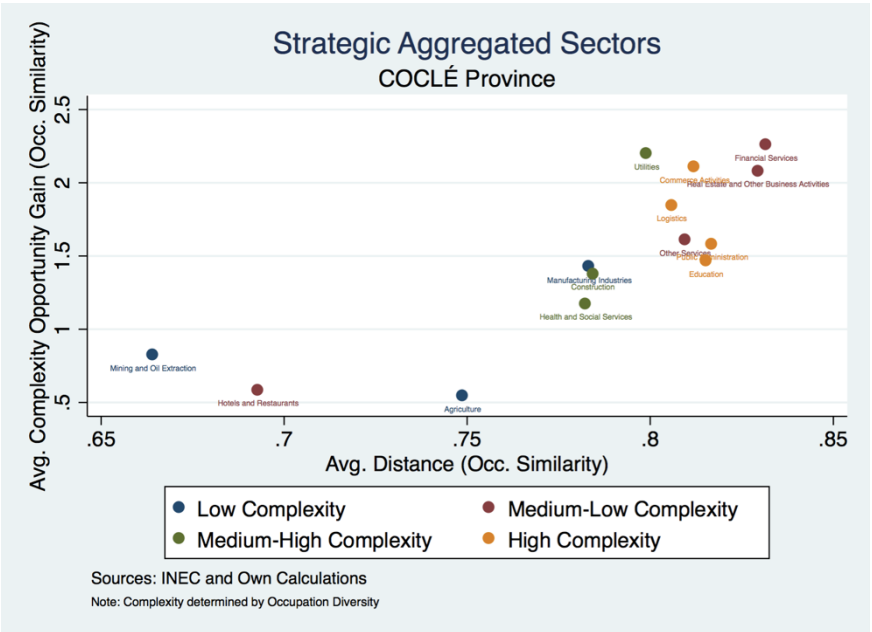
Appendix 10 - Industrial Sectors by Ripe Fruit approach (Bocas del Toro Province)



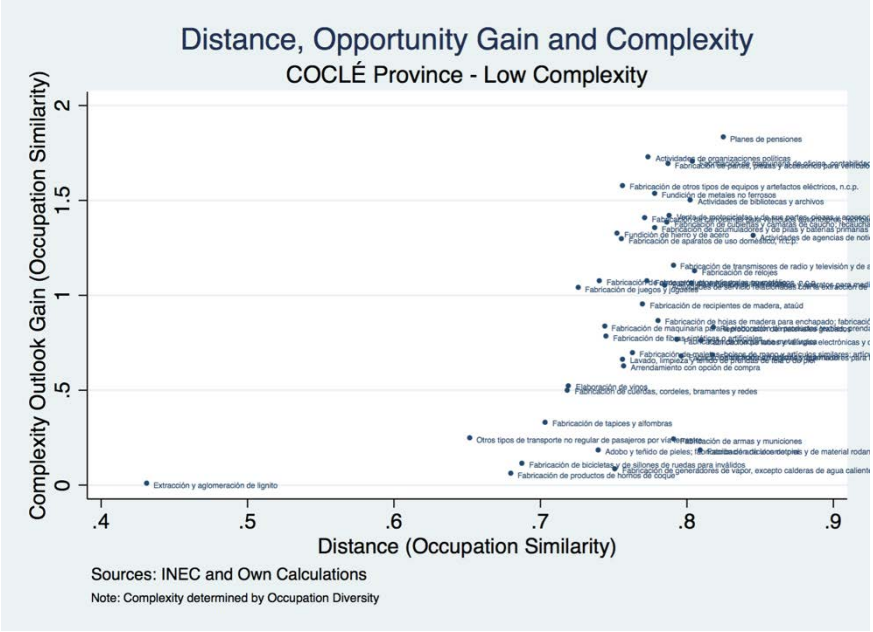
Appendix 11 - Strategic Industries (Ripe Fruit Approach, Bocas del Toro Province)



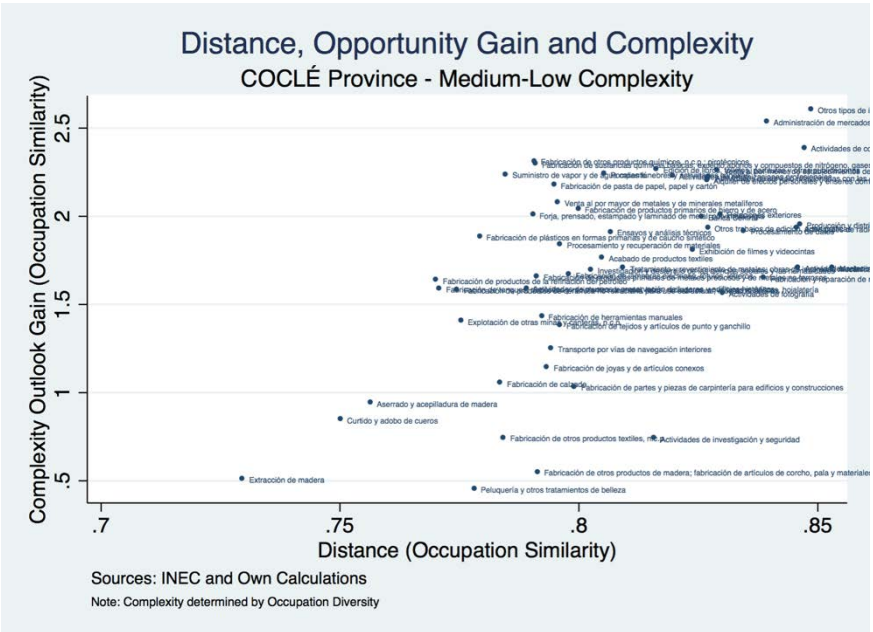
Appendix 12 - Distance, Opportunity Gain and Complexity (Coclé Province)



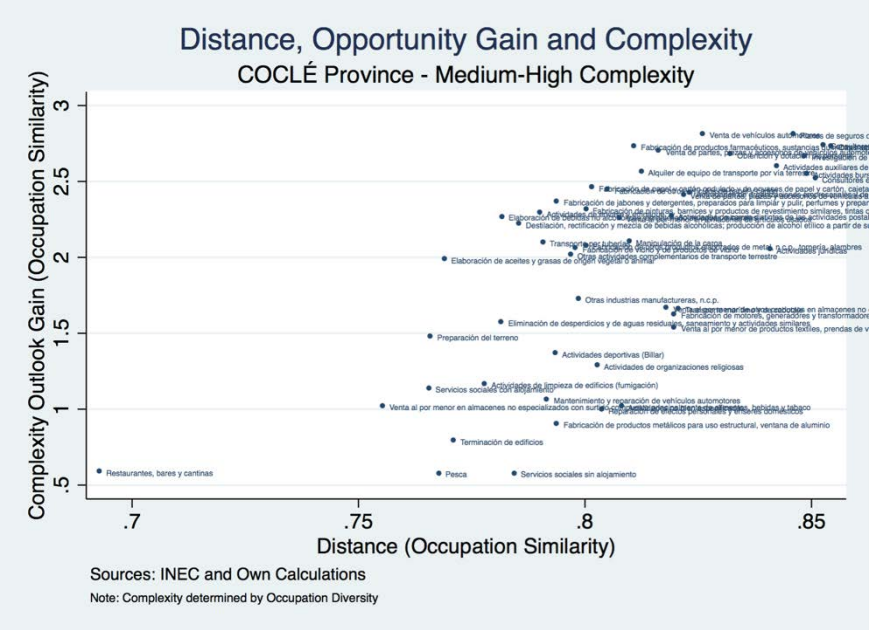
Appendix 13 - Strategic Aggregated Sectors (Coclé Province)



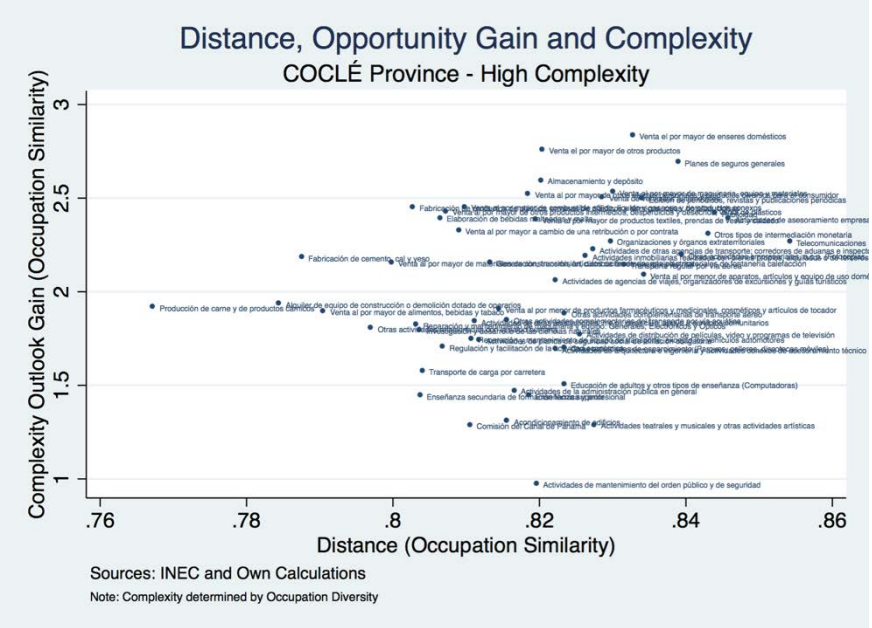
Appendix 14 - Distance, Opportunity Gain and Complexity (Coclé Province - Low Complexity)



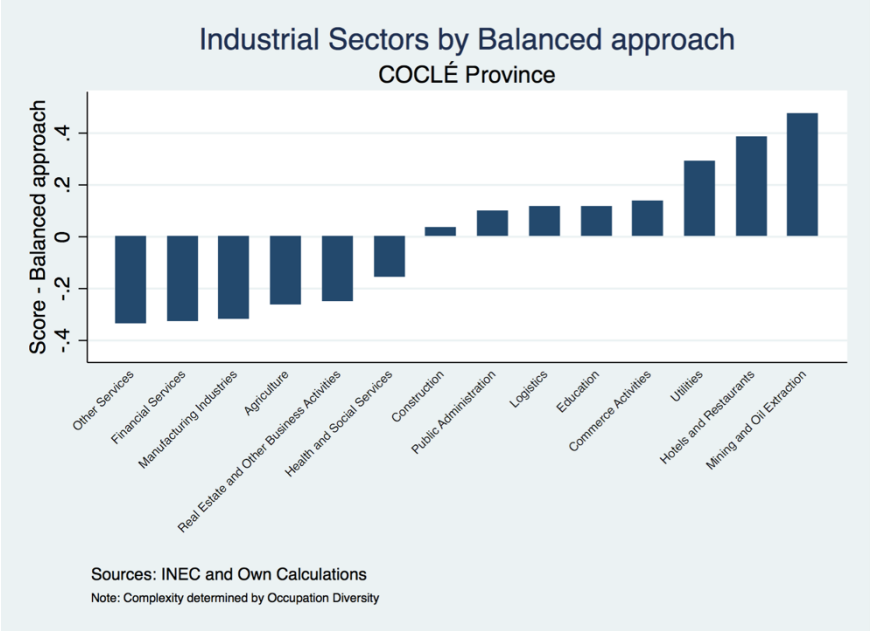
Appendix 15 - Distance, Opportunity Gain and Complexity (Coclé Province - Medium-Low Complexity)



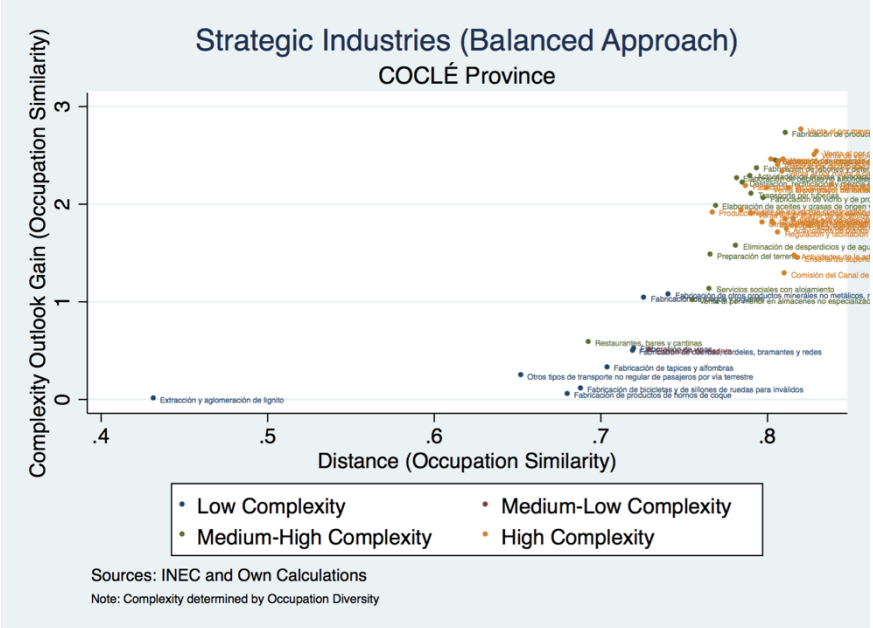
Appendix 16 - Distance, Opportunity Gain and Complexity (Coclé Province - Medium-High Complexity)



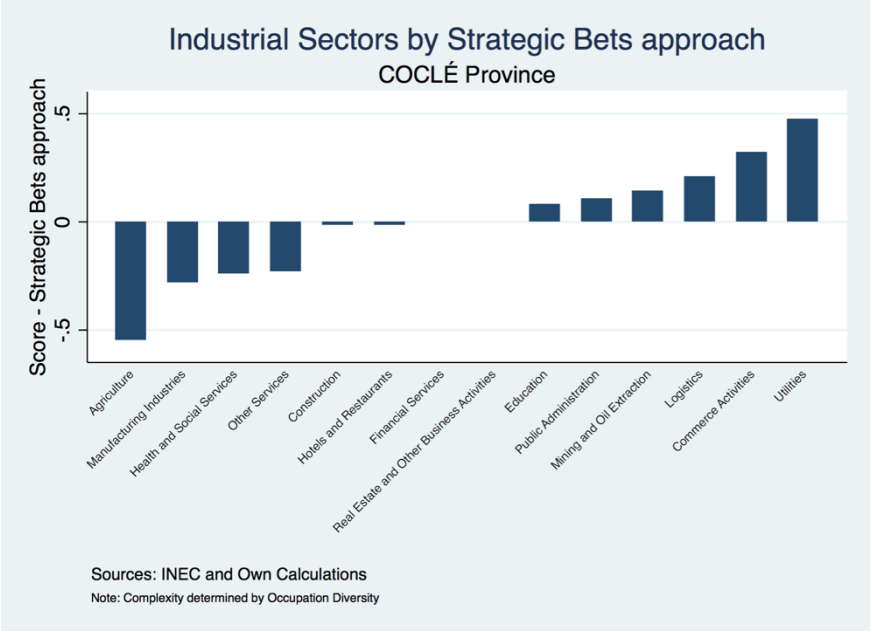
Appendix 17 - Distance, Opportunity Gain and Complexity (Coclé Province - High Complexity)



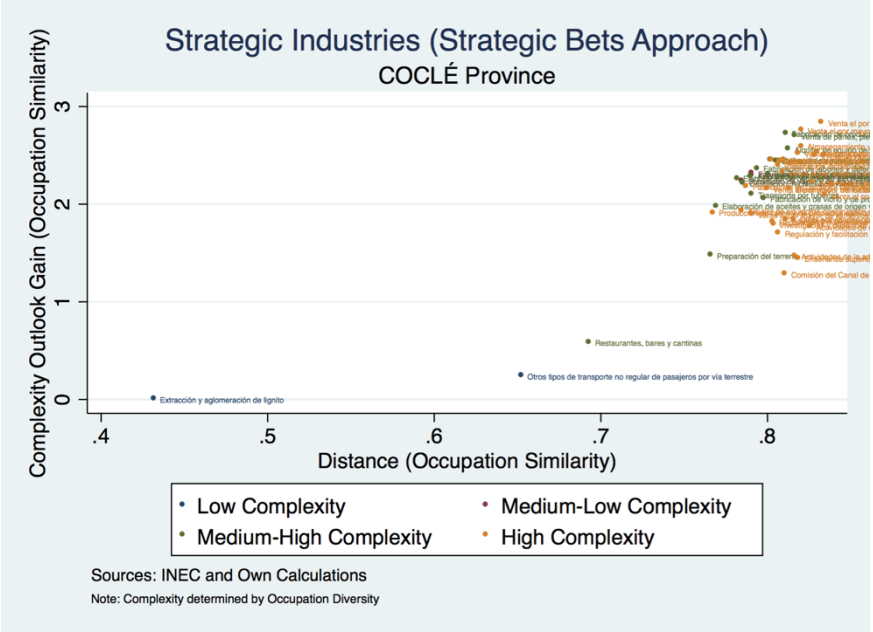
Appendix 18 - Industrial Sectors by Balanced approach (Coclé Province)



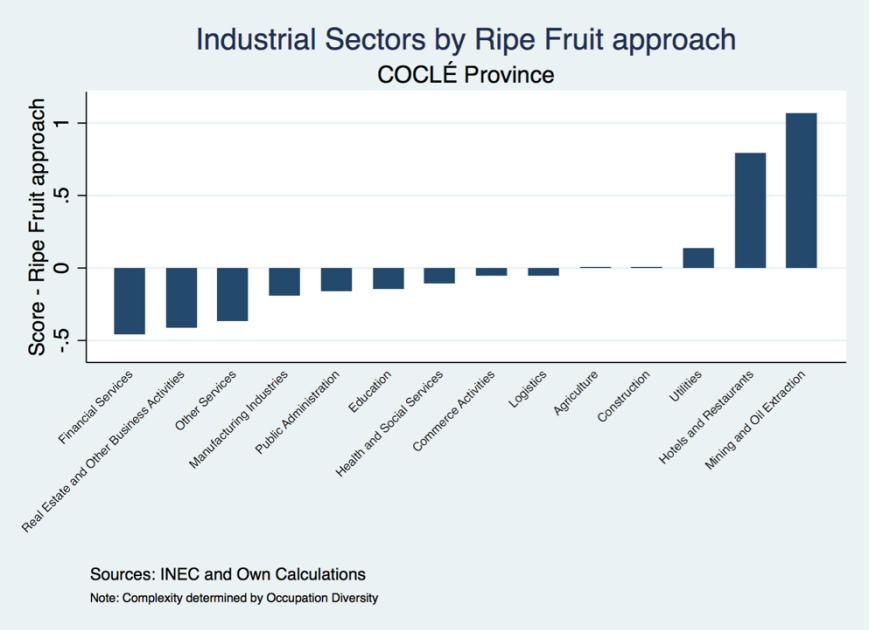
Appendix 19 - Strategic Industries (Balanced Approach, Coclé Province)



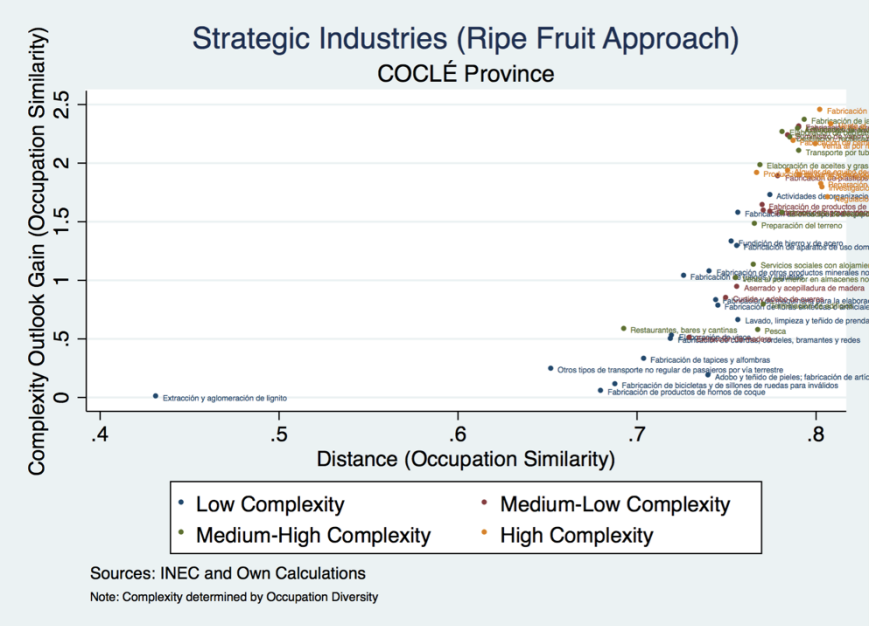
Appendix 20 - Industrial Sectors by Strategic Bets approach (Coclé Province)



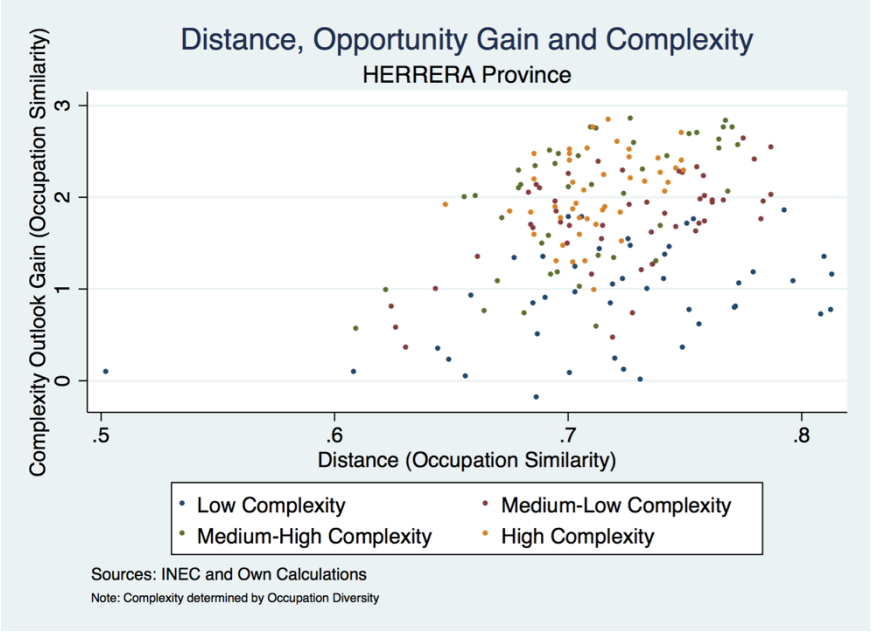
Appendix 21 - Strategic Industries (Strategic Bets Approach, Coclé Province)



