Data analysis for the offshoring of financial systems production chains

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***Abstract*—The world economy now suffers from the need to understand, improve and predict current and potential trade relations, making it necessary to develop a method that allows a clear analysis of possible strategies. Using the physical formula of the law of attraction between bodies and its financial analogy, it is possible to observe different sales opportunities for a given country than those it currently possesses.**

***Index Terms*—trade, friend-shoring, improve, world, relationships**

I. Introduction

It is fundamental to understand reality and even more so the economy as the fundamental basis of society. The way a country produces, the use of the means of production, and the distribution of wealth are areas that define the well-being of the population. In addition, without it, the development of the countries would not be allowed, since they do not manage, do not know what to produce, how to produce, and for whom to produce. The current economy tends to be characterized by a new form of relations between the different productive actors. This phenomenon, which has given rise to several works on what is called the economy of conventions, is based on the notion of transaction costs developed by the author Richardson *et al.* (2003). According to him, in order to make their relationships more flexible, the economic actors tend to establish among themselves a series of conventions that determine ways of structuring their customer-supplier relationships, in such a way that a quality contractual relationship can be organized.

In recent years, following a series of historical, social, and political events, many countries around the world have restructured the way they produce, distribute, trade, and consume goods and services. Fragility in the network of individuals and companies involved in the creation of a product and its delivery to the consumer has been evidenced by both predictable and unpredictable events that greatly affect the economy of nations. A key issue for the success of any organization, in a supply chain environment, is to ensure the smooth functioning of each and every entity in the chain by effectively managing risks and disruptions.

It is clear that it is vitally important to increase economic development and social welfare. Economics professor Guzel *et al.* (2021) comments that increasing the level of social welfare is a complex process that depends on economic and non-economic factors. Achieving economic development or increasing the level of well-being depends on the achievement and maintenance of the main objectives in the political, economic and social spheres. Today, development is no longer a process that can be achieved through policies implemented solely by governments. It requires cooperation between governments and societies. Although cooperation between different countries requires globalization in the economic, social and political fields, democracy is the way to ensure cooperation between governments and societies.

As a proposal to minimize the risks brought about by unexpected situations in a country's economy, in addition to strengthening ties between allied states, the term friend-shoring is introduced by Baschuk (2022). Basically, it consists of isolating global supply chains from external shocks and economic imposition by preventing nations that are less sympathetic to a given country from taking advantage of their position in the market for raw materials, technologies, or products to disrupt the economy of specific territory or that of its allies. Thus "de-localizing" various sectors of the economy and moving their operations to places where it might be more feasible to operate.

Supply chains of the past were focused on network design, depot location and distribution fleet. Today, optimization is the key factor in developing a competitive advantage and protecting the brand, with a focus on execution-oriented applications and real-time decision support. Developing countries are key elements of this methodology as their incursion into new markets, beyond advancing economic growth, allows for the creation of a more elaborate network between allied countries that challenges the system that has been in place and provides income benefits for both buyer and seller.

In order to choose possible products and sellers, it is necessary to use indicators that show how profitable the

industry is on the market in different countries. But, as these are elements that require previous data collection and analysis, they take time to be calculated, this presents a disadvantage for the search for new markets, since the sales actions of the country interested in economic growth must be immediate as it is involved in a competitive world where opportunities must be seized as quickly as possible, therefore the best alternative for the solution of our questioning is the previous preparation in front of the situations that occur in the day to day so that in case of any inconvenience in the world market, the country has already made the management of opportunities and risks and the different alternatives, all these using parameters of easy access and updating.

II. State of art:

Several studies have been conducted in the past to develop models for risk and disruption management in production and supply chain systems. The literature basically presents several types of models, such as models on imperfect production processes, production and inventory management with disruptions, and supply chain management with disruptions. These models have been solved using different solution approaches, and some of them were applied to real cases Paul *et al.* (2016).

In some of the models mentioned before, there is a presence of a powerful tool that allows a better understanding of economics is called Economic complexity, it was developed by Hidalgo & Hausmann (2009) to measure the accumulated productive know-how of a country and to deduce from it its future growth prospects. Economic complexity focuses on the duality between economic inputs and outputs. This involves the use of machine learning and network techniques to predict and explain the economic trajectories of countries, cities, and regions.