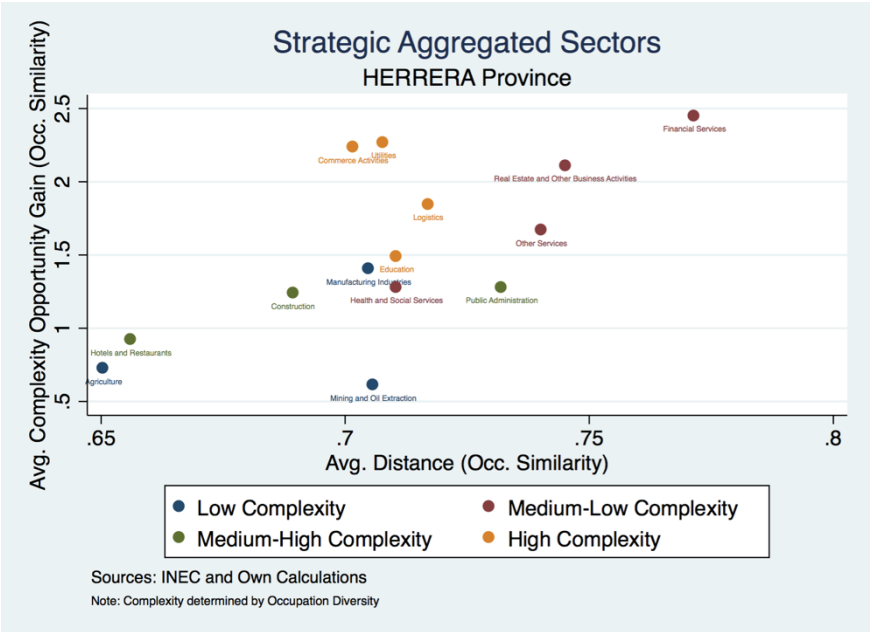
Appendix 22 - Industrial Sectors by Ripe Fruit approach (Coclé Province)



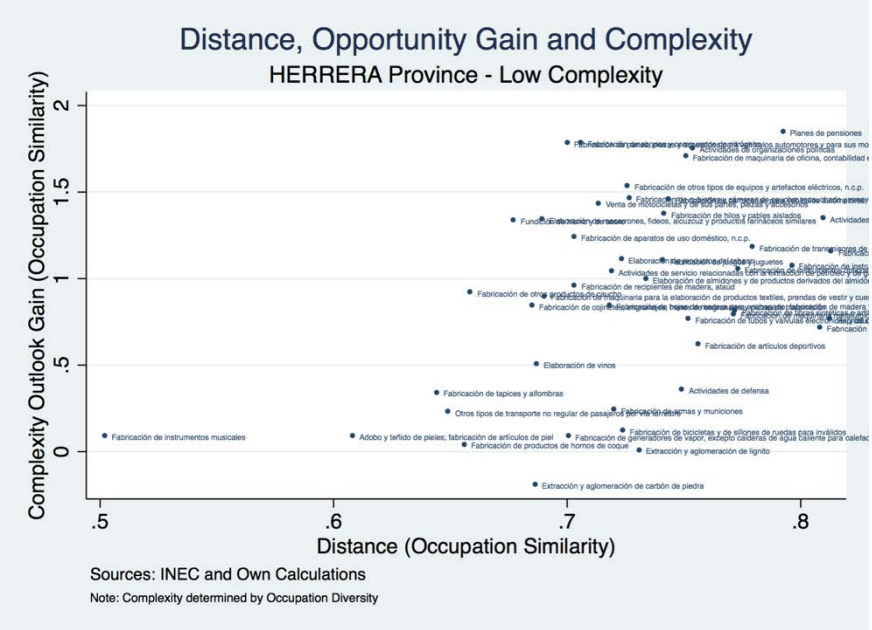
Appendix 23 - Strategic Industries (Ripe Fruit Approach, Coclé Province)



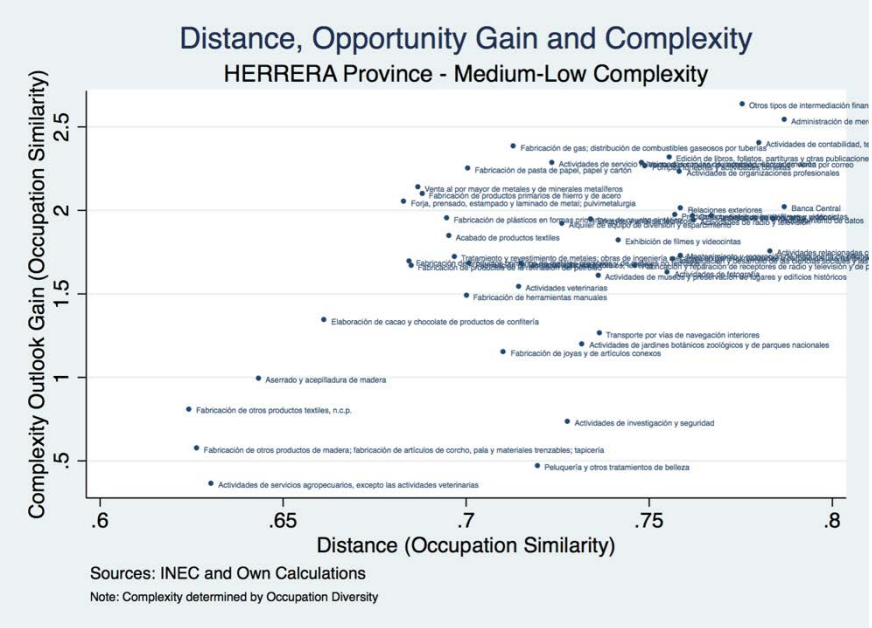
Appendix 24 - Distance, Opportunity Gain and Complexity (Herrera Province)



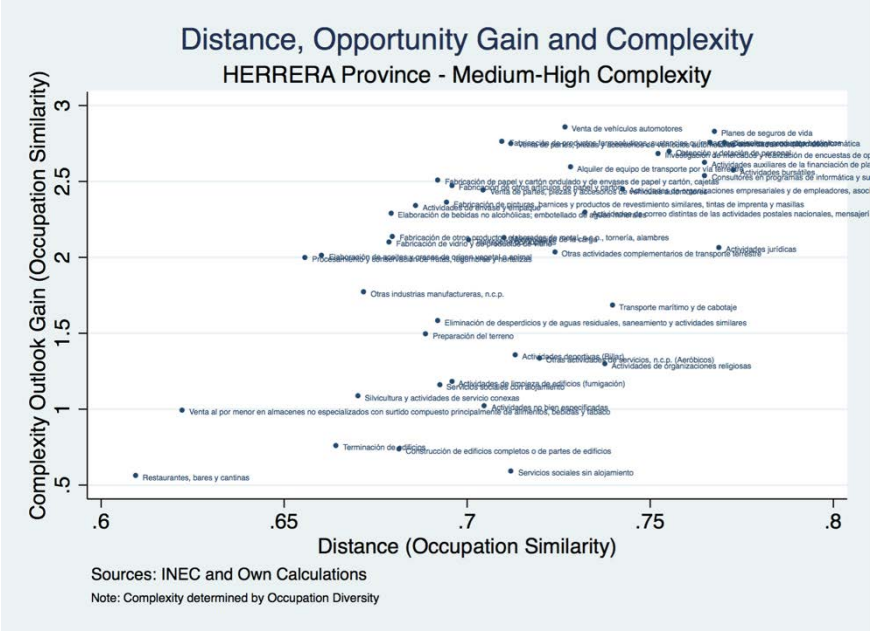
Appendix 25 - Strategic Aggregated Sectors (Herrera Province)



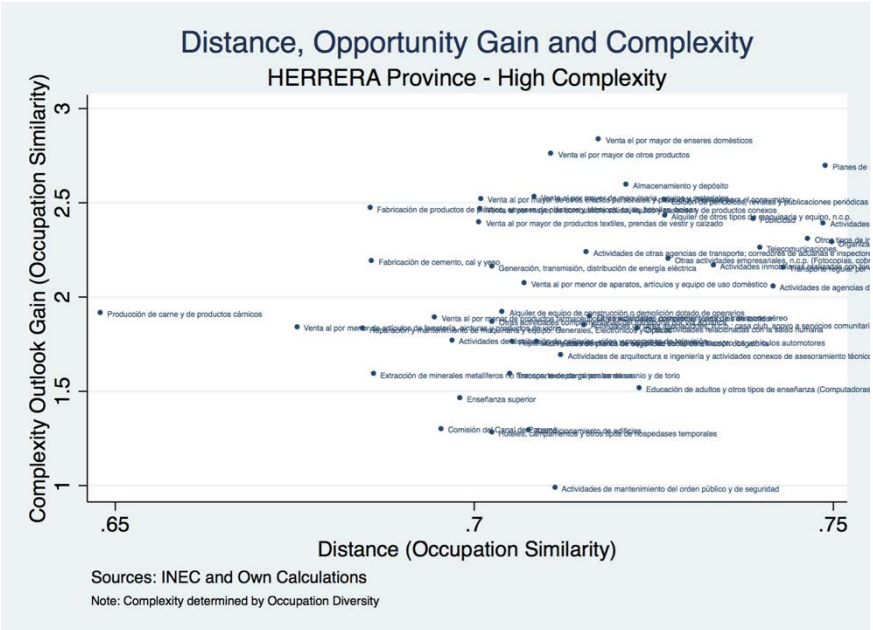
Appendix 26 - Distance, Opportunity Gain and Complexity (Herrera Province - Low Complexity)



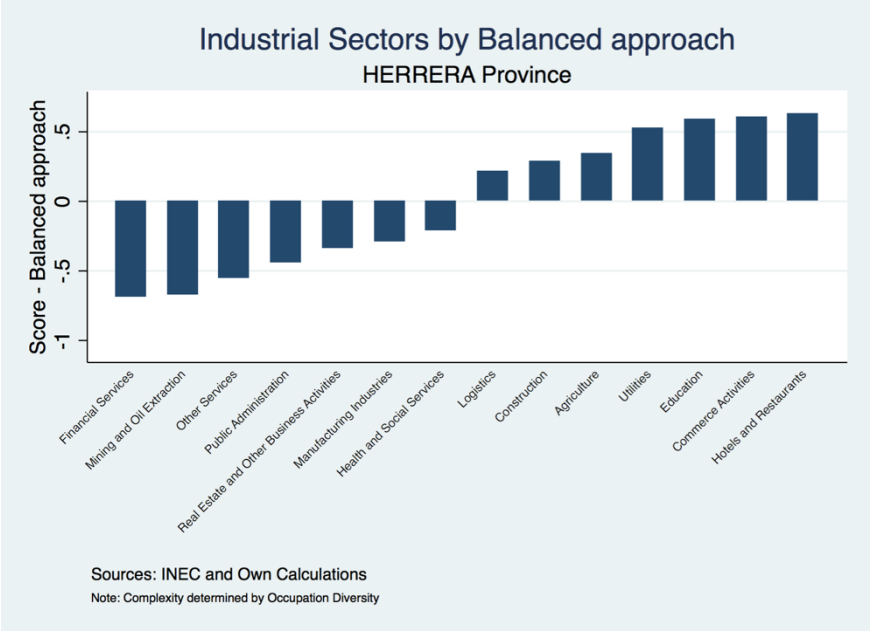
Appendix 27 - Distance, Opportunity Gain and Complexity (Herrera Province - Medium-Low Complexity)



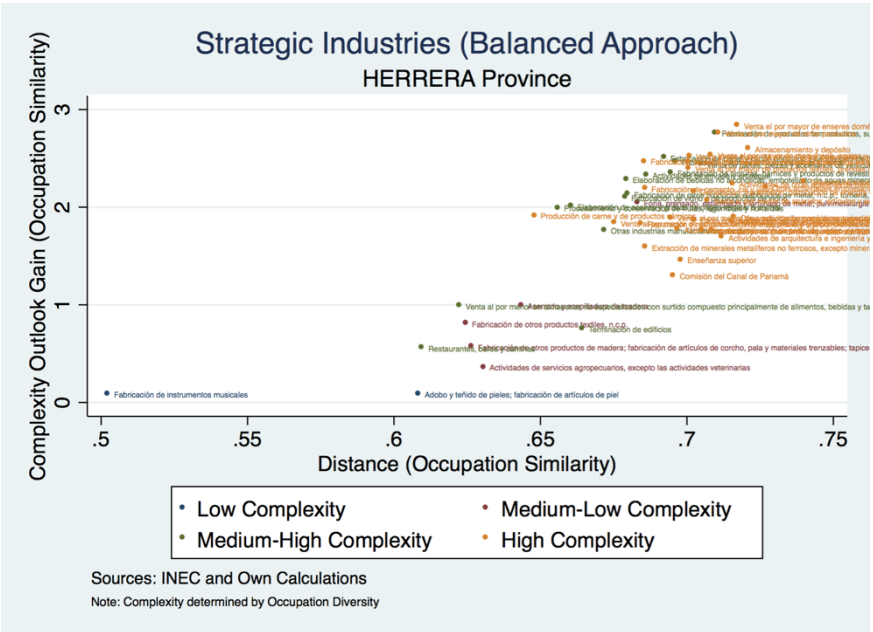
Appendix 28 - Distance, Opportunity Gain and Complexity (Herrera Province - Medium-High Complexity)



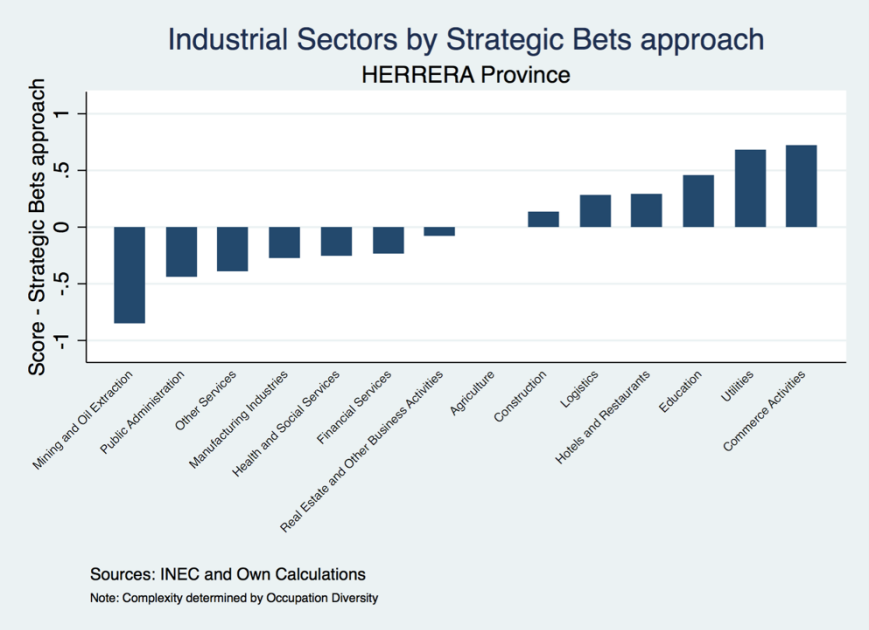
Appendix 29 - Distance, Opportunity Gain and Complexity (Herrera Province)



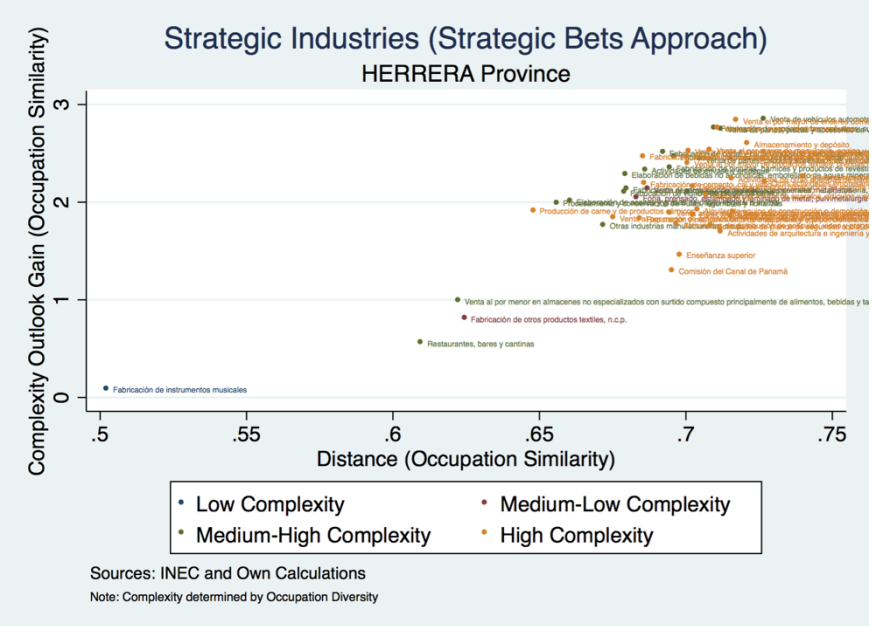
Appendix 30 - Industrial Sectors by Balanced approach (Herrera Province)



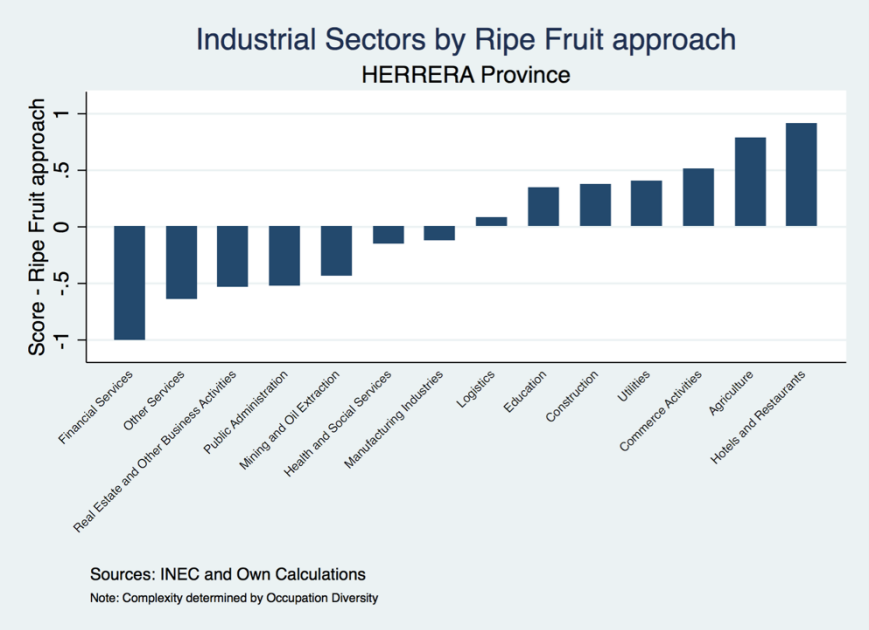
Appendix 31 - Strategic Industries (Balanced Approach, Herrera Province)



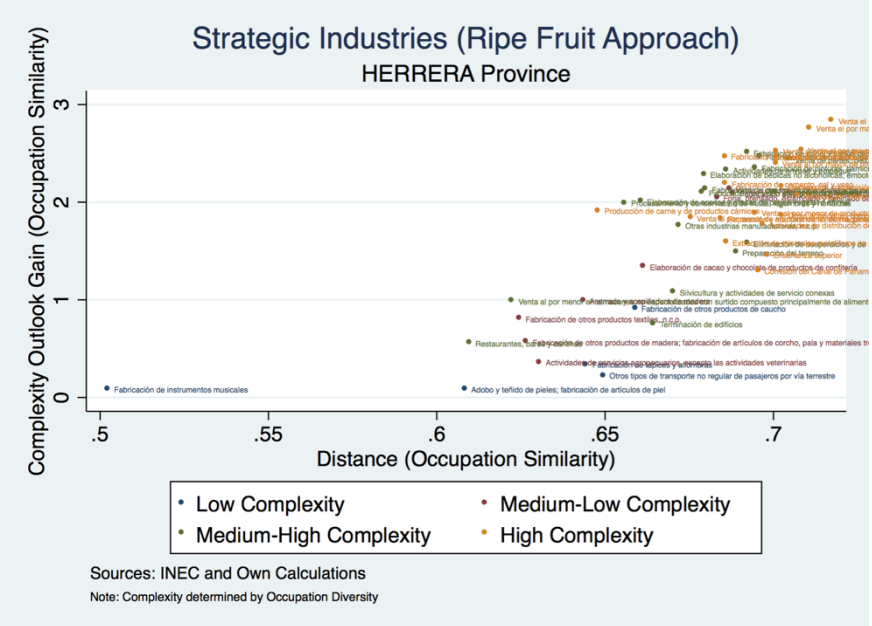
Appendix 32 - Industrial Sectors by Strategic Bets approach (Herrera Province)



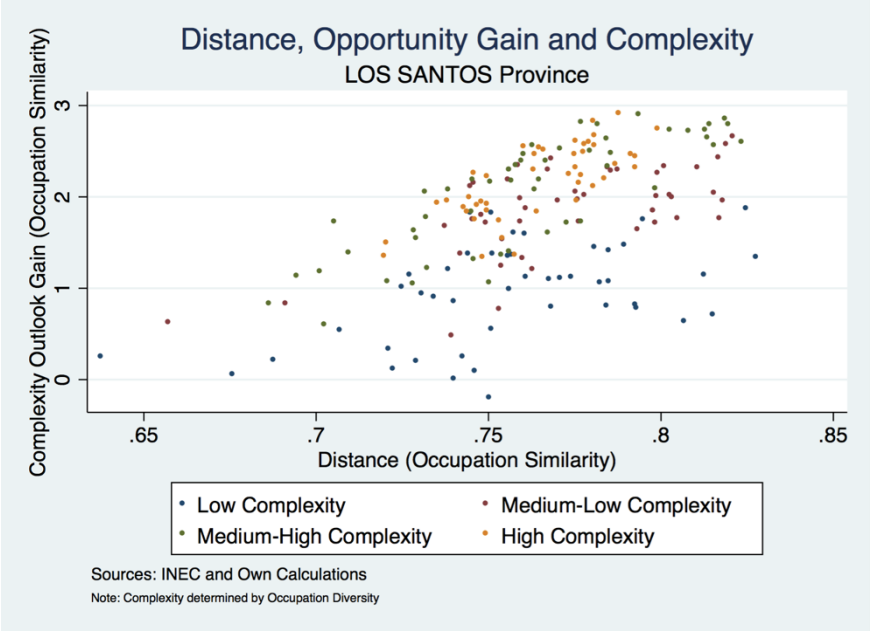
Appendix 33 - Strategic Industries (Strategic Bets Approach, Herrera Province)



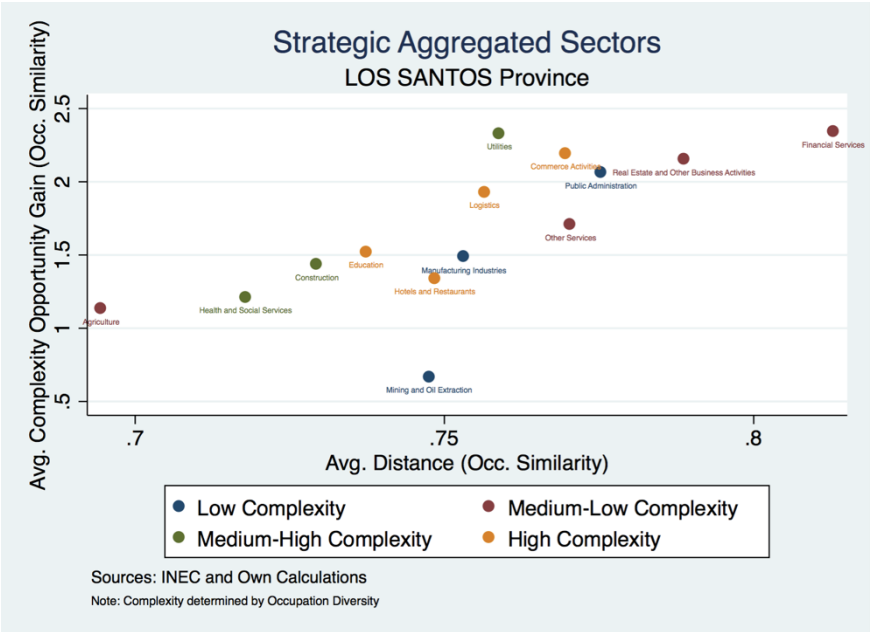
Appendix 34 - Industrial Sectors by Ripe Fruit Approach (Herrera Province)