Based on the imports and exports of some countries, Hausmann *et al.* (2014) also created an indicator called the economic complexity index (ECI), which ranks countries based on how diversified and complex their export basket is. Using this index is possible to measure the social and cultural development of a nation, which depends on the presence of a good and stable economy, which encourages the creation of useful tools for citizens that allow them to have a better quality of life and growth in their purchasing power. Likewise, there is progress in the appearance of new business and service models, together with greater technological innovation.

In 2017, Albeaik *et al.* (2017) also developed research in which predictions of future economic growth were obtained for the period between 2013 and 2033; Using a matrix containing information on which countries were major exporters of which products and indicators based on the ECI, they contributed to the growing literature on economic complexity by advancing an improved metric for estimating the total knowledge content of an economy and its capacity to generate income, but concluded that economic complexity should not be the only factor taken into account for predicting future economic growth but it can be a great.

Some research presents ideas of long-term improvements for economic growth. Several of them mention education as a key element of a boom in the economy of the countries, based on arguments that more graduates will lead to faster growth, and therefore higher wages for people, greater effectiveness of the labor force. that would lead countries to have a higher gross domestic product Montoya (2017). However, empirical analysis does not support this general proposition. As Hanushek Guzel *et al.* (2021) mentioned, differences in countries' cognitive skills and knowledge capital can explain most of the differences in growth rates between countries, but historically only adding more years of schooling without increasing cognitive abilities have had little systematic influence on growth.

Many forces contribute to economic growth. However, there is no single factor that consistently stimulates the perfect or ideal amount of growth an economy needs. Therefore, it is necessary for the development of future works to take into account different factors such as geopolitical and geofinancial events in order to have good analyzes of the economic expansion.

III. Statement of the problem

The question arises, how quickly can a supply chain respond to change, whether in customer demands, competition or supply disruptions? Modern supply chains must be agile to remain competitive in the marketplace. For this reason, developing countries are currently considering alternatives and methods to analyze, improve and satisfy their economic system, in order to obtain proposals for new markets in which they could intervene. Strengthening these systems allows countries to generate more opportunities for both individuals and businesses, improving the quality of life in the country, enabling the creation of both material and human capital within communities and increasing their capacity to provide resources and other types of support, reducing dependence on external support and the need to migrate.

In this situation, data could be considered the most valuable resource of organizations, since it allows them to analyze supply chains over time, capturing situations that help to understand their behavior. Countries and companies need to be clear about what data they will use to improve the quality of their decisions in pursuit of their strategic objectives. The main problem with this initiative lies in the speed of decision-making and the dependence on traditional statistics for entering new markets, since they do not provide information in time to generate a response

to the different problems that arise in global production chains.

When the relationship with suppliers is based on simply obtaining the lowest price, multiple competencies that other criteria can contribute to the efficiency and effectiveness of the different production chains are wasted. Considering the competencies of suppliers at a level of commitment to generate better solutions and efficient interrelationships between companies should be considered a weighty factor in the decision to select different importers and exporters. Focusing strategic suppliers under a policy of collaboration and joint growth guarantees a solid projection and prepares the chain to face any possible interruption. This research project is based on the need to strengthen the growing industry in the countries of the world, especially in developing countries, by analyzing their different export products and finding alternatives that allow the exchange of new products that expand the country's economy when gaps occur in the chains and develop products that provide greater quality and benefit, not only for the exporter but also for the importer, taking into account various spatial, political, financial and economic factors.

Formalization of the problem

Sets:

Let P = $\{P_1(x_1, y_1), P_2(x_2, y_2), ..., P_n(x_n, y_n)\}$ be the group of n countries in the world with coordinates (x, y).

i = $\{i_1, i_2, ..., i_n\}$ be the group of the n industries.

Attributes:

Let $d^i_{p_0,p_d}$ denote the trade relationship between the country p_0 and p_d with the industry i.

Problem: Given a country x with location (x', y') and a set of industries I that can produce X. Find the subset of industries O, such that $O \subset I$, for which country X has a comparative advantage in exporting.

Country X has comparative advantage with the country p_d if:

$$O_{x,p_d} \text{ when } f(x, d, i, \mathcal{D}_(x, d), ...) \gg f(y, d, i, \mathcal{D}_(y, d), ...)$$

where f is the selling opportunity function that receives a country, a destiny, a industry and the distance between the country X and d.

Goal: Find the vector O and the vector d that maximize f(x).

IV. Methods

A. Data:

The World Governance Indicators (WGI) is a research dataset that summarizes the views on the quality of governance presented by a large number of respondents from businesses, citizens and experts in industrialized and developing countries. This data is collected from a number of survey institutes, think tanks, non-governmental organisations, international organizations and private sector companies. It is necessary to assume that these indicators are sufficiently informative for the purpose of the project, since the idea is also to minimize the number of variables to be considered so as not to obtain a model that is too complicated to analyze or improve.

There are six indicators available:

- Voice and accountability (VA) reflects perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.
- Political Stability and Absence of Violence (PV) measures perceptions of the likelihood of political instability and politically-motivated violence, including terrorism.
- Goverment Efectiveness (GE) emulates perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.
- Regulatory Quality (RQ) catches perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.
- Rule of law (RL) reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.
- Control of corruption (CC) returns perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.

Each one of them ranges from -2.5 (weak) to 2.5 (strong) governance performance and was collected in 2020 from the World Bank page.

Gross domestic product (GDP) is the standard measure of the value added created through the production of goods and services in a country during a certain period. As such, it also measures the income earned from that production, or the total amount spent on final goods and services (less imports). It measured in US dollars (USD) and was collected in 2020 from The Organization for Economic Co-operation and Development. It is going to be necesasary because in futher calculus will give information about the size of the economy and how an economy is performing.

Imports result in an outflow of funds from the country, since import transactions involve payments to sellers residing in another country. Exports are goods and services that are

produced domestically but are then sold to customers residing in other countries. This information will be of the utmost importance since it allows to publicize what products and services each country offers in order to analyze possible buyers given the current transactions between countries. This information will be obtained from the Observatory Economic Clomplexity using web-scrapping for the information of each country in the world. It will return all exports of each country in the world with the respective product, trade and importer.

Finally, it is important to take into account the characteristics of each country, such as its population, region and its respective distance from each country in the world.

B. Implementation

First of all, the obtained data is given in non-comparable units, so becames necessary to normalize this information. Statistical normalization is the transformation of the scale of the distribution of a variable in order to be able to make comparisons with respect to sets of elements.

Direct Standarization: Variable X requires direct classic standardization when the variables are proportional, the higher the value, the better the score. In these cases, the following standardisation approach is used:

Let X be the observed value of the variable and let $X^{(s)}$ be its standardised value. Then

$$X^{(s)} = \left(100 * \frac{X - \text{Min}(X)}{\text{Max}(X) - \text{Min}(X)}\right) + 1$$

Where $\text{Max}(X)$ and $\text{Min}(X)$ are the maximum and minimum values observed for X respectively.

Inverse Standarization: Variable X requires direct classic standardization when the variables are inversely proportional, i.e., the higher the value, the worse the score.

Let X be the observed value of the variable and let $X^{(s)}$ be its standardised value. Then

$$X^{(s)} = \left(100 * \left(1 - \frac{X - \text{Min}(X)}{\text{Max}(X) - \text{Min}(X)}\right)\right) + 1$$

Where $\text{Max}(X)$ and $\text{Min}(X)$ are the maximum and minimum values observed for X respectively.

The next tables show the stadarization applied to each one of the variables obtained for the data analysis and the creation of the algorithim:

Variable	**Trade**	**Distance**	**VA**	**PV**	**GE**
Standarization	Direct	Inverse	Direct	Inverse	Direct

Variable	**RQ**	**RL**	**CC**	**GDP**	**Population**
Standarization	Direct	Inverse	Direct	Direct	Direct

To calculate distance between a country exporter and a country importer, we used harvesine distance which determines the great-circle distance between two points on a sphere given their longitudes and latitudes. Important in navigation, it is a special case of a more general formula in spherical trigonometry, the law of haversines, that relates the sides and angles of spherical triangles. It is given by the next formula:

$$\text{d} = 2{\cdot}r \arcsin\left(\sqrt{\sin^2\left(\tfrac{\varphi_2-\varphi_1}{2}\right) + \cos\varphi_1 \cdot \cos\varphi_2 \cdot \sin^2\left(\tfrac{\lambda_2-\lambda_1}{2}\right)}\right)$$

Where r is the circunference of the Earth, d is the distance between the two points along a great circle of the sphere, ϕ_1, ϕ_2 are the latitude of point 1 and latitude of point 2 and λ_1, λ_2 are the longitude of point 1 and longitude of point 2. To find the two points to calcule the distance between two countries, we use the closest point on the border of the exporter and the center of importer.