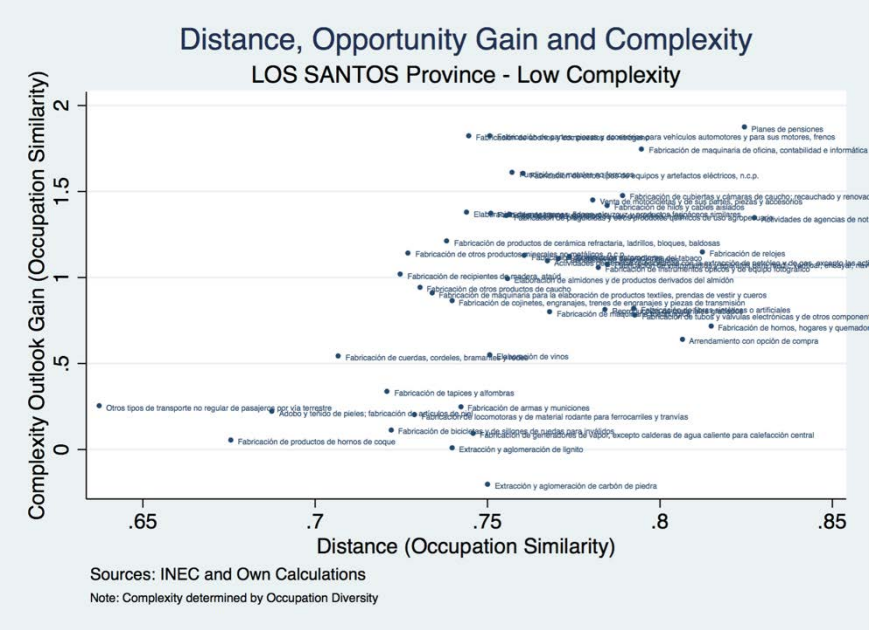
Appendix 35 - Strategic Industries (Ripe Fruit Approach, Herrera Province)



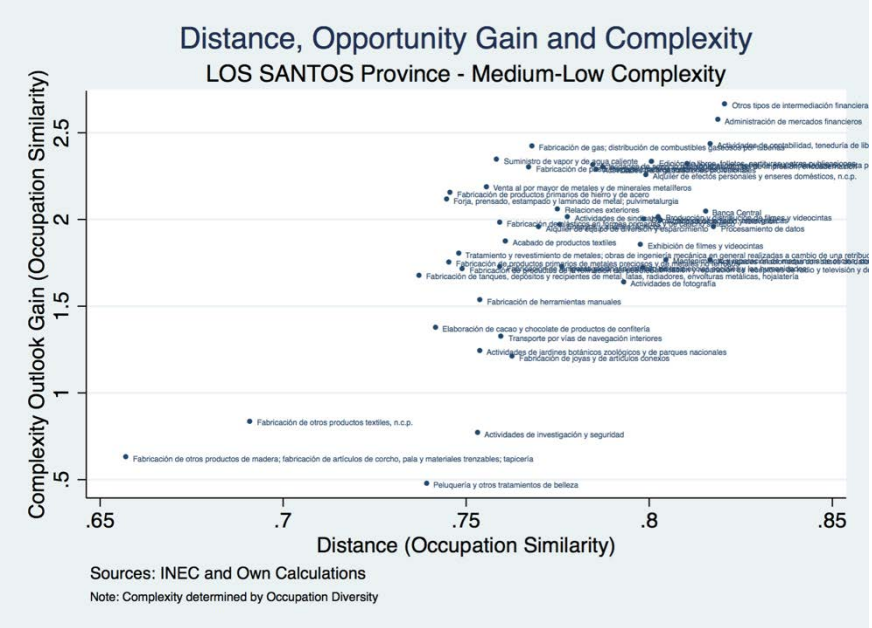
Appendix 36 - Distance, Opportunity Gain and Complexity (Los Santos Province)



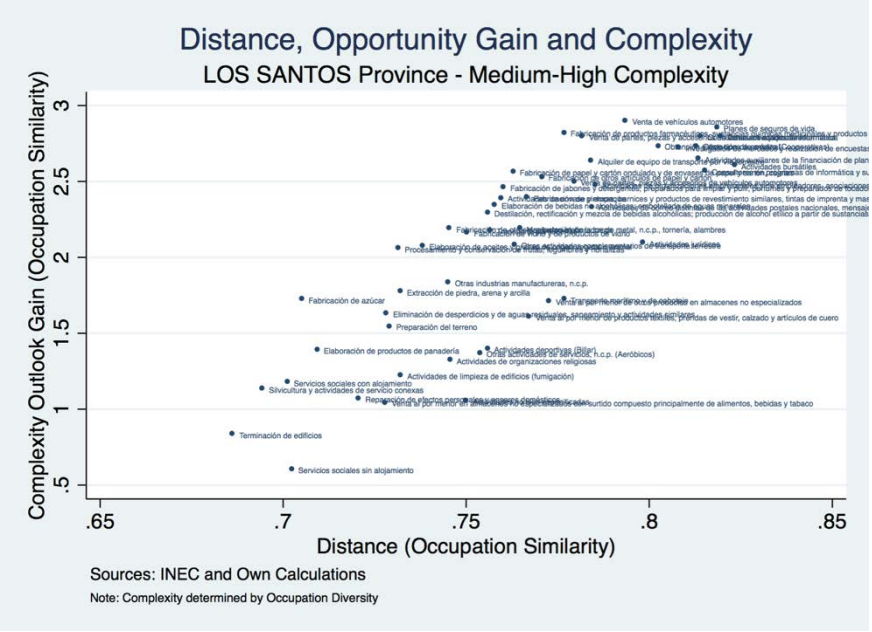
Appendix 37 - Strategic Aggregated Sectors (Los Santos Province)



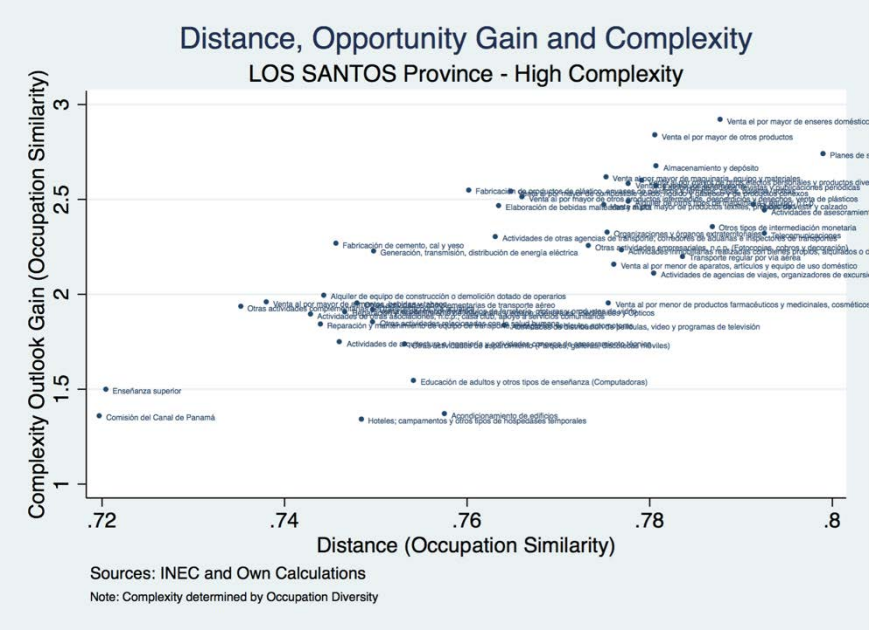
Appendix 38 - Distance, Opportunity Gain and Complexity (Los Santos Province - Low Complexity)



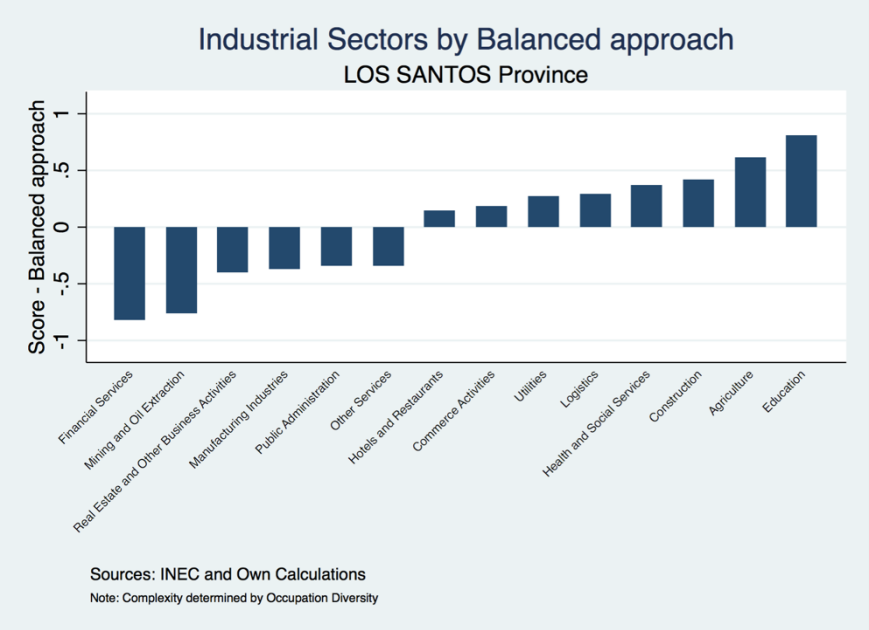
Appendix 39 - Distance, Opportunity Gain and Complexity (Los Santos Province - Medium-Low Complexity)



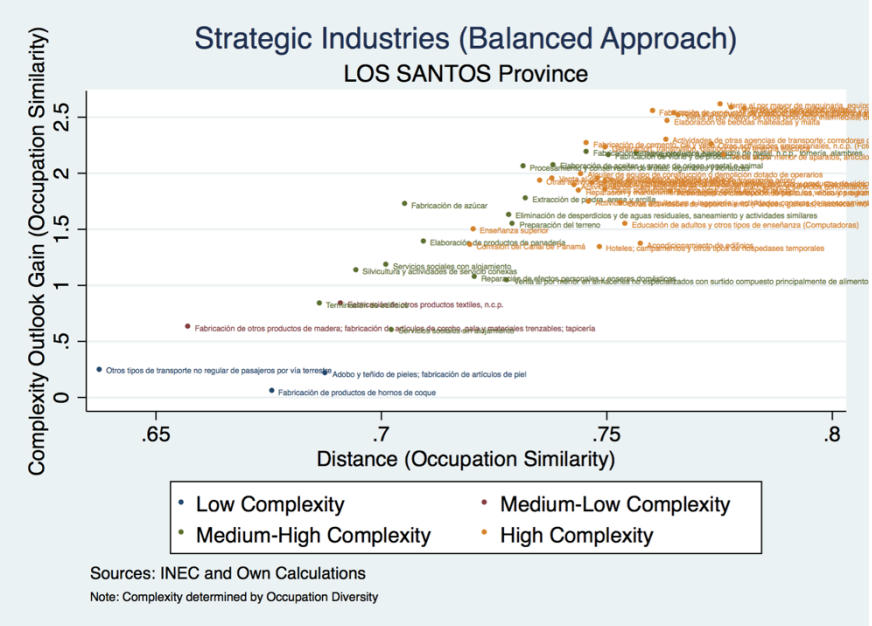
Appendix 40 - Distance, Opportunity Gain and Complexity (Los Santos Province - Medium-High Complexity)



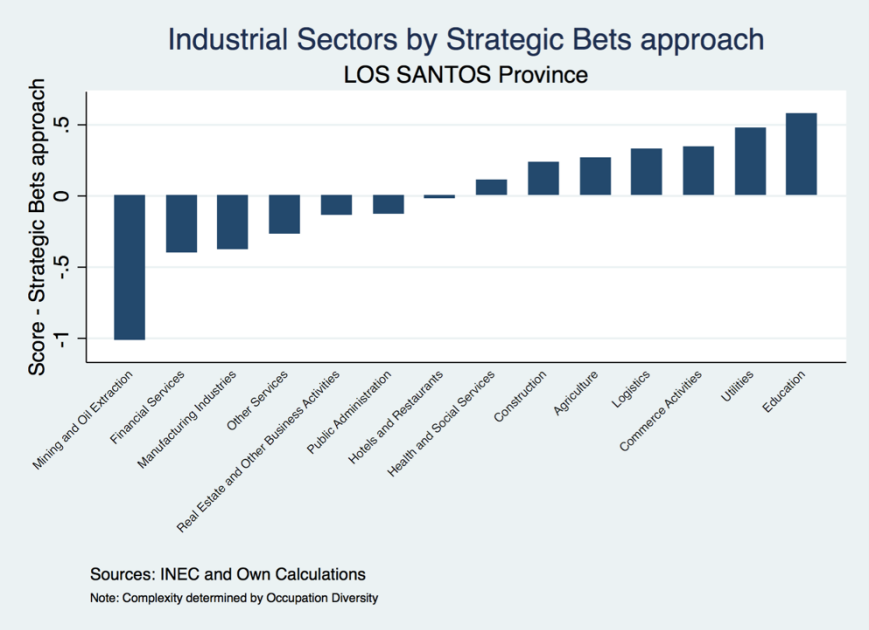
Appendix 41 - Distance, Opportunity Gain and Complexity (Los Santos Province - High Complexity)



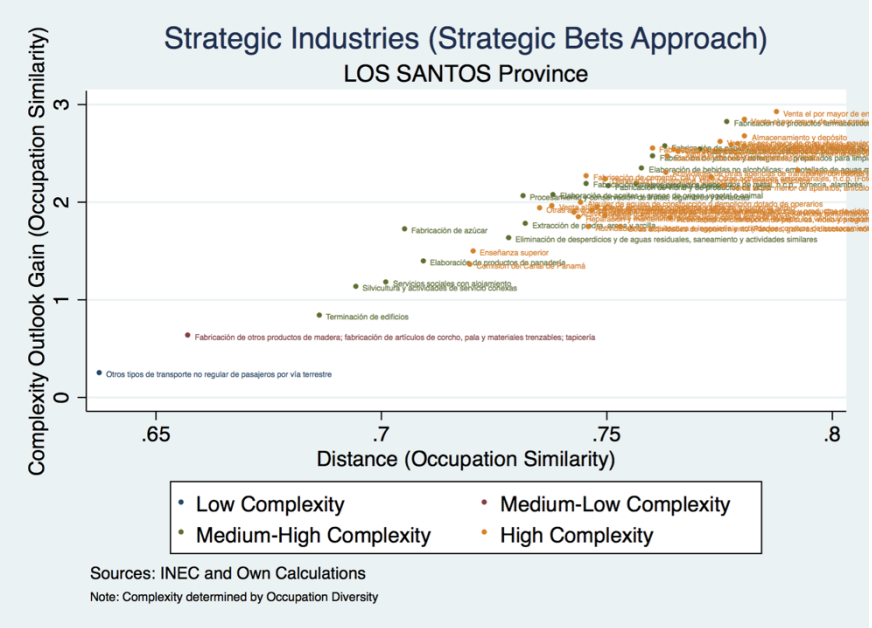
Appendix 42 - Industrial Sectors by Balanced approach (Los Santos Province)



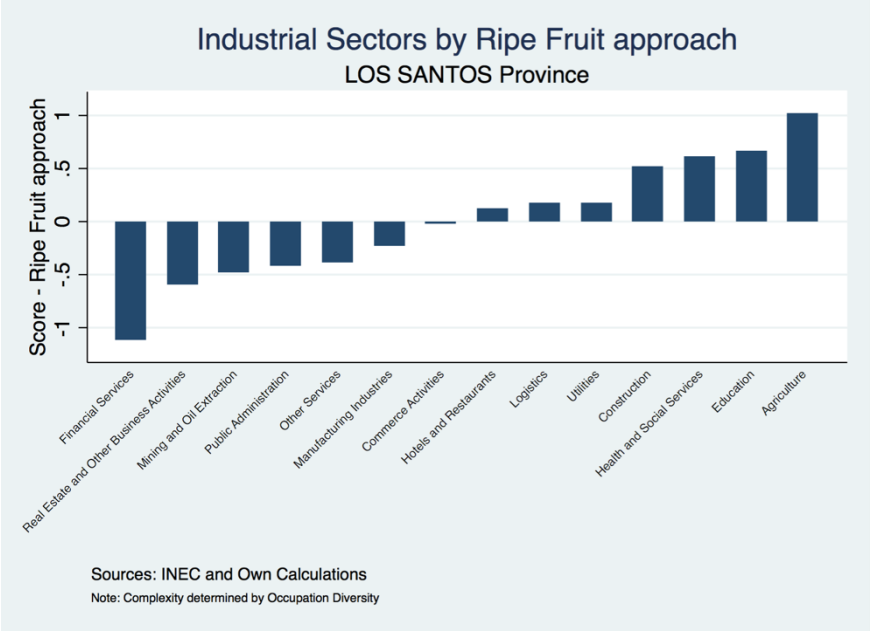
Appendix 43 - Strategic Industries (Balanced Approach, Los Santos Province)



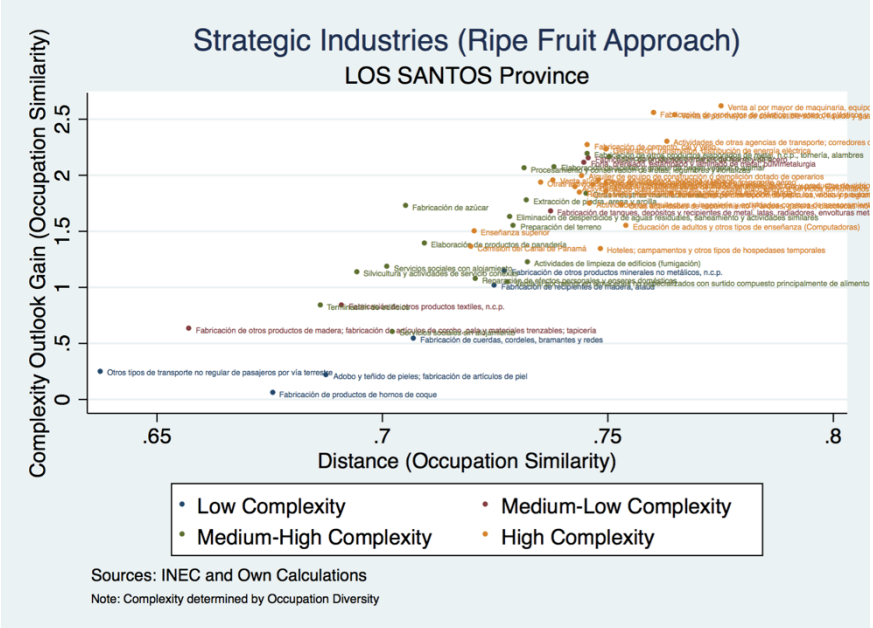
Appendix 44 - Industrial Sectors by Strategic Bets approach (Los Santos Province)



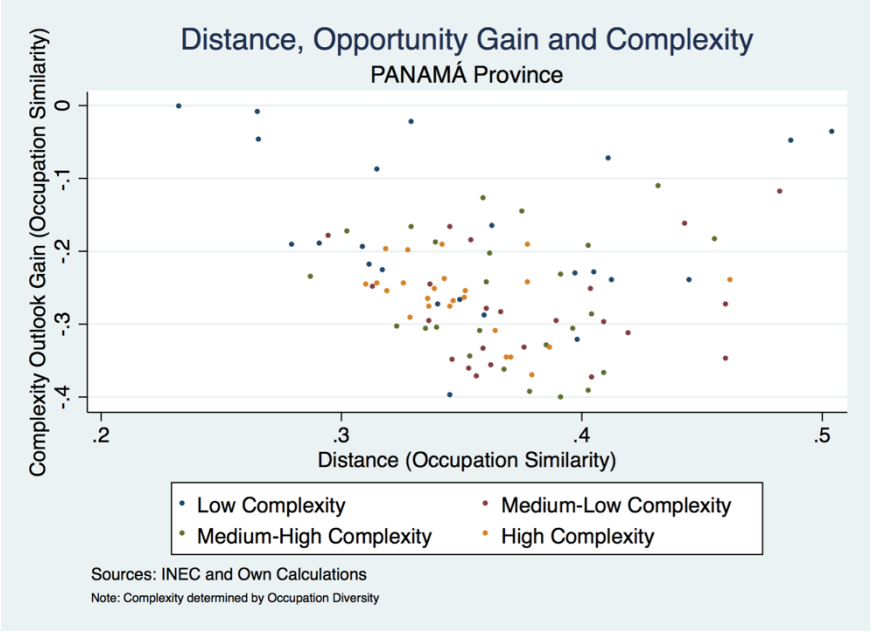
Appendix 45 - Strategic Industries (Strategic Bets Approach, Los Santos Province)



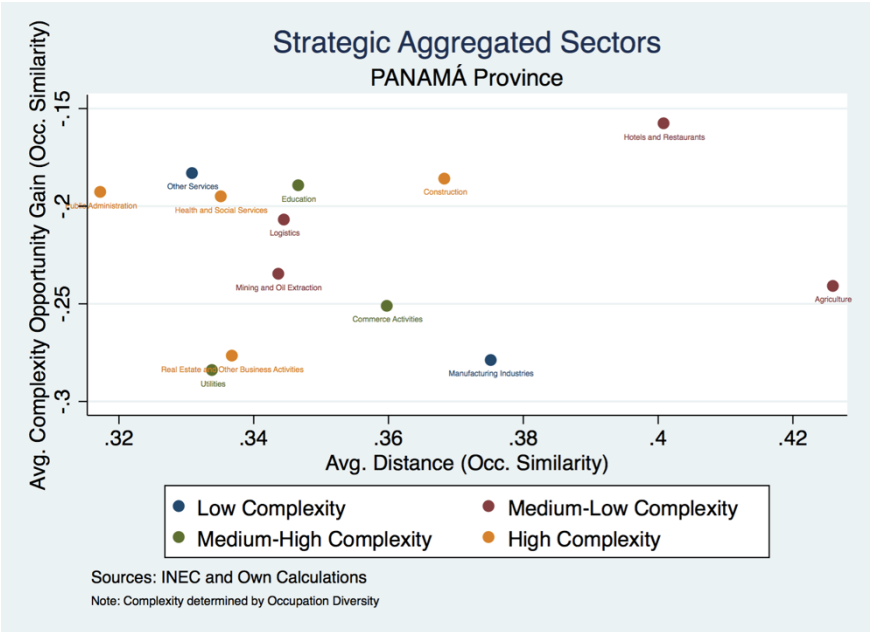
Appendix 46 - Industrial Sectors by Ripe Fruit approach (Los Santos Province)



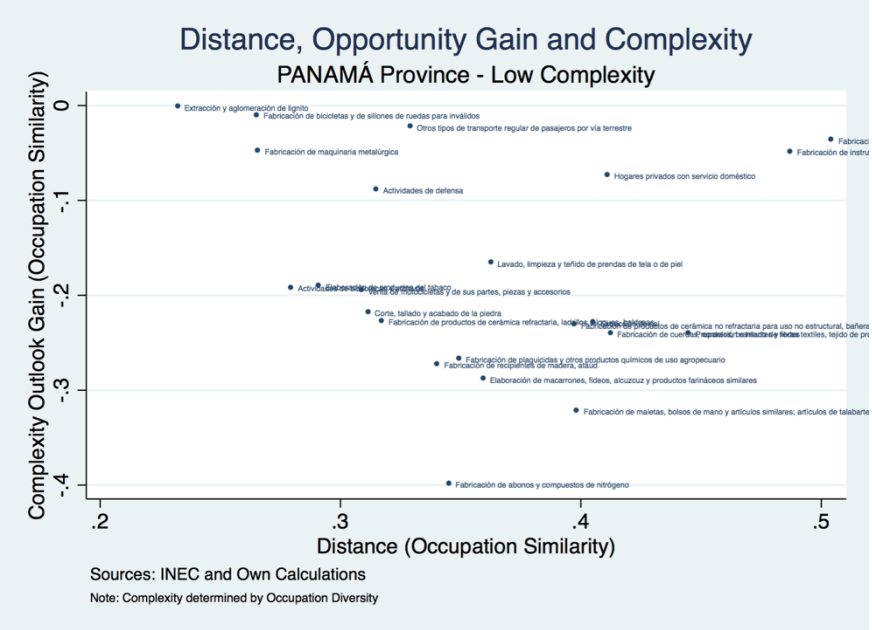
Appendix 47 - Strategic Industries (Ripe Fruit Approach, Los Santos Province)



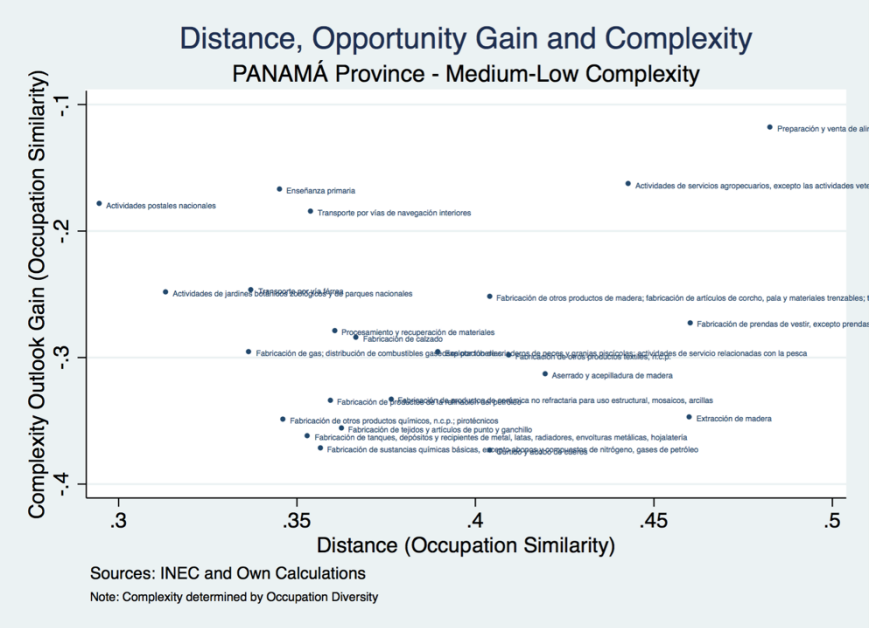
Appendix 48 - Distance, Opportunity Gain and Complexity (Panamá Province)



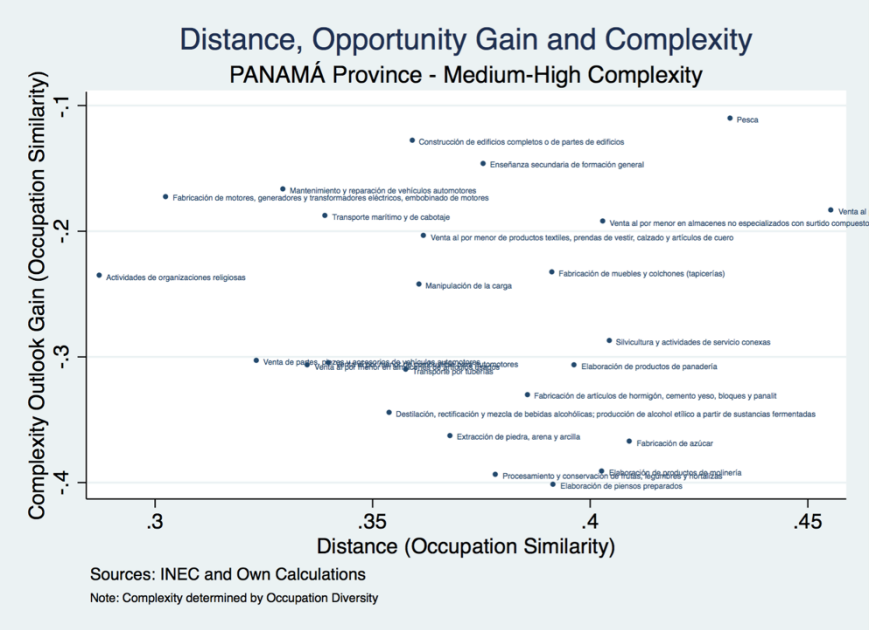
Appendix 49 - Strategic Aggregated Sectors (Panamá Province)



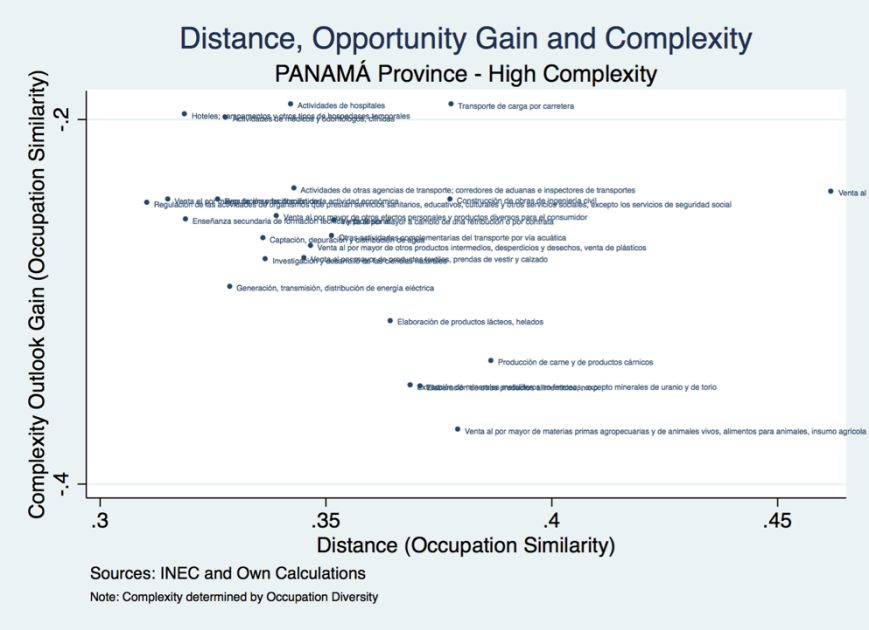
Appendix 50 - Distance, Opportunity Gain and Complexity (Panamá Province - Low Complexity)



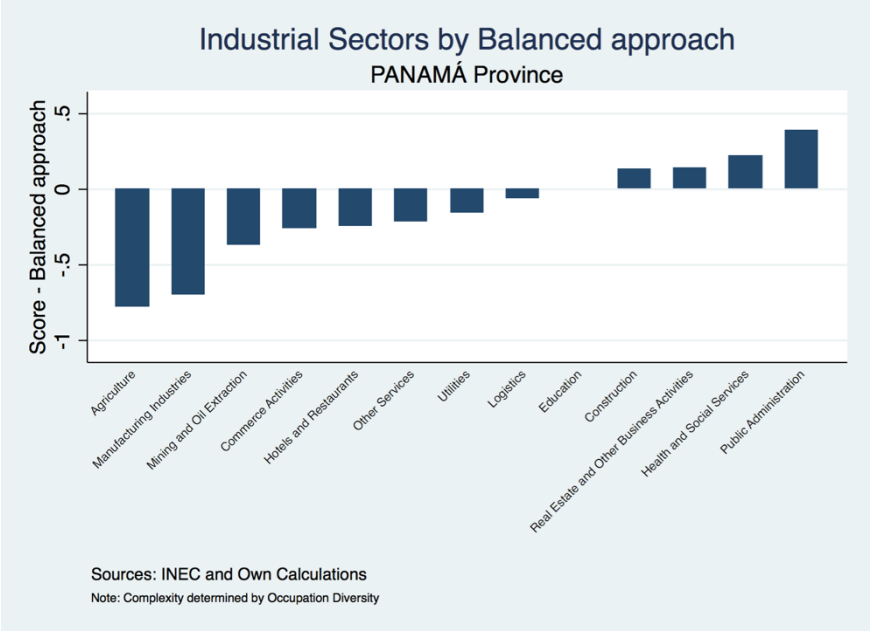
Appendix 51 - Distance, Opportunity Gain and Complexity (Panamá Province - Medium-Low Complexity)



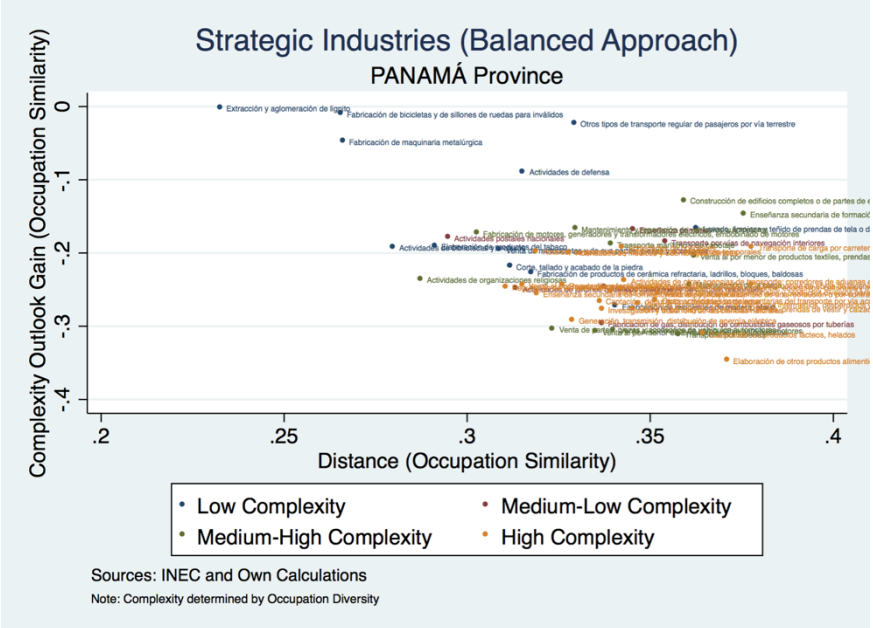
Appendix 52 - Distance, Opportunity Gain and Complexity (Panamá Province - Medium-High Complexity)



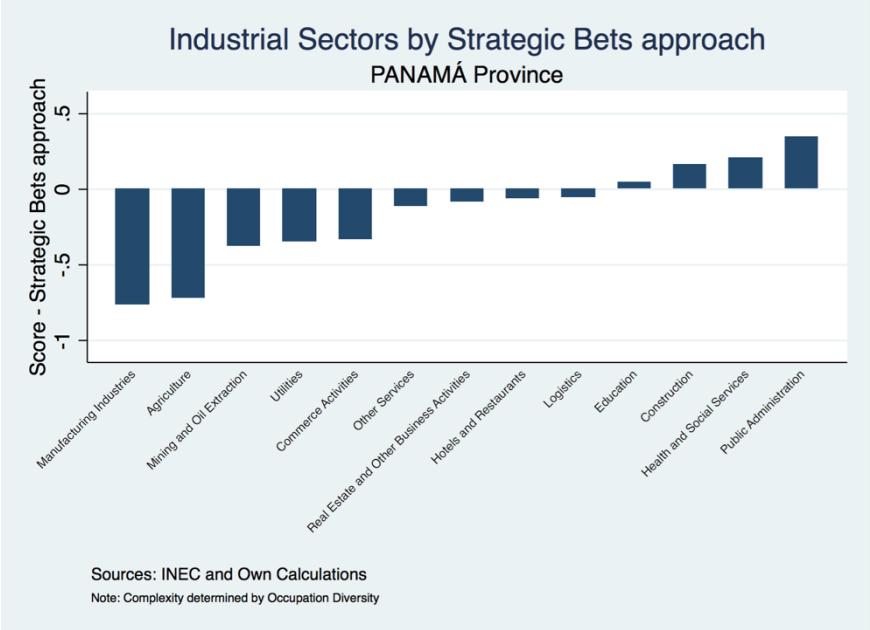
Appendix 53 - Distance, Opportunity Gain and Complexity (Panamá Province - High Complexity)



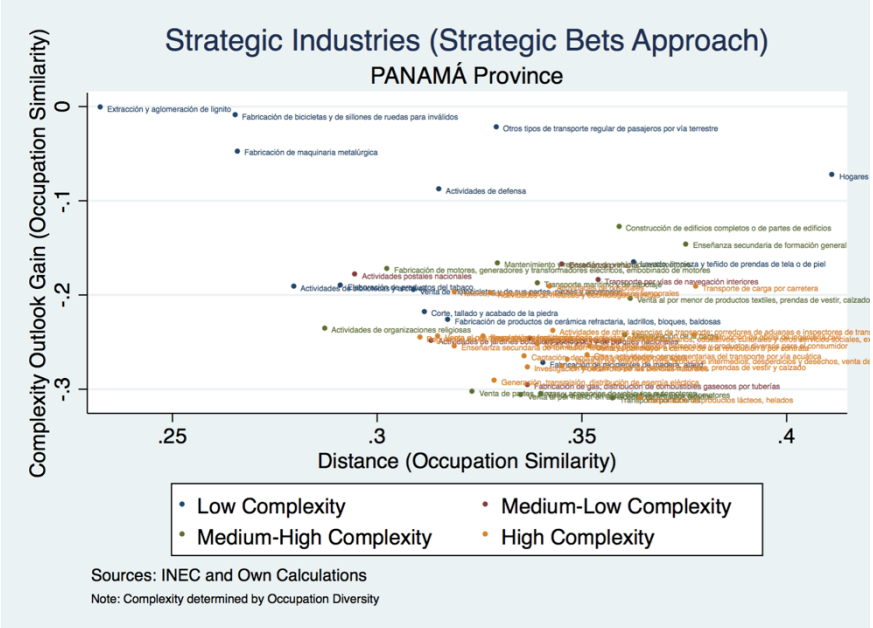
Appendix 54 - Industrial Sectors by Balanced approach (Panamá Province)



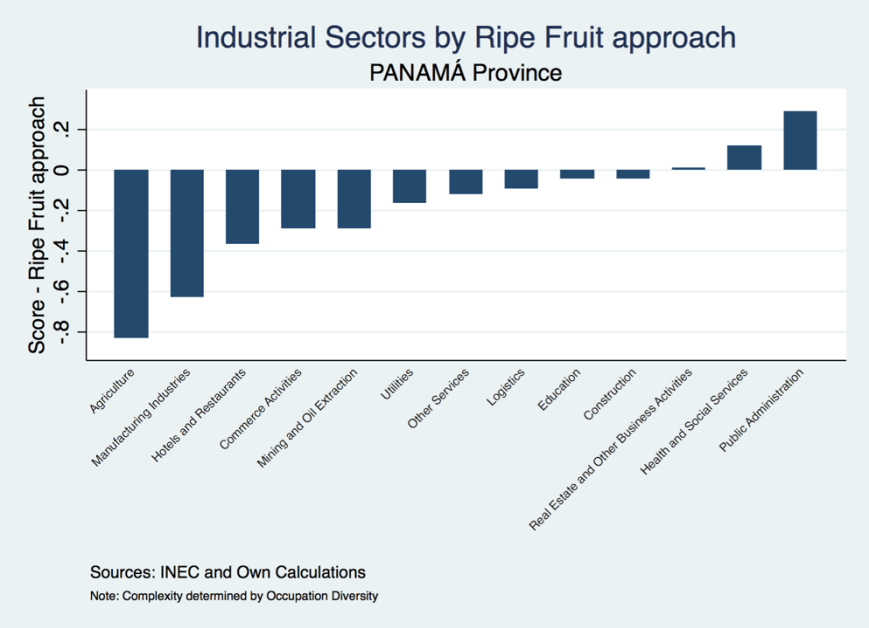
Appendix 55 - Strategic Industries (Balanced Approach, Panamá Province)



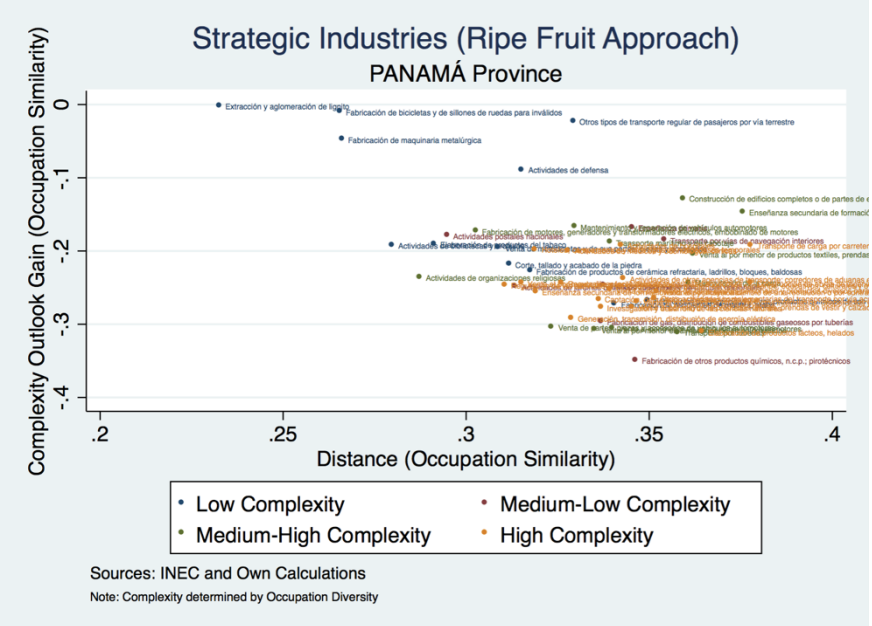
Appendix 56 - Industrial Sectors by Strategic Bets approach (Panamá Province)



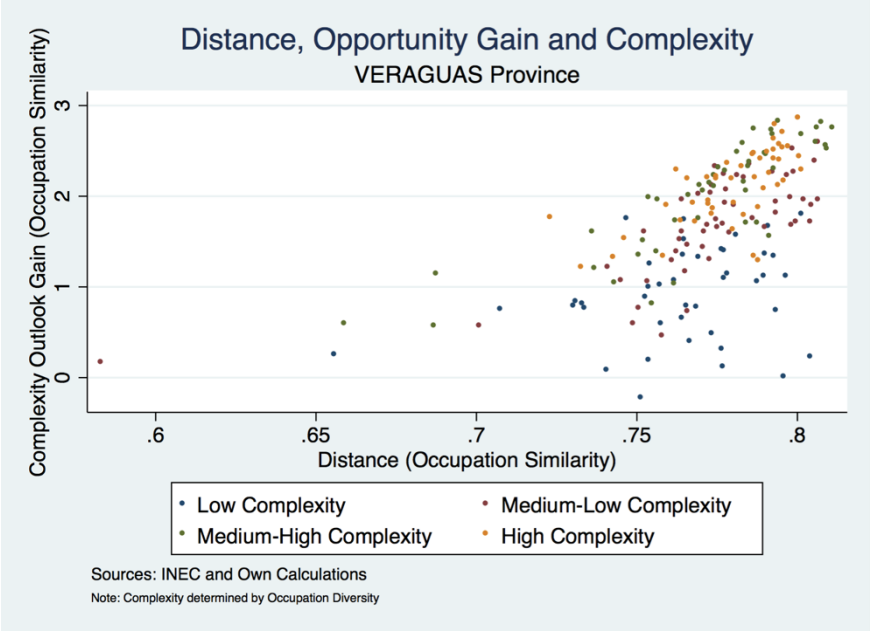
Appendix 57 - Strategic Industries (Strategic Bets Approach, Panamá Province)



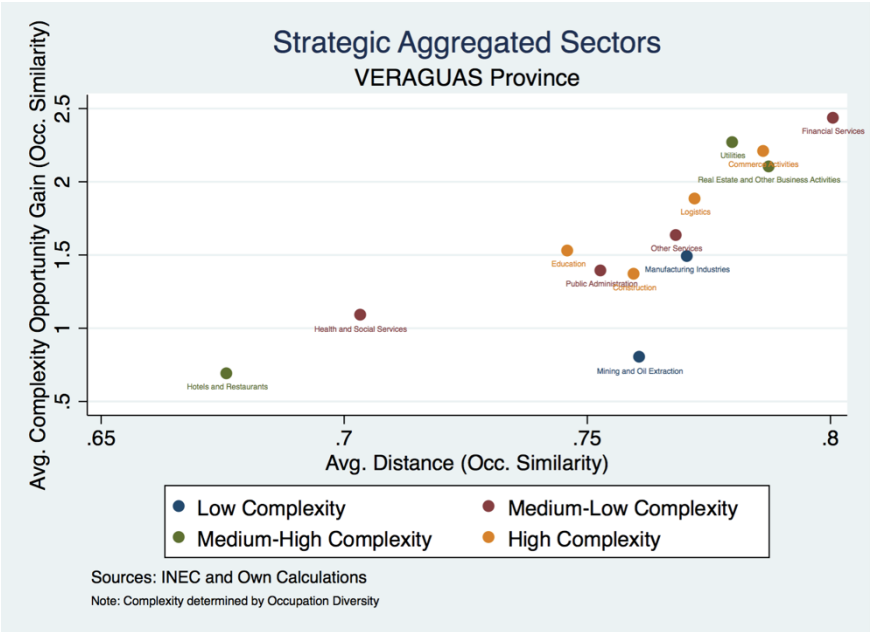
Appendix 58 - Industrial Sectors by Ripe Fruit approach (Panamá Province)



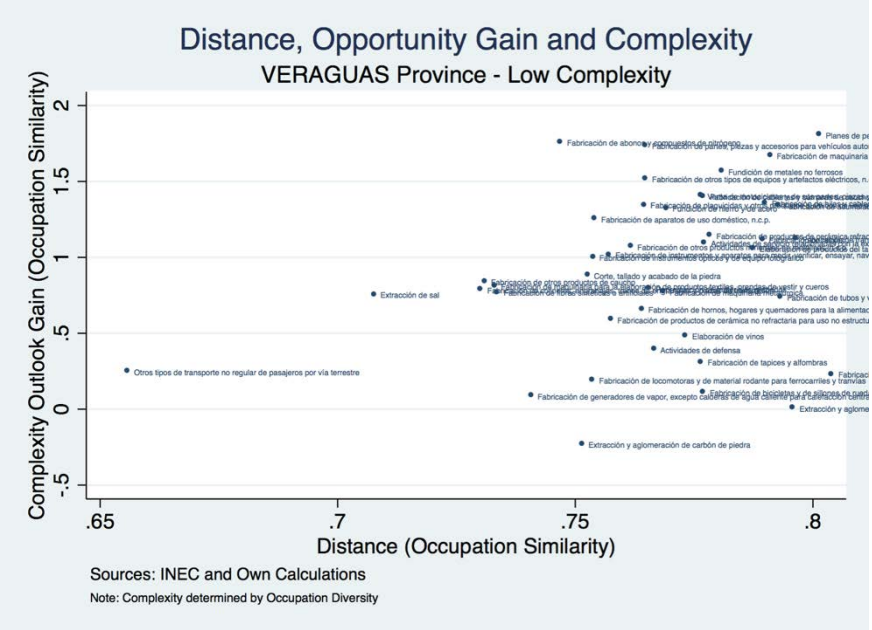
Appendix 59 - Strategic Industries (Ripe Fruit Approach, Panamá Province)