Next, we are going to create a data frame that will contain the information of all the exporters in the world of a product given its HS4 code, with their respective information (Importer, product, trade, world government indicators, population, region, GDP) in order to perform a multiple linear regression that will allow us to find the coefficients that determine the level of importance of each of these variables in the trade of the product given the export.

Let y be the dependent variable:

$$y_j = \sum_{i \in I} t_{jip}$$

where y_j is the sum of the trades of each of the exports from country j to the set of countries I, t_{ijp} will be the trade of the product *p* from the country *i* to *j*.

Let the independent variables $x_{j1}, x_{j2}, x_{j3}, x_{j4}, x_{j5}, x_{j6}$ each one of the world goverment indicators of the country j that exports the product p.

The variable region is represented with a categorical value, so it is necessary to transform it into 6 different variables that represent each region, if the country belongs to the region the variable will have a value of 1, otherwise 0.

After performing this second transformation with the categorical variable, we introduce the auxiliary variables of the regression $x_{j7}, x_{j8}, x_{j9}, x_{j10}, x_{j11}, x_{j12}$ that represent the region of country j, its respective population and GDP. Auxiliary variables will allow us to avoid possible correlations between our variables, thus making our regression more truthful.

Finally, after obtaining the parameters that measure the level of significance of each indicator in the product trade,

we will apply the formula of the law of universal gravitation, proposed by Newton, which describes the gravitational force or interaction between different bodies with mass.

The scientist states that the force exerted between two bodies of mass m_1 and m_2, separated by a distance d is equal to the product of their masses and inversely proportional to the square of the distance, that is:

$$\vec{F} = \frac{m_1 \cdot m_2}{d^2}$$

As has been done in other financial phenomena this formula will be applied to model the force of attraction between the economies of two countries, defining:

- Gravity: is the sum of the product of the value of the parameters obtained by the regression together with the actual value, both exporter and importer, of each indicator representing the parameter.
- Mass: is defined as the sum total of the trade value of the country's exports.
- Distance: haversian distance from the central point of the importing country and the closest point to it of the exporting country.

Finally, we are going to carry out a "competition" between the chosen country and the current exporters of the selected product together with their respective importers. The proposed formula will be calculated between the selected country and the importers against the exporter and it's importers. The country with the highest attractiveness will be the winner and will be selected for the export of the product to the importer.

V. Results

Colombia will be chosen as the country to which the potential buyers of product 52709 (Coffee) will be calculated. Below is a graph of the current exports of this product.

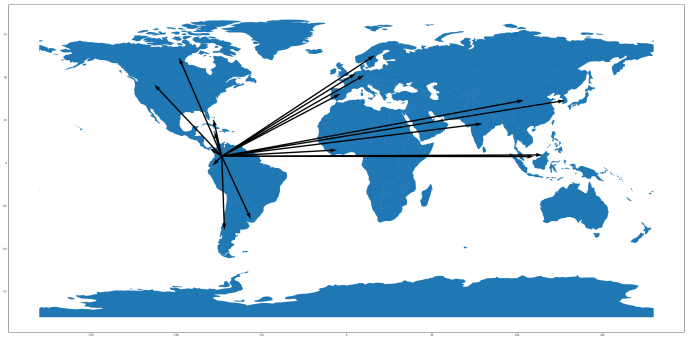

Fig. 1. Colombia's Coffee exports

There are around 1168 trade relations in which coffee is exported, countries such as Angola, Brazil, South Africa are some of the current sellers. Of these 1168 Colombia has a total of 16 countries to which it exports coffee. Let see how the proposed method behaves in relation to the country and the selected product.

	coef
Intercept	2739.7939
x1	-0.2667
x2	12.8592
x3	-9.6333
x4	-4.0121
x5	-22.3126
x6	-8.9343

Fig. 2. Lineal Regression Results

After performing a linear regression with the information from the coffee exporters, we obtained the following parameter shown in 2

The regression results show that the indicator Political Stability and no violence is of great importance for the coffee trade.

Finally, we carried out the aforementioned contest among the countries to see which one had the best sales opportunity, and the following results were obtained.