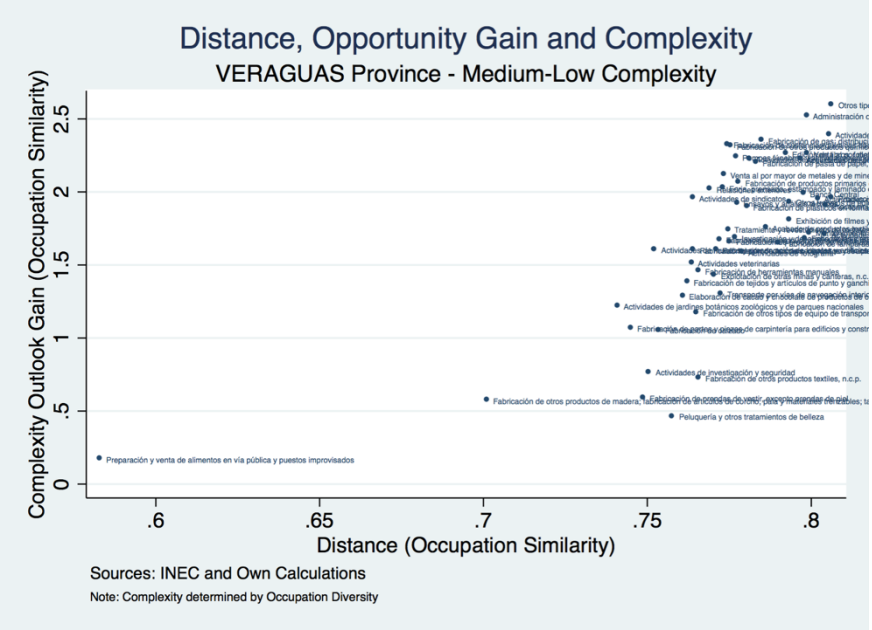
Appendix 60 - Distance, Opportunity Gain and Complexity (Veraguas Province)



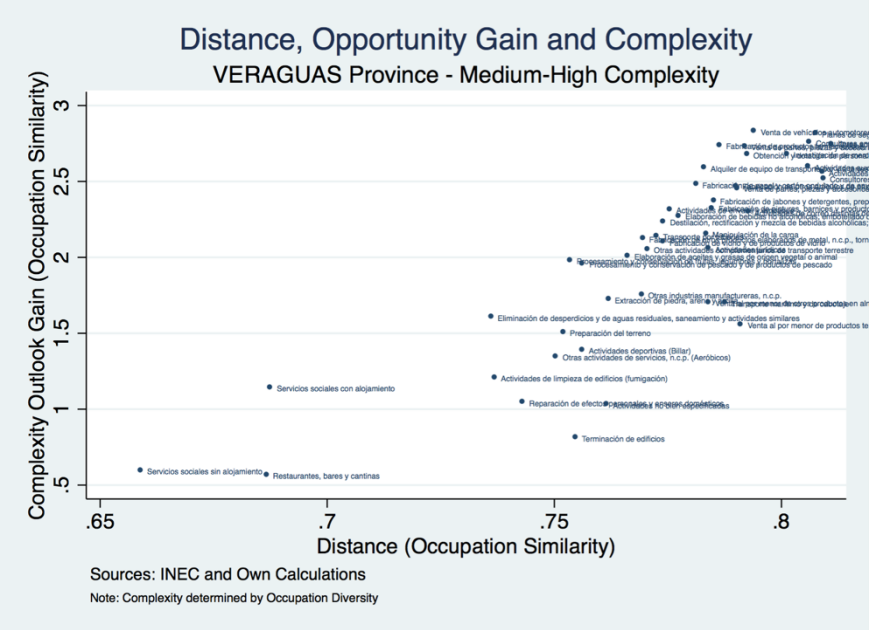
Appendix 61 - Strategic Aggregated Sectors (Veraguas Province)



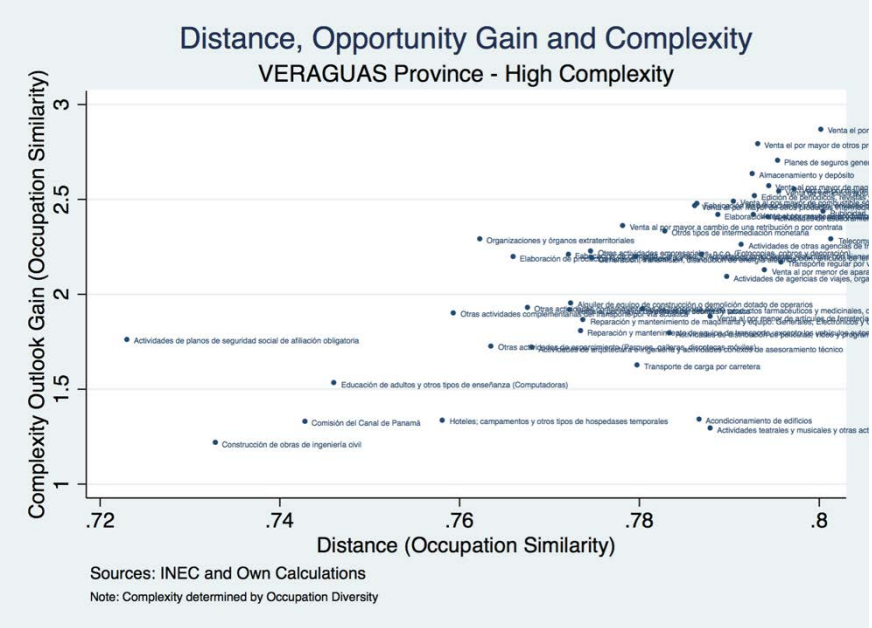
Appendix 62 - Distance, Opportunity Gain and Complexity (Veraguas Province - Low Complexity)



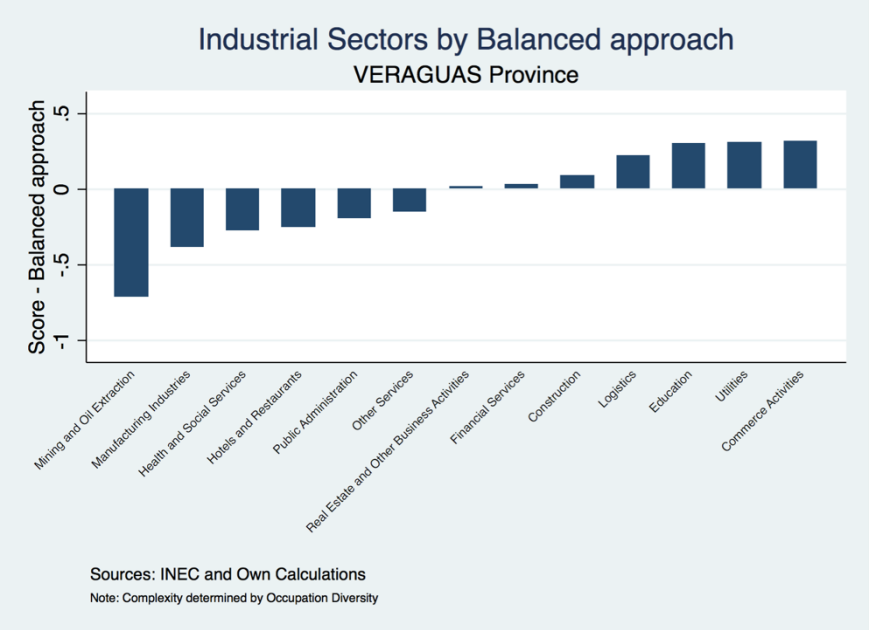
Appendix 63 - Distance, Opportunity Gain and Complexity (Veraguas Province - Medium-Low Complexity)



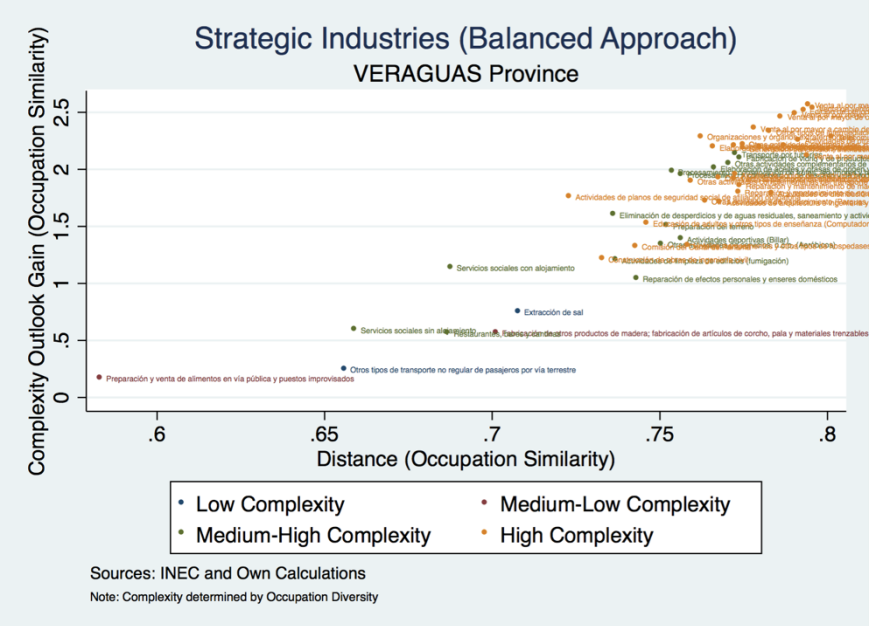
Appendix 64 - Distance, Opportunity Gain and Complexity (Veraguas Province - Medium-High Complexity)



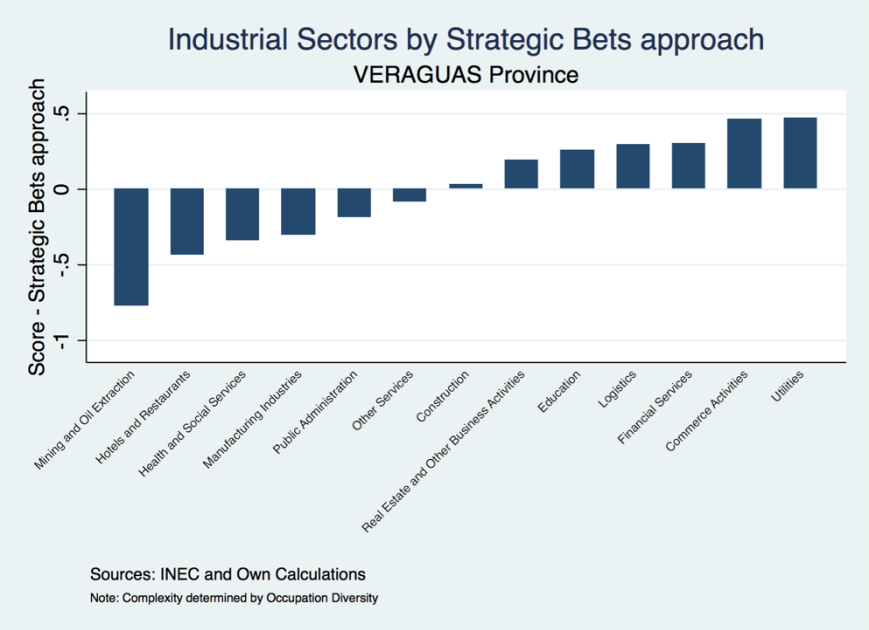
Appendix 65 - Distance, Opportunity Gain and Complexity (Veraguas Province - High Complexity)



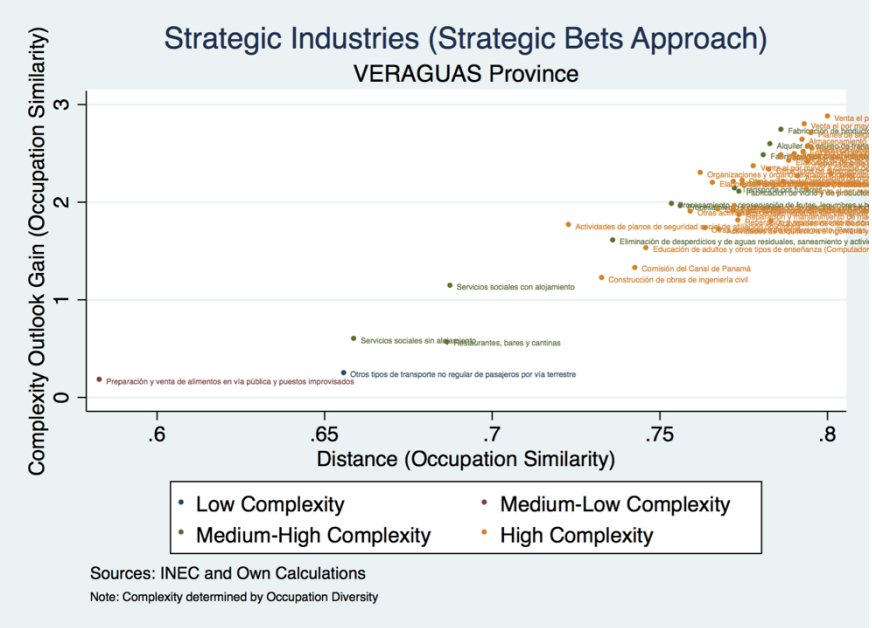
Appendix 66 - Industrial Sectors by Balanced approach (Veraguas Province)



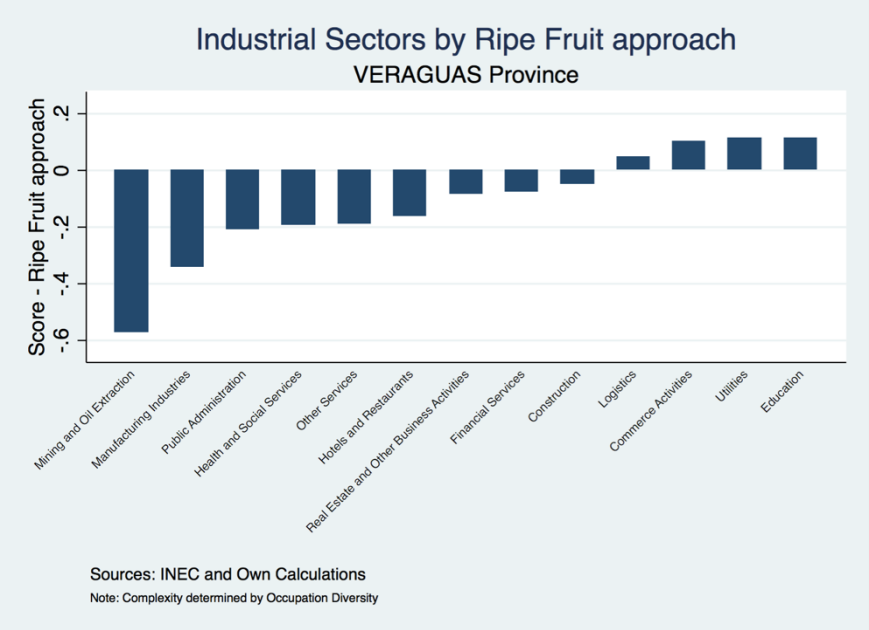
Appendix 67 - Strategic Industries (Balanced Approach, Veraguas Province)



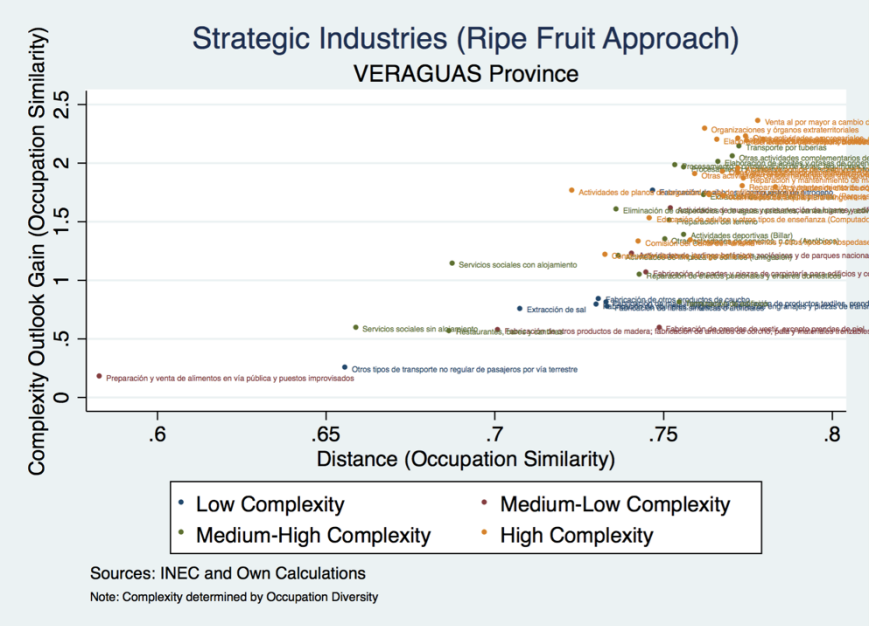
Appendix 68 - Industrial Sectors by Strategic Bets approach (Veraguas Province)



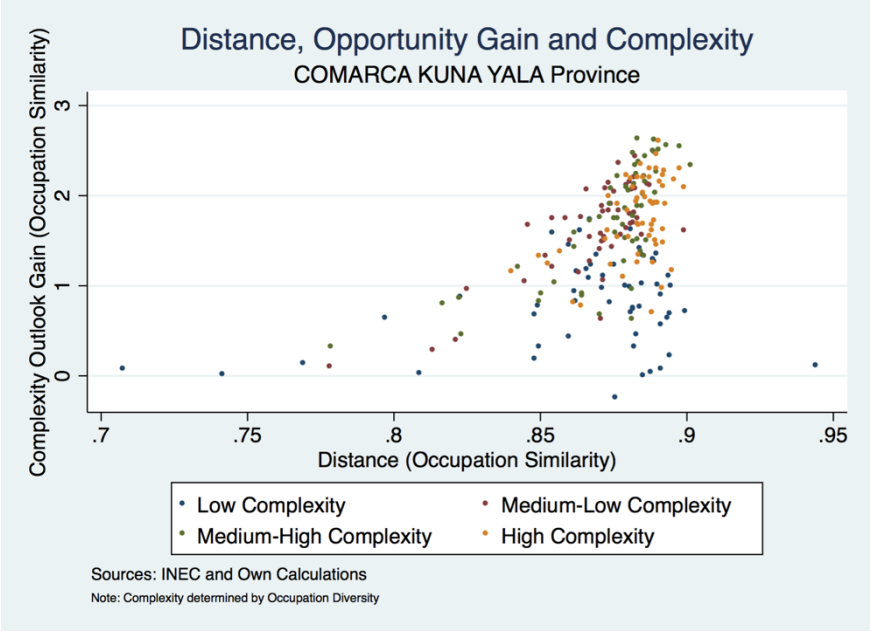
Appendix 69 - Strategic Industries (Strategic Bets Approach, Veraguas Province)



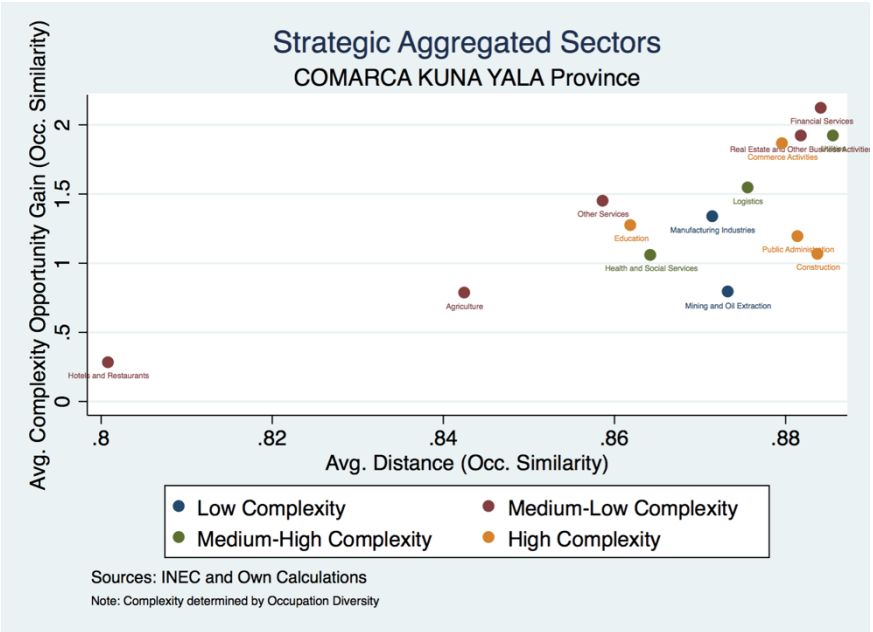
Appendix 70 - Industrial Sectors by Ripe Fruit approach (Veraguas Province)



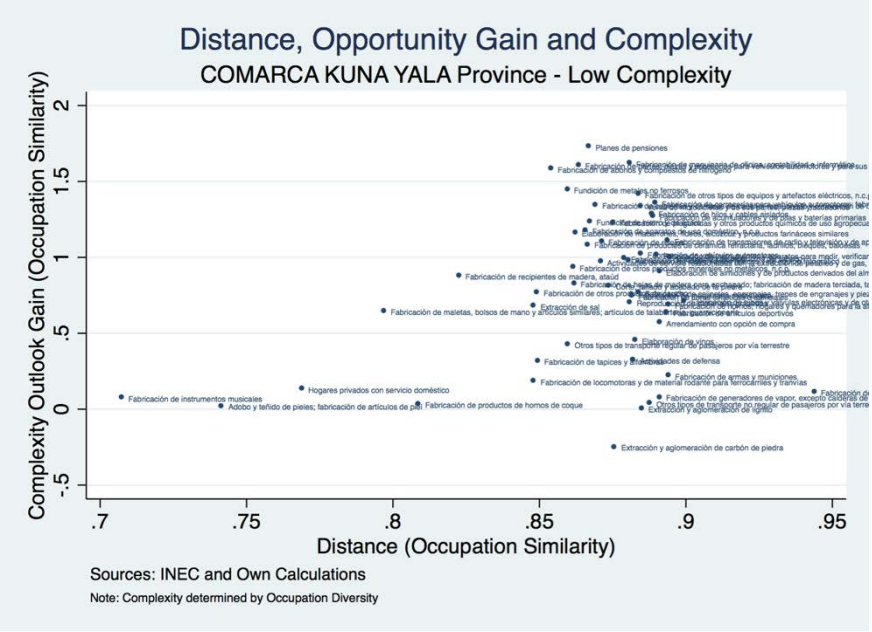
Appendix 71 - Strategic Industries (Ripe Fruit Approach, Veraguas Province)



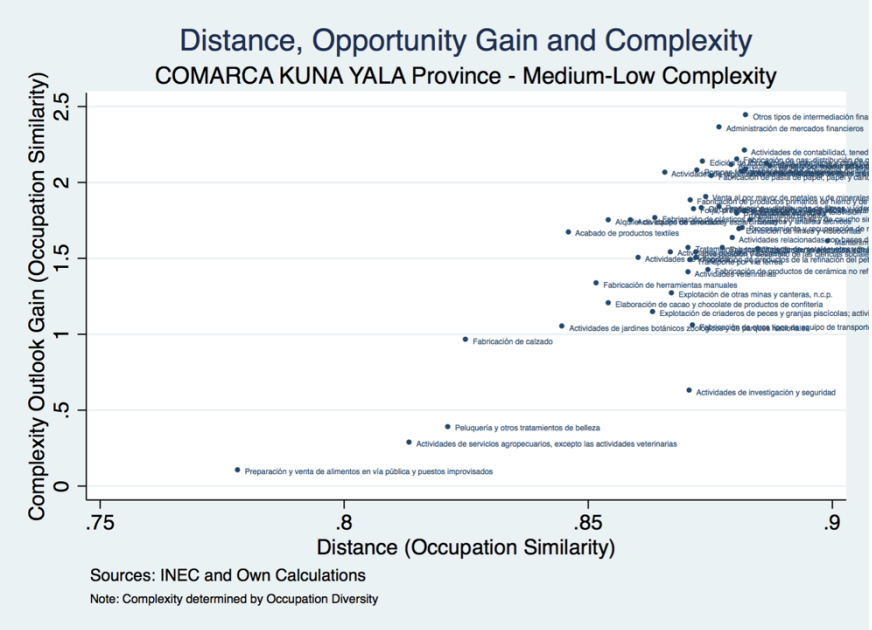
Appendix 72 - Distance, Opportunity Gain and Complexity (Comarca Kuna Yala Province)



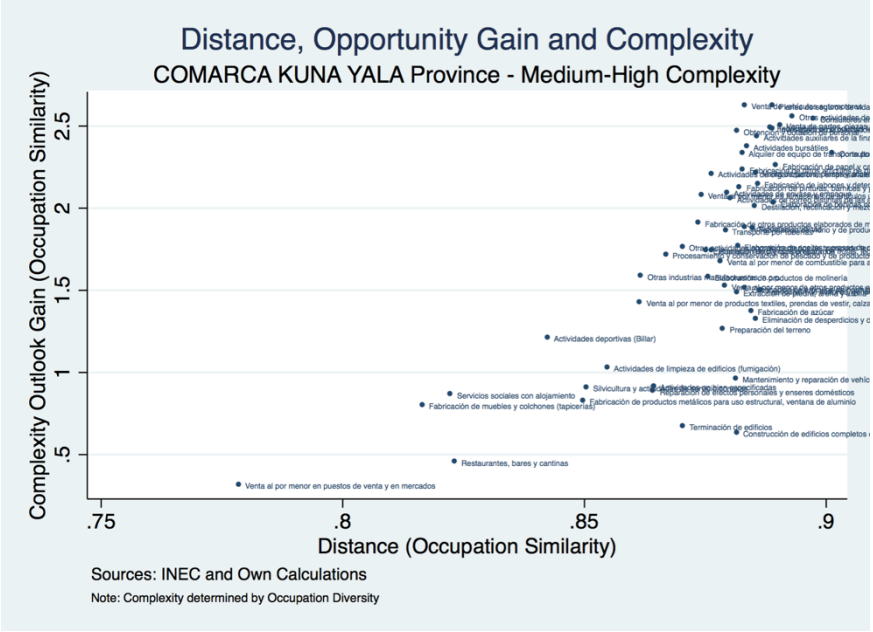
Appendix 73 - Strategic Aggregated Sectors (Comarca Kuna Yala Province)



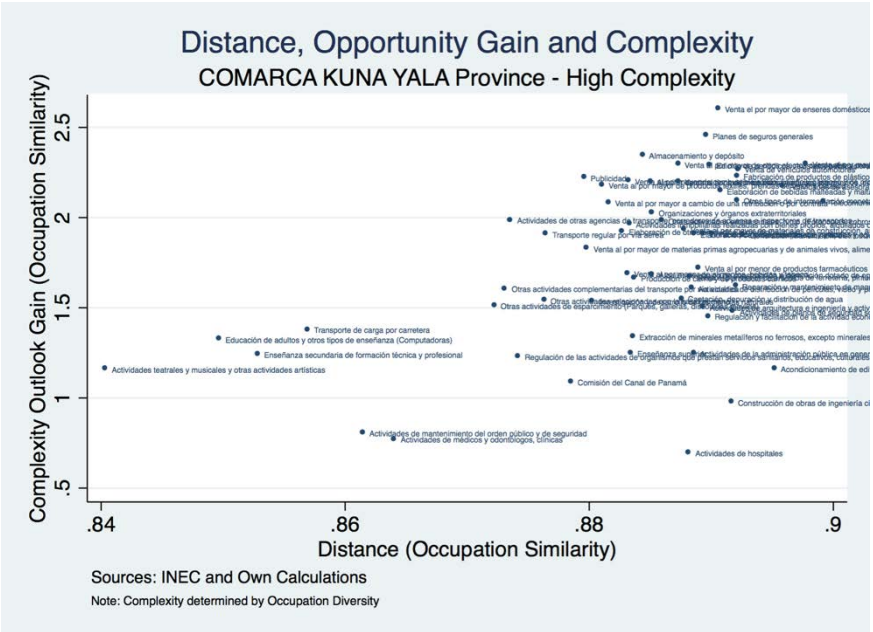
Appendix 74 - Distance, Opportunity Gain and Complexity (Comarca Kuna Yala Province - Low Complexity)



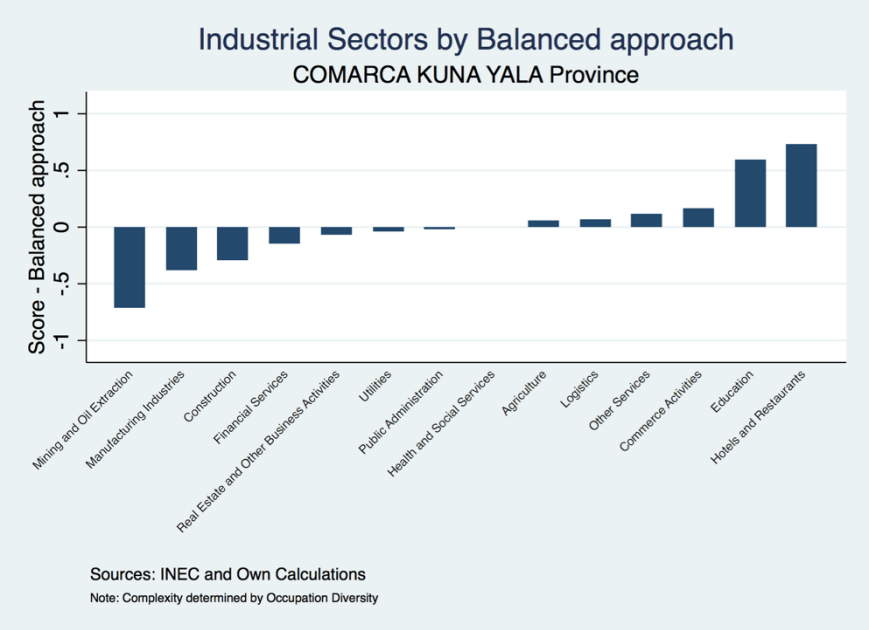
Appendix 75 - Distance, Opportunity Gain and Complexity (Comarca Kuna Yala Province - Medium-Low Complexity)



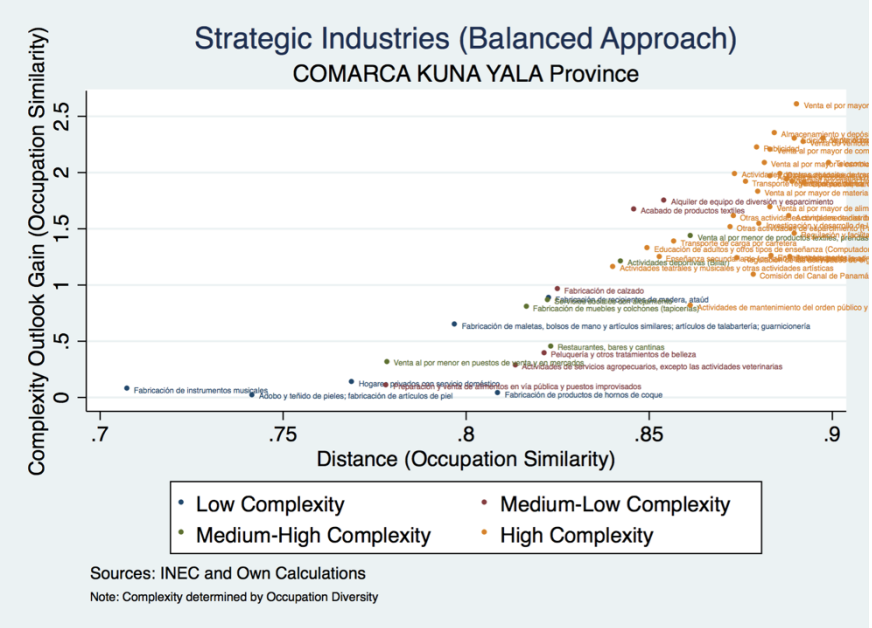
Appendix 76 - Distance, Opportunity Gain and Complexity (Comarca Kuna Yala Province - Medium-High Complexity)



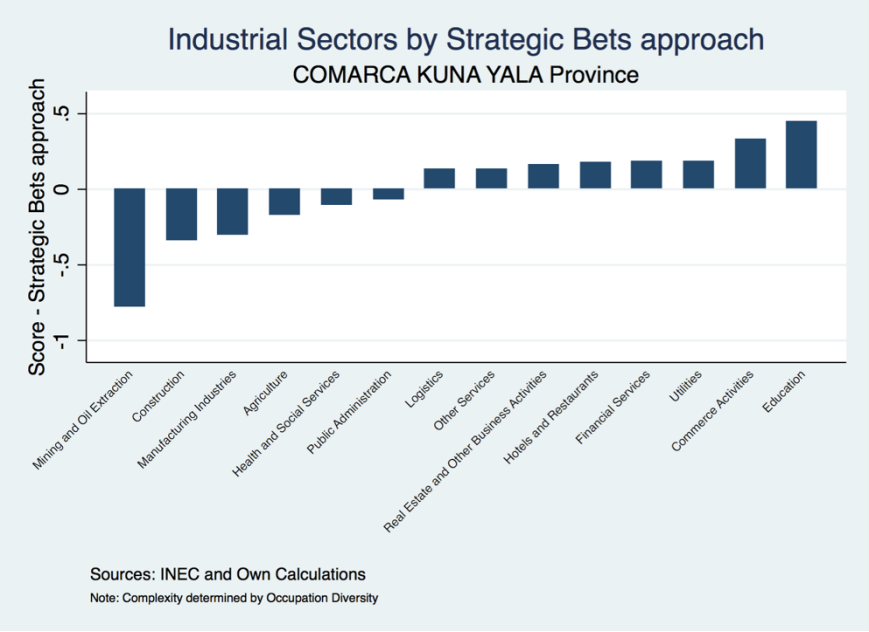
Appendix 77 - Distance, Opportunity Gain and Complexity (Comarca Kuna Yala Province - High Complexity)



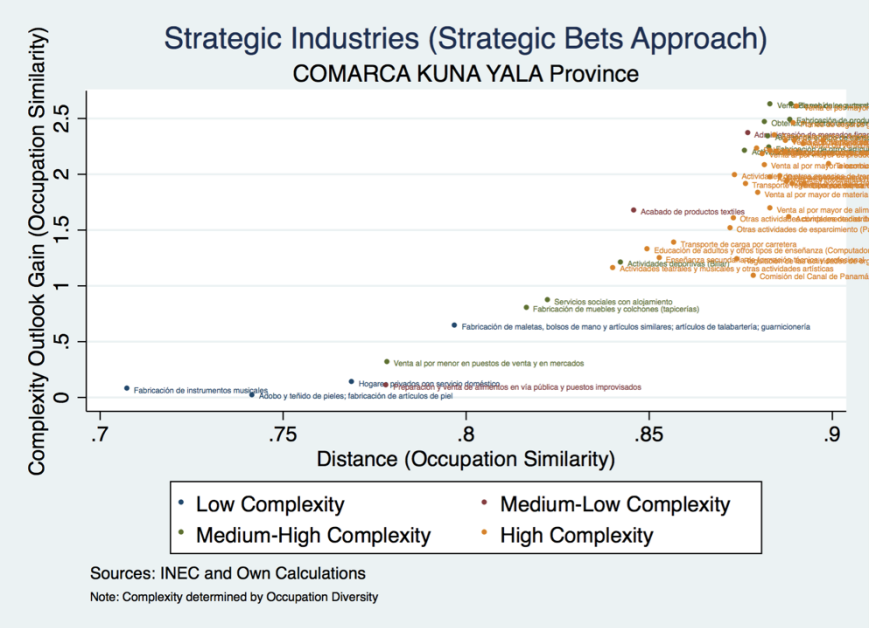
Appendix 78 - Industrial Sectors by Balanced approach (Comarca Kuna Yala Province)



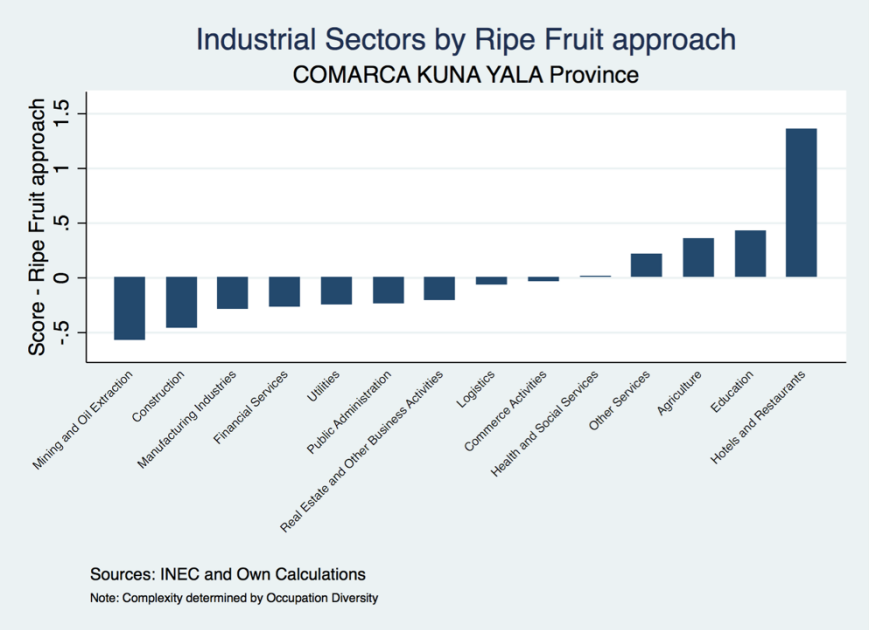
Appendix 79 - Strategic Industries (Balanced Approach, Comarca Kuna Yala Province)



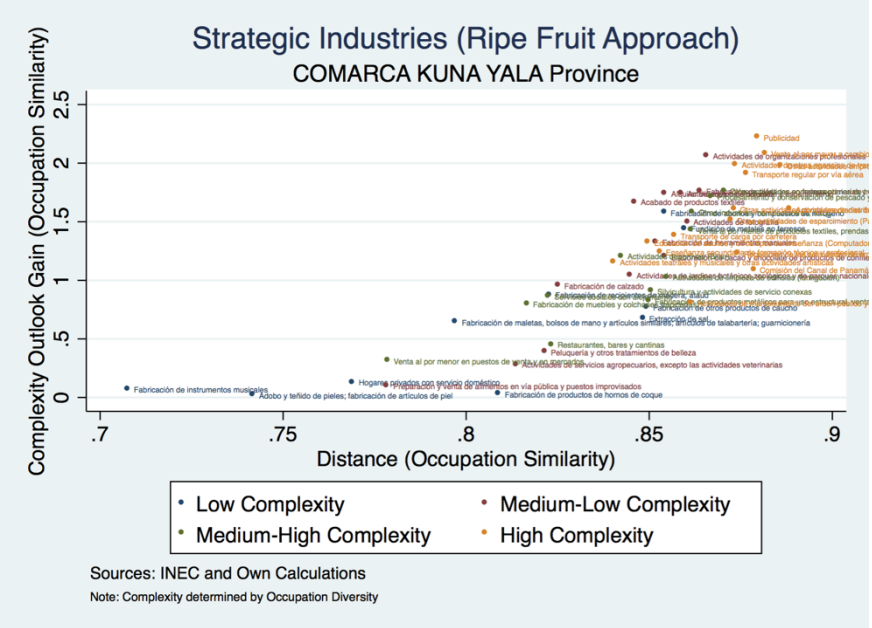
Appendix 80 - Industrial Sectors by Strategic Bets approach (Comarca Kuna Yala Province)



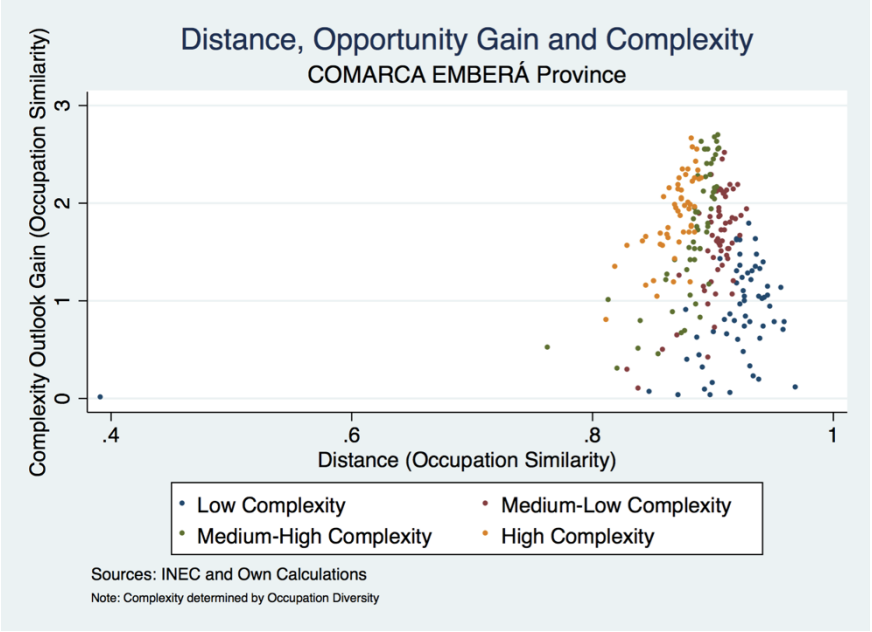
Appendix 81 - Strategic Industries (Strategic Bets Approach, Comarca Kuna Yala Province)



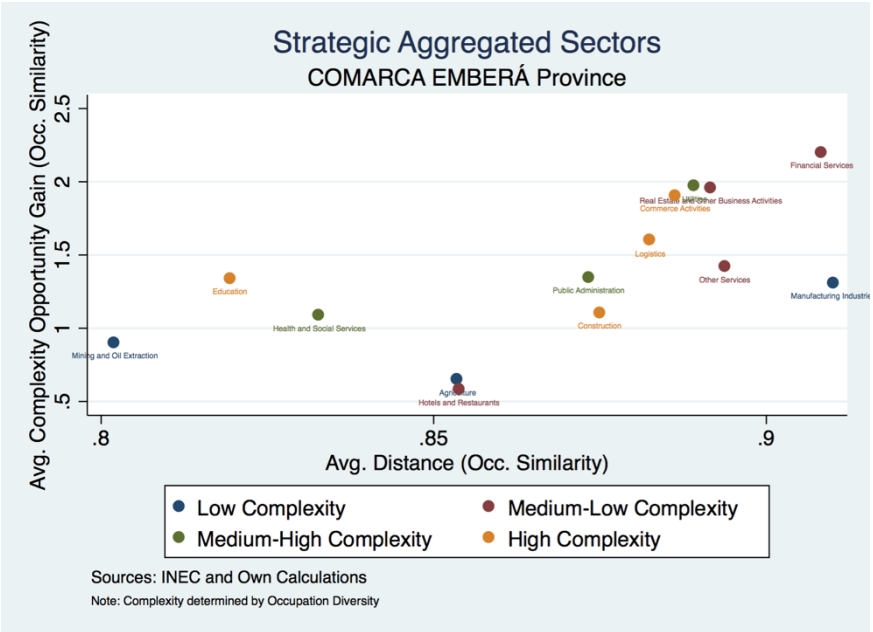
Appendix 82 - Industrial Sectors by Ripe Fruit approach (Comarca Kuna Yala Province)



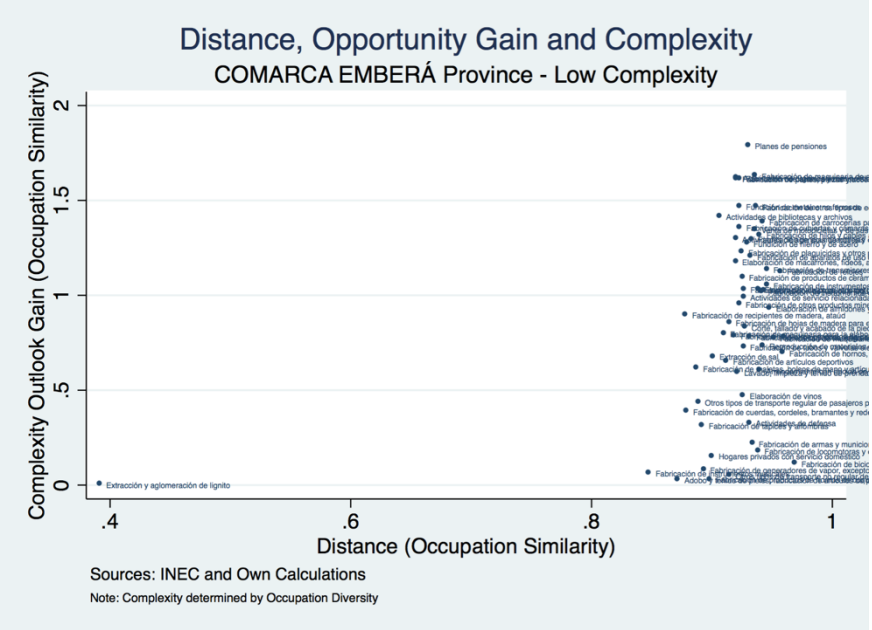
Appendix 83 - Strategic Industries (Ripe Fruit Approach, Comarca Kuna Yala Province)



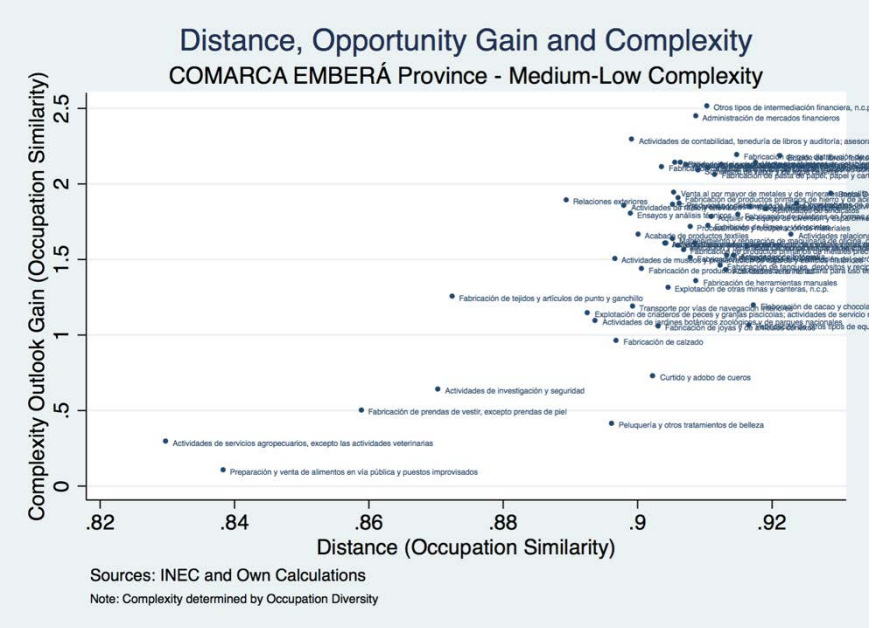
Appendix 84 - Distance, Opportunity Gain and Complexity (Comarca Emberá Province)