- Colombia has better opportunities to export coffee than the current exporter in a total of 916 trade relations.
- Colombia hasn't better opportunities to export coffee than the current exporter in a total of 235 trade relations.

Here are some of that opportunities:

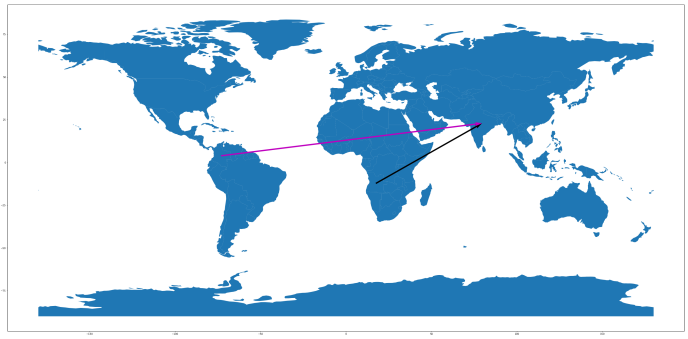

Fig. 3. Colombia is a better option to export coffee to India than Angola

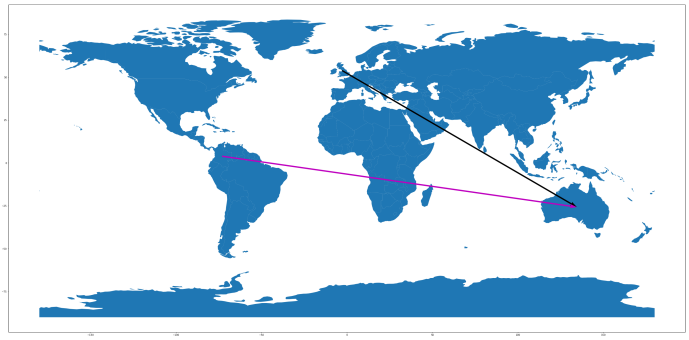

Fig. 4. Colombia is a better option to export coffee to Australia than United Kingdom

As well as some contries which is not viable to export:

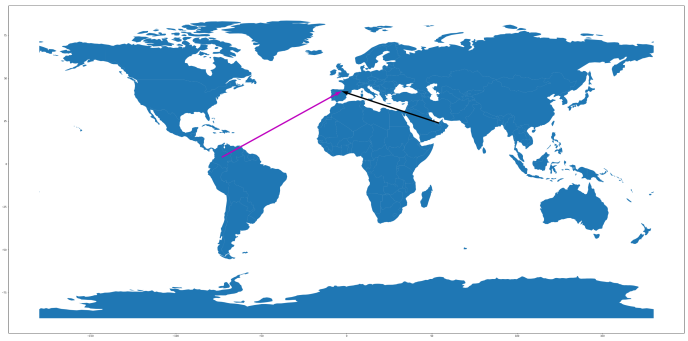

Fig. 5. Colombia is not a better option to export coffee to France than Angola

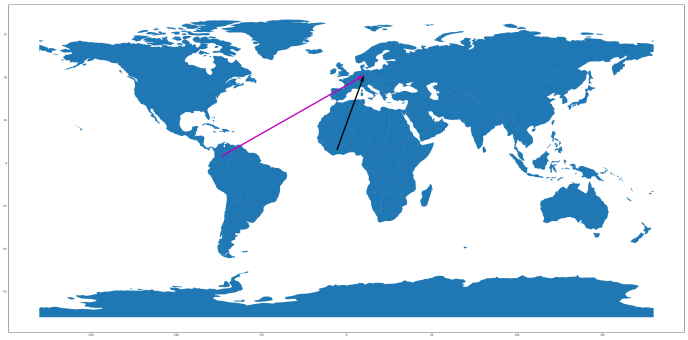

Fig. 6. Colombia is not a better option to export coffee to Germany than Republic of Côte d'Ivoire,

VI. Conclusions

As we can see, the knowledge of physics can be applied in other fields very different from the natural sciences to obtain the same or very similar results to those obtained from other branches of knowledge, as in the case of finance and economics. We found that the gravitational function that is inversely proportional to the square of the distance works well to calculate the commercial attraction between countries.

The friend shoring strategy alone is not feasible, but this, together with the analysis of a number of geopolitical and geo-financial attributes, could lead to a strengthening of the economy.

Future research could conduct an analysis of the dimensions to better test the results obtained.

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