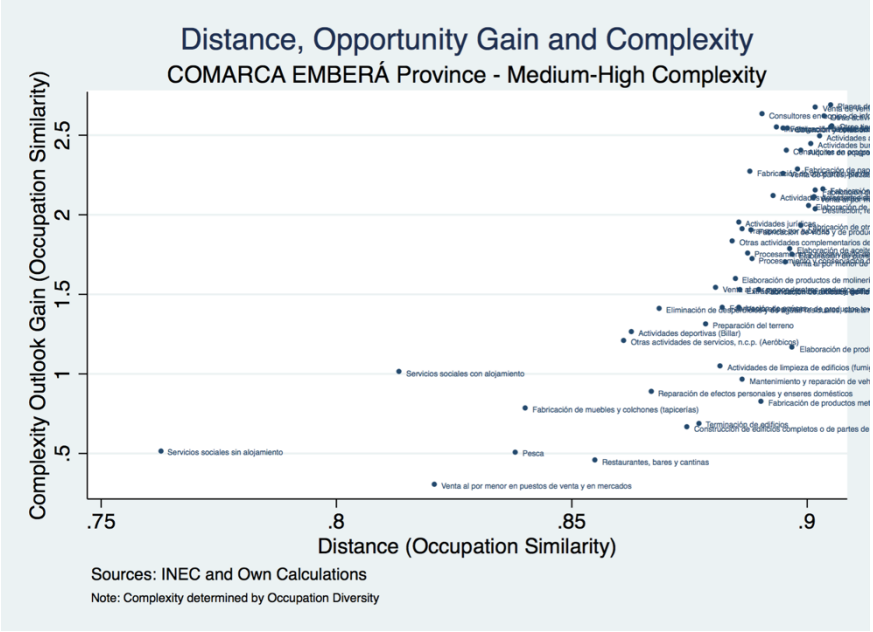
Appendix 85 - Strategic Aggregated Sectors (Comarca Emberá Province)



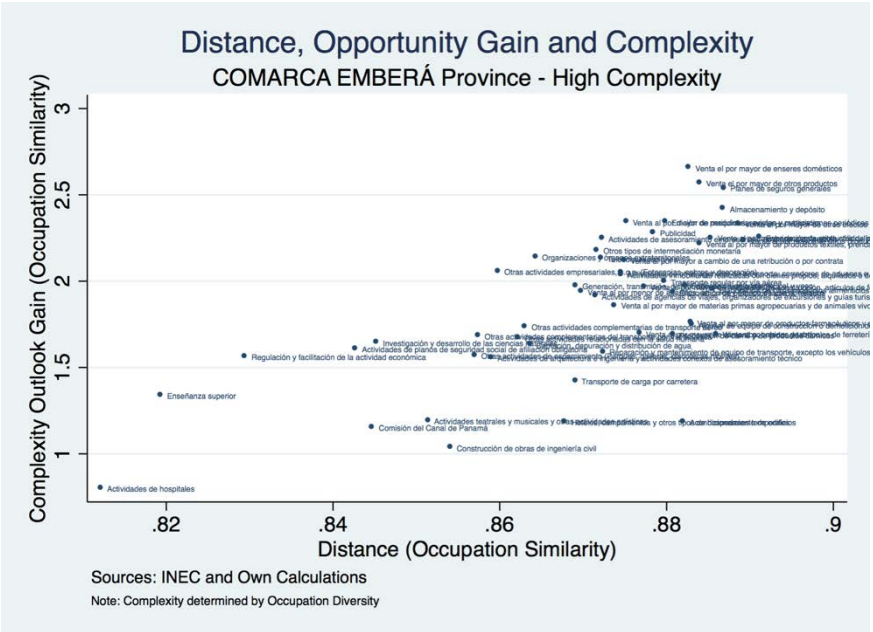
Appendix 86 - Distance, Opportunity Gain and Complexity (Comarca Emberá Province - Low Complexity)



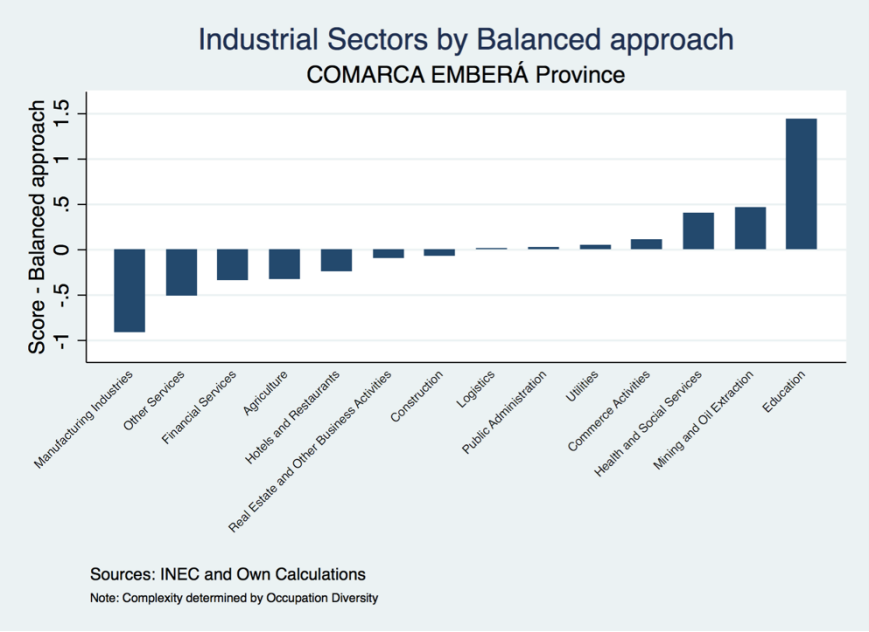
Appendix 87 - Distance, Opportunity Gain and Complexity (Comarca Emberá Province - Medium-Low Complexity)



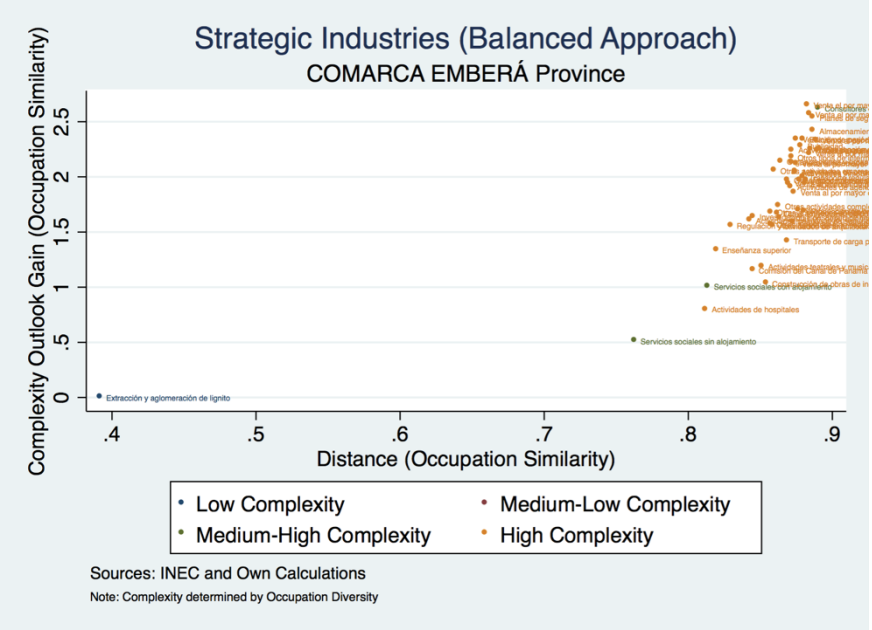
Appendix 88 - Distance, Opportunity Gain and Complexity (Comarca Emberá Province - Medium-High Complexity)



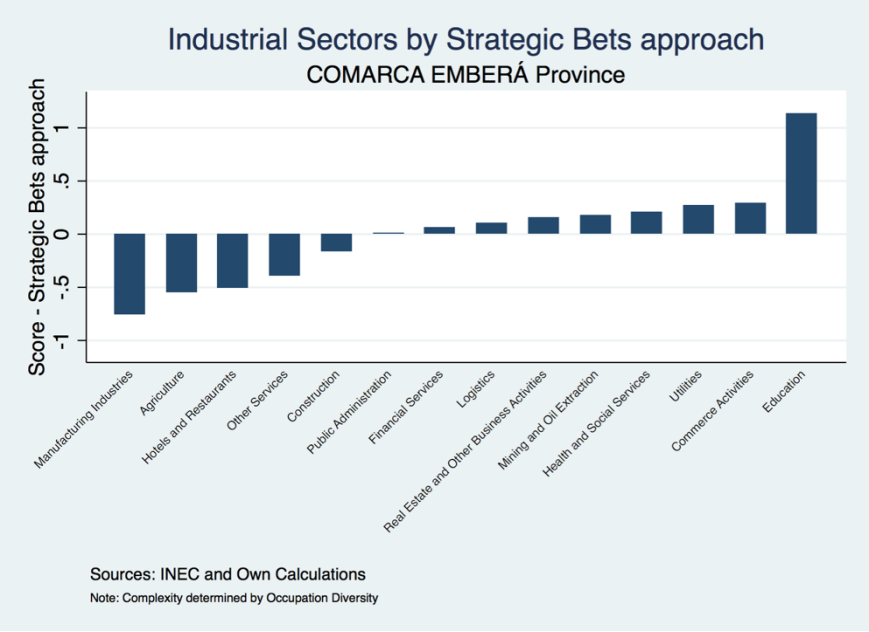
Appendix 89 - Distance, Opportunity Gain and Complexity (Comarca Emberá Province - High Complexity)



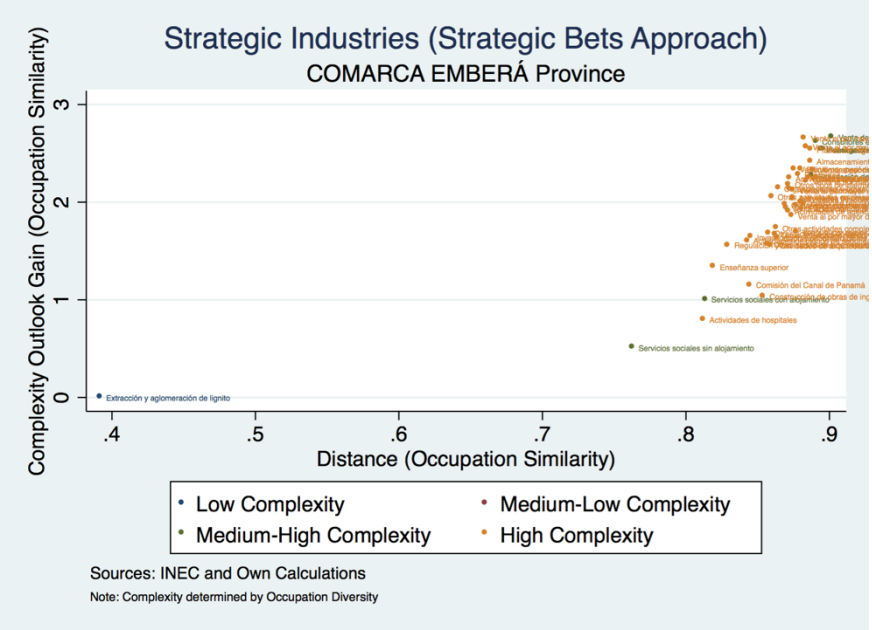
Appendix 90 - Industrial Sectors by Balanced approach (Comarca Emberá Province)



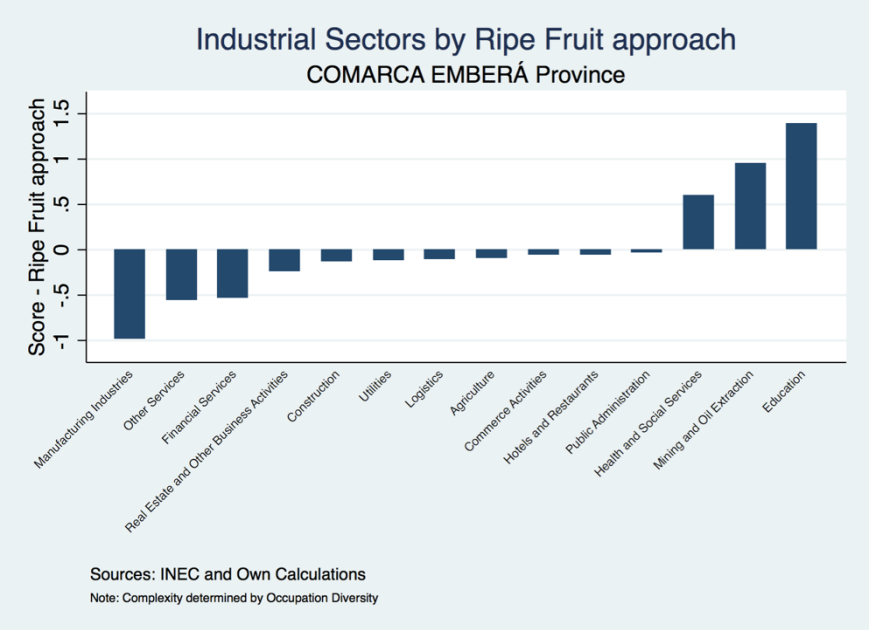
Appendix 91 - Strategic Industries (Balanced Approach, Comarca Emberá Province)



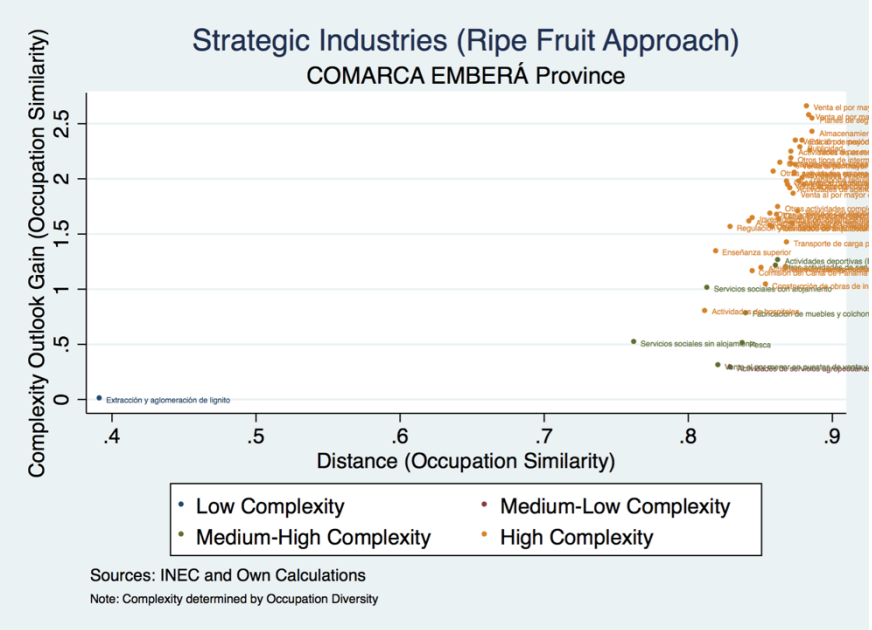
Appendix 92 - Industrial Sectors by Strategic Bets approach (Comarca Emberá Province)



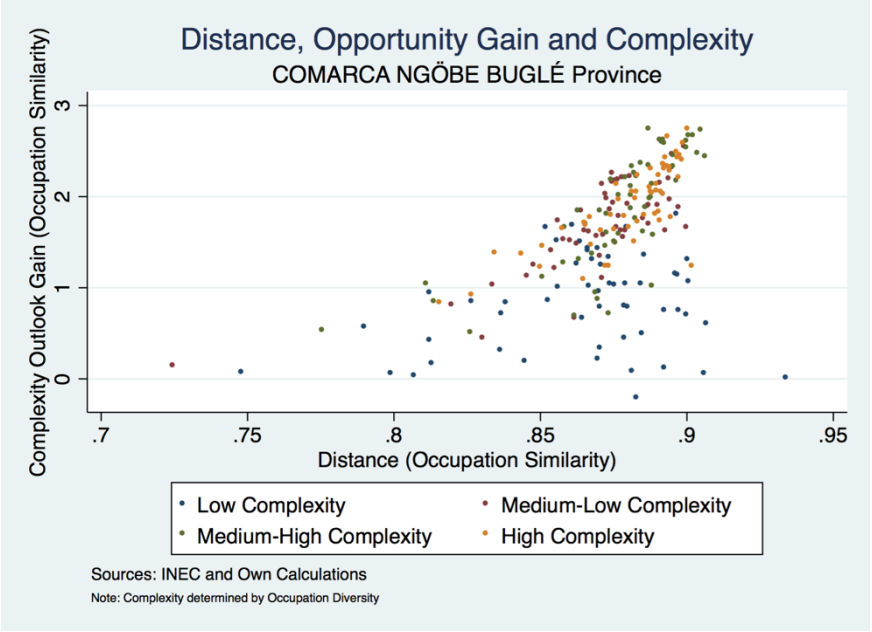
Appendix 93 - Strategic Industries (Strategic Bets Approach, Comarca Emberá Province)



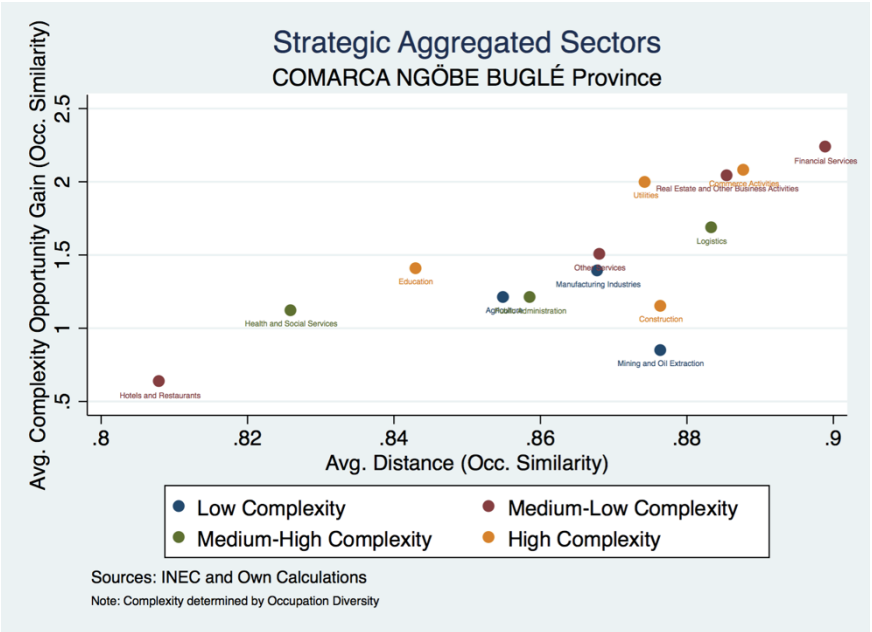
Appendix 94 - Industrial Sectors by Ripe Fruit approach (Comarca Emberá Province)



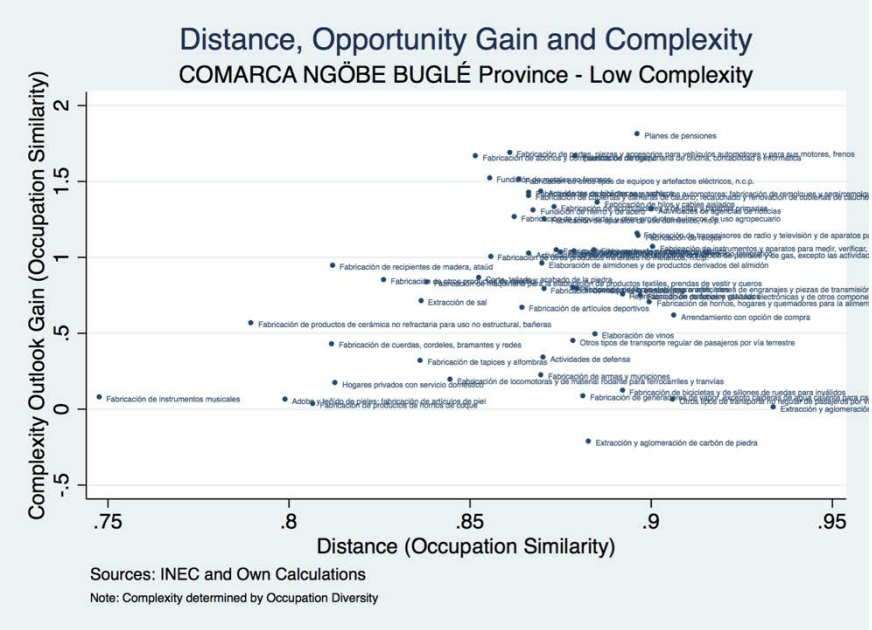
Appendix 95 - Strategic Industries (Ripe Fruit Approach, Comarca Emberá Province)



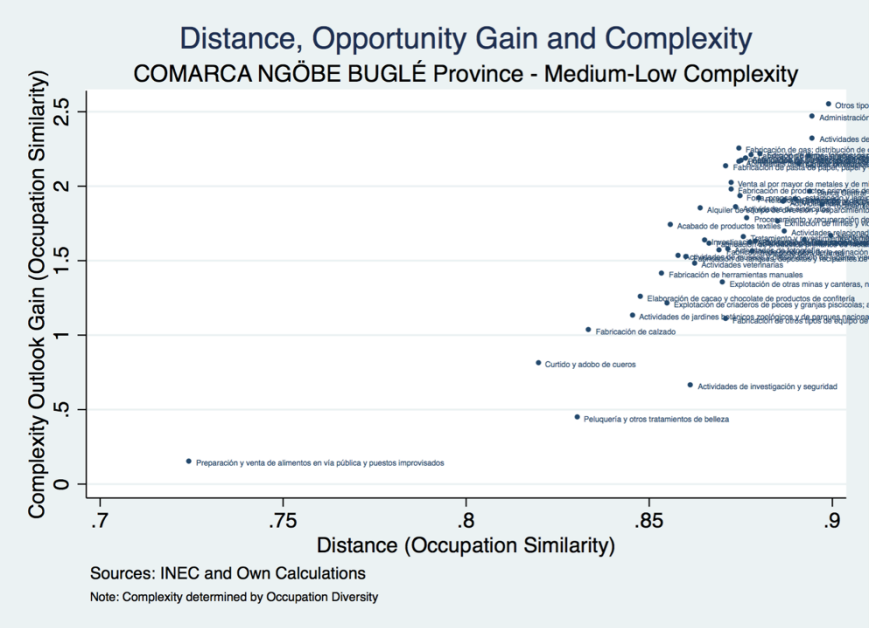
Appendix 96 - Distance, Opportunity Gain and Complexity (Comarca Ngöbe Buglé Province)



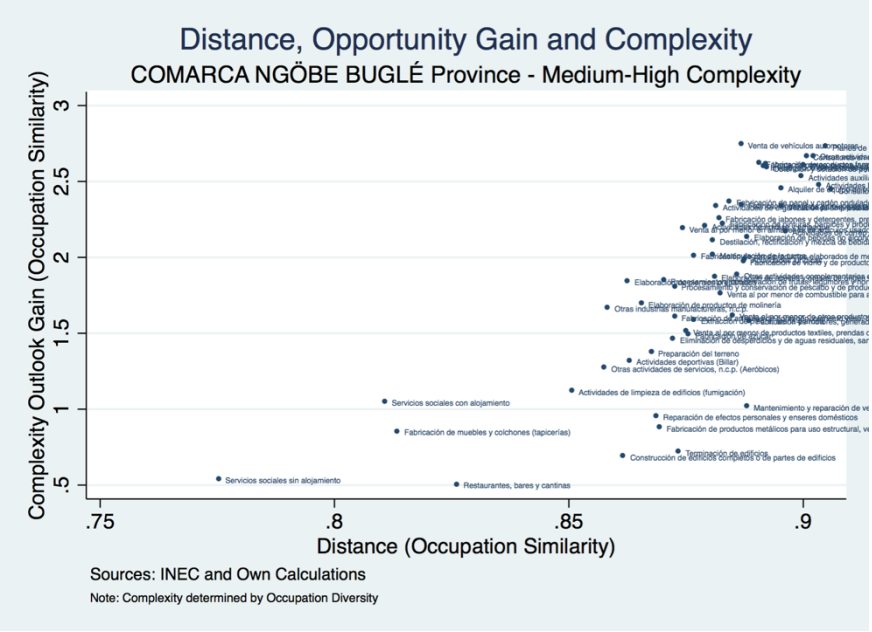
Appendix 97 - Strategic Aggregated Sectors (Comarca Ngöbe Buglé Province)



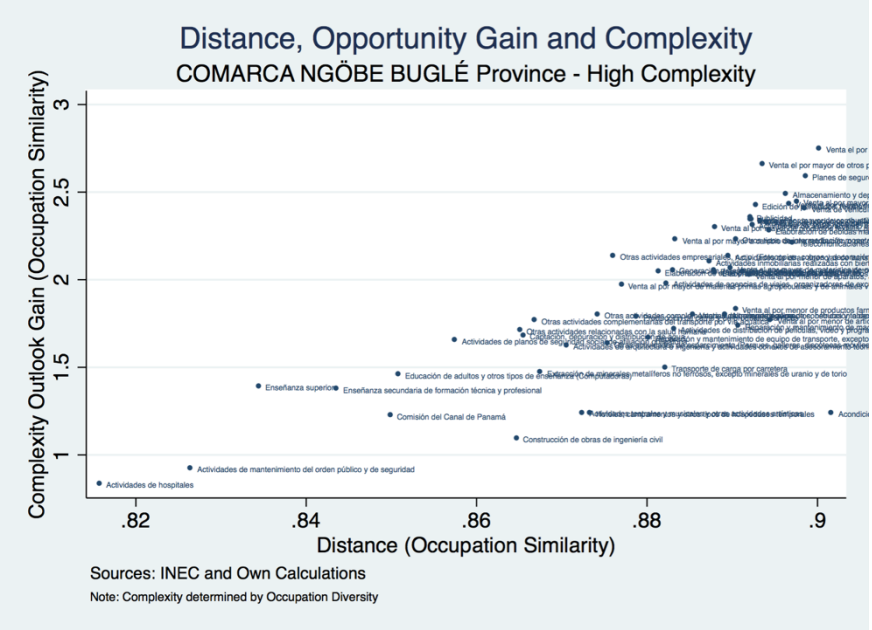
Appendix 98 - Distance, Opportunity Gain and Complexity (Comarca Ngöbe Buglé Province - Low Complexity)



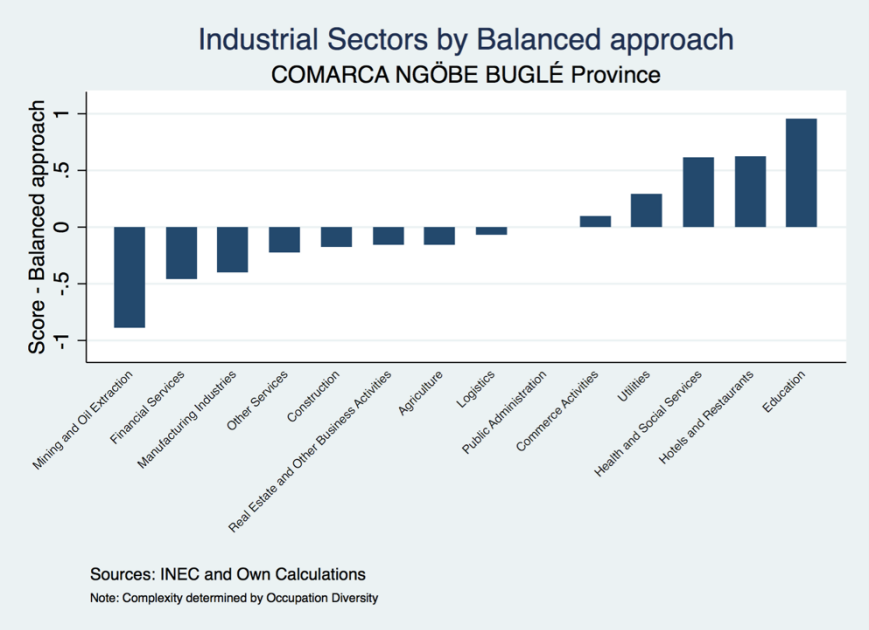
Appendix 99 - Distance, Opportunity Gain and Complexity (Comarca Ngöbe Buglé Province - Medium-Low Complexity)



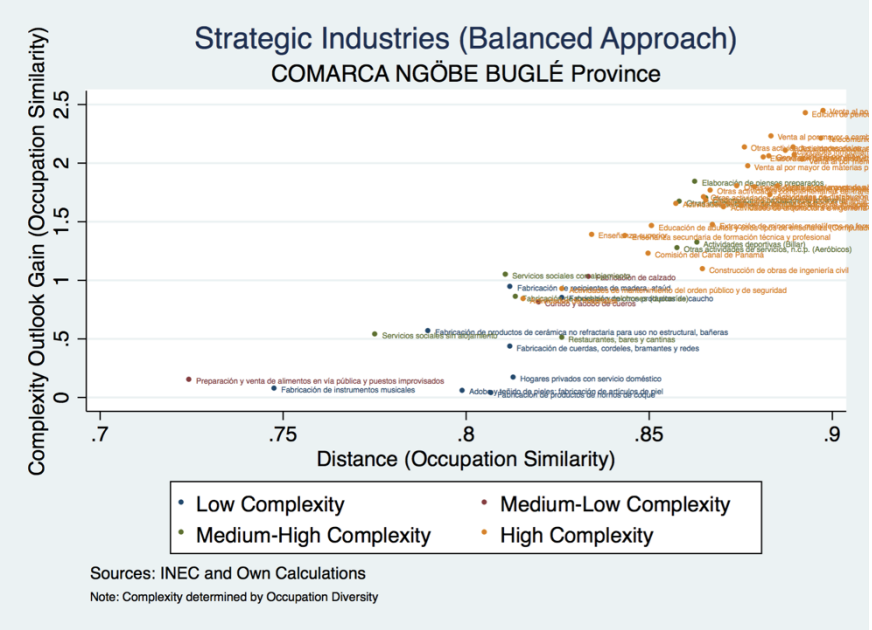
Appendix 100 - Distance, Opportunity Gain and Complexity (Comarca Ngöbe Buglé Province - Medium-High Complexity)



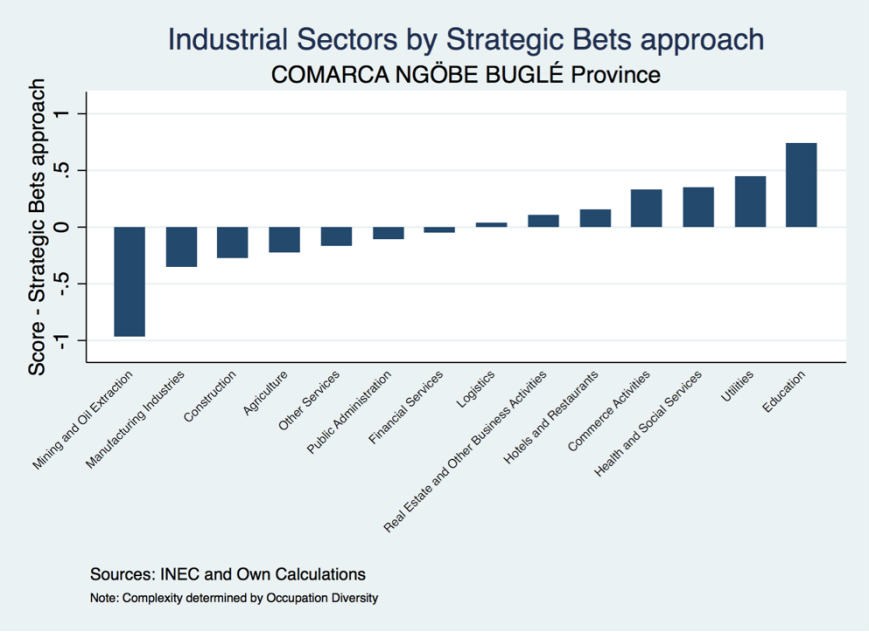
Appendix 101 - Distance, Opportunity Gain and Complexity (Comarca Ngöbe Buglé Province - High Complexity)



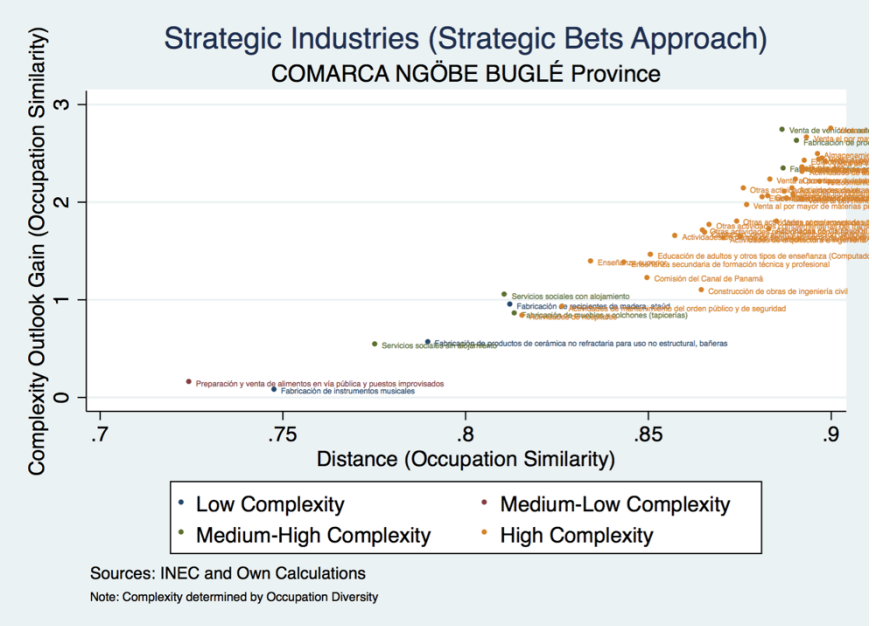
Appendix 102 - Industrial Sectors by Balanced approach (Comarca Ngöbe Buglé Province)



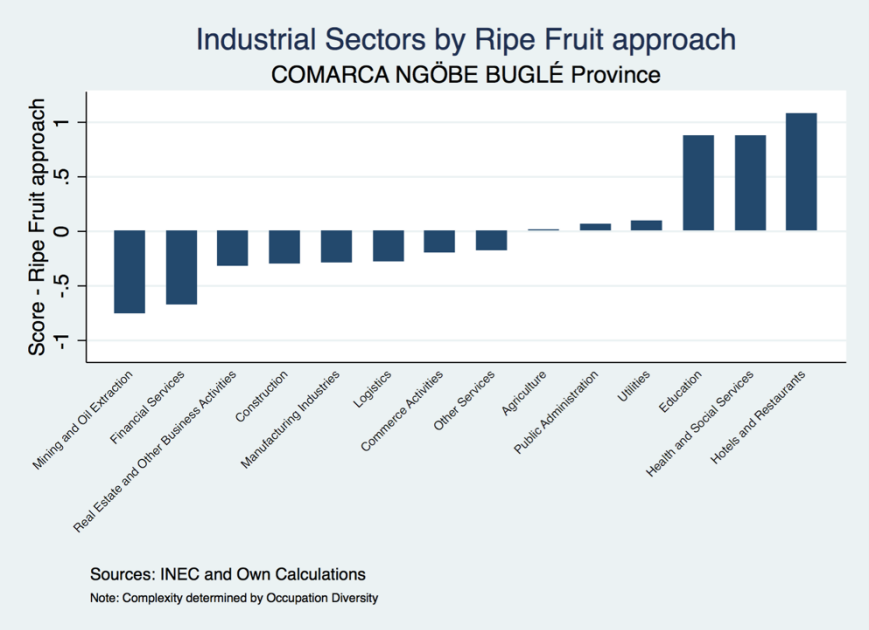
Appendix 103 - Strategic Industries (Balanced Approach, Comarca Ngöbe Buglé Province)



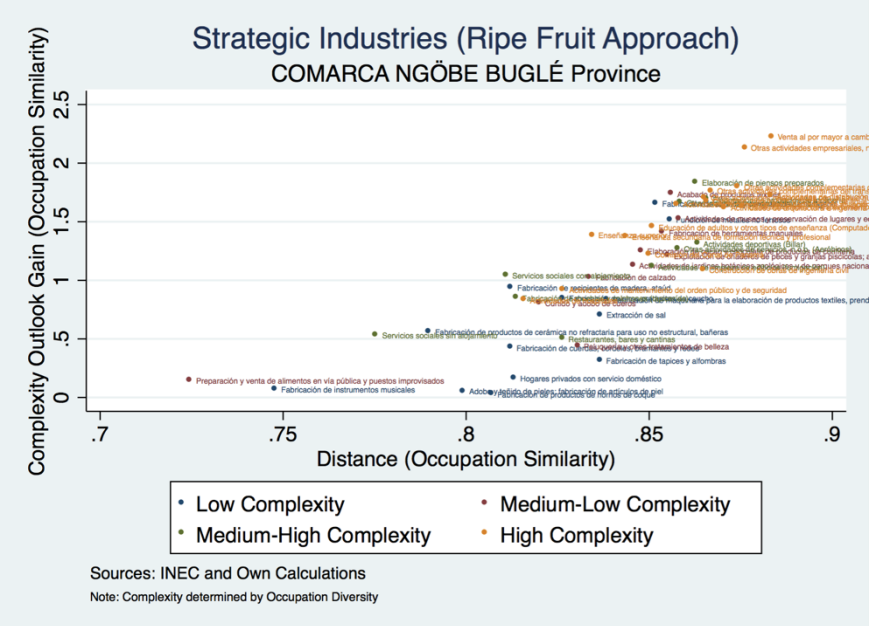
Appendix 104 - Industrial Sectors by Strategic Bets approach (Comarca Ngöbe Buglé Province)



Appendix 105 - Strategic Industries (Strategic Bets Approach, Comarca Ngöbe Buglé Province)



Appendix 106 - Industrial Sectors by Ripe Fruit approach (Comarca Ngöbe Buglé Province)



Appendix 107 - Strategic Industries (Ripe Fruit Approach, Comarca Ngöbe Buglé Province)

Appendix II: Technical Appendix

In this appendix, we describe the methods utilized for calculating the economic complexity metrics used in this study. The analysis is based on two separate groups of metrics: those based on exports of goods (HS Rev. 3, at 4 digits, based on customs data from ANA for years 2013-2014), and those based in employment of all industries producing either goods or services (Panama-adapted ISIC classification, Rev. 3, 4 digits, based on Population Census data for 2000 and 2010).

In the explanation that follows, the methods as executed on the exports from Panamanian exports are described. Precisions will be made whenever the procedures followed on employment data by industry differ mathematically from those executed on export data. In the equations below, the sub-index *c* indicates countries, provinces or districts, and the sub-index *p* indicates products or industries, depending on the case. While no sub-index for years is shown in order to simplify notation, all calculations are applied for each year separately.

Calculation of Revealed Comparative Advantages:

Exports by product, year and countries are organized in matrix form:

$$X_{cp}$$

From this matrix, country and product aggregates can be constructed:

$$X_c = \sum_p X_{cp}$$

$$X_p = \sum_c X_{cp}$$

$$X = \sum_c \sum_p X_{cp}$$

Building on these metrics, the Revealed Comparative Advantage (RCA) for each country/product combination can be developed:

$$RCA_{cp} = \frac{X_{cp}/X_p}{X_c/X}$$

In terms of province- or district-specific employment in different industries, the location quotient is basically the same mathematical expression. However, it must be noted that calculations on employment data by industry use the Panamanian

totals as a benchmark (*Xp* in this case is the total employment in Panama on industry *p*, and *X* is the total employment across industries).

Diversity and Ubiquity Calculations

The RCA matrix is transformed in a binary matrix depending on whether a particular value is larger than 1 or not.

$$M_{cp} = \begin{cases} 1 & RCA_{cp} \geq 1 \\ 0 & RCA_{cp} < 1 \end{cases}$$

This matrix indicates the products (or industries) that are relatively large in each country, province and district. From this matrix, the basic Diversity indicator at the locality level, and Ubiquity at the product (or industry) level can be built. These account for the number of products with relatively large exports for each locality, and the count of the places that export a given product with a relatively high intensity.

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

In the case of employment, the same metrics are also calculated from a location-occupation and an industry-occupation perspective – that is, an Mcp matrix that captures whether an occupation is relatively large for a given location, and another that measures the same concept for every given industry. The respective occupation diversities at the location and industry levels are also calculated.

Economic Complexity Metrics by product and localities

One metric of the complexity of a location is its diversity weighed by the relative ubiquity of the products (or industries) in which it displays a relative comparative advantage levels larger than one. Similarly, the complexity of a product or industry can be measured by its ubiquity weighed by the diversity of the localities that are competitive in such product or industry. The matrix-algebra method that extends this iterative exercise of correcting diversity with ubiquity and vice-versa, *ad infinitum*, is called the *method of reflections*. Its use allows the development of the following metrics:

$$k_{c,n} = \frac{1}{k_{c,0}} \sum_p M_{cp} \frac{1}{k_{p,0}} \sum_{c'} M_{c'p} k_{c',n-2}$$
$$= \sum_{c'} k_{c',n-2} \sum_p \frac{M_{c'p} M_{cp}}{k_{c,0} k_{p,0}}$$
$$= \sum_{c'} k_{c',n-2} \widetilde{M}^C_{c,c'}$$

Where:

$$\widetilde{M}^C_{c,c'} \equiv \sum_p \frac{M_{c'p} M_{cp}}{k_{c,0} k_{p,0}}$$

Using vector notation, this can be expressed in the following way:

$$\vec{\mathbf{k}}_n = \widetilde{\mathbf{M}}^C \times \vec{\mathbf{k}}_{n-2}$$

When n → ∞, we obtain the following expression:

$$\widetilde{\mathbf{M}}^C \times \vec{\mathbf{k}} = \lambda \vec{\mathbf{k}}$$

Where $\vec{\mathbf{k}}$ is an eigenvector of $\widetilde{\mathbf{M}}^C$.

The second largest eigenvector of $\widetilde{\mathbf{M}}^C$ in the international trade data accounts for the Economic Complexity Index (ECI) at the country level, and the second largest eigenvector of $\widetilde{\mathbf{M}}^P$ accounts for the Product Complexity Index (PCI). The ECI of a country is mathematically equivalent to the average of the PCIs of those products (or sectors) in which a location has an RCA larger than 1.

In the case of employment, the calculation of the ECI at the province or district level follows the same logic, just applied to the Mcp, diversity and ubiquity values from the location-occupation perspective. Following the criteria used in http://dataviva.info, the complexity of different economic activities is simply measured as its occupational diversity from an industry-occupation perspective.

Technological proximity between products (or industries), and distance from a location to a product or sector

In the exports module, technological proximities between products are calculated on international trade data at the country level. The technological proximity between two products is calculated as the conditional probability that a country exports a product with an RCA larger than 1, given that it does so with the other product –this kind of conditional probability is called the "co-location" proximity metric. To guarantee symmetry in the resulting proximity matrix, the ubiquity of the most ubiquitous product in each pair of products is considered the fixed denominator for the conditional probability – that is, the metric is always the minimum conditional probability between each pair or products.

$$\Phi_{p,p'} = \frac{\sum_c M_{cp} M_{cp'}}{\max\left(\sum_c M_{cp}, \sum_c M_{cp'}\right)} = \frac{\sum_c M_{cp} M_{cp'}}{\max\left(k_{p,0}, k_{p',0}\right)}$$

For the employment module, different approaches were developed and tested in section 3 of this study. The technological proximity approach followed to develop the industry diversification opportunities section is Occupation similarity alternative. The mechanics of calculating this matrix are exactly those described above for the export co-location proximities, applied on the relevant industry-occupation matrix. That is, the proximity metric between pairs or industries used for all complexity calculations at the province and district levels are based on the minimum conditional probability for an occupation to be demanded with an RCA larger than 1 by an industry, given that it is so demanded by the other industry.

Feasibility and opportunity metrics

Building on the proximity metric between pairs of products, the density of a country around a product or industry is the sum of the proximities between the products that such country exports with RCA >1 and each given product.

$$d_{cp} = \frac{\sum_{p'} M_{cp'} \Phi_{p,p'}}{\sum_{p'} \Phi_{p,p'}}$$

The distance from a country to a product is measured as the unit minus the density value for that country-product cell.

$$\text{distance}_{cp} = 1 - d_{cp}$$

The Complexity Outlook Index (COI) of a locality is the sum of the densities for the products in which a location has RCA lower than 1, multiplied by their PCIs.

$$\mathrm{COI}_c = \sum_p d_{cp}(1 - M_{cp})\mathrm{PCI}_p$$

Hence, places "closer" to producing a larger number of more complex products show higher COI values.

Finally, the Complexity Outlook Gain (COG) of a product in a location is the COI gain that a locality would observe by adding a given product to its export mix. This metric takes into account both the immediate gain of adding the product and the indirect gain of becoming "closer" to other products with RCA lower than 1.

$$\mathrm{COG}_{cp} = \left[\sum_{p'} \frac{\Phi_{p,p'}}{\sum_{p''} \Phi_{p'',p'}}(1 - M_{cp'})\mathrm{PCI}_{p'}\right] - d_{cp}\mathrm{PCI}_p$$

These metrics are calculated in exactly the same fashion for the employment module at the province and district levels, just using with the relevant industry proximities and complexity metrics described above.

For more information

For a more detailed discussion on the conceptual basis of the Economic Complexity Metrics, and to find further relevant technical literature, we invite you to visit the Atlas of Economic Complexity (http://atlas.cid.harvard.edu) and to download the book of the Atlas of Economic Complexity (http://atlas.cid.harvard.edu/book).