

Insertion of Emerging Countries Exports in Global Supply Chains

Julio Padilla

Professor. University of Lima. Peru. ORCID: [0000-0001-9854-8936](https://orcid.org/0000-0001-9854-8936).

Christiam Mendez

Professor. University of Lima. Peru. ORCID: [0000-0001-5668-3806](https://orcid.org/0000-0001-5668-3806).

jpadilla@ulima.edu.pe, cmendezl@ulima.edu.pe

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Abstract

The objective of this research is to create a reference model to help an emerging country prepare a strategic and tactical plan for its export potential using information from digital media. Countries' economic planning has to evolve using current knowledge of international business and global supply chains—areas that dominate commerce in the world today. Linking the foreign trade approach and the supply chain approach for the model development allows structured planning of the insertion of a country's companies into global supply chains and the reorientation of export sectors towards more sustainable benefits. The research demonstrates the possibility of applying and adapting knowledge from supply chain models to develop a model of global supply chain management supported by computerized tools designed from the perspective of suppliers. The modeling and planning of the coffee export chain in Peru illustrates this potential. The paper proposes the integration of two knowledge areas, international trade and supply chain management, to form a new field of interest. Knowledge in both areas is solid, but its integration across the two fields is not. Although there are several studies on this topic, very little has been achieved in terms of the creation of a reference model and even less in terms of the development of computerized support for adequate strategic and tactical planning.

Keywords

Global Supply Chains; Analytics; International Business; Coffee Export Market

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1. Introduction

Many researchers and entrepreneurs have highlighted the growing importance of global supply chain management (Tomas Hult, 2014) (UNCTAD, Geneva, 2013). The progressive liberalization of and advances in international transactions in production systems, facilities for access to real-time world information and improvements in logistics and services have encouraged the creation of global chains with participants located in different countries.

The conditions and methods for creating a management model for these global chains are of both academic and business concern. This new field of interest is formed through the integration of two areas of knowledge, international business trade and supply chain management. Knowledge in both areas is solid, but its integration across the two fields is not. Although there are several studies on this aspect, very little has been achieved in terms of the creation of a reference model and even less in terms of the development of computerized support for adequate strategic and tactical planning. On the one hand, we have many years' worth of knowledge and experience in the development of computer systems with specialized supply chain models for the strategic, tactical and operational planning of business supply chains. The goal of these developments is the economic profitability of the company. On the other hand, knowledge of foreign trade, reflecting an understanding of global supply chains formed by many companies located around the world, is widespread and accessible.

Linking these two areas to develop a reference model makes it possible to review the insertion of companies in global supply chains and reorient this insertion towards more sustainable benefits. The vision of this proposal focuses on the possibility of applying and adapting all knowledge of supply chain business models to develop a global supply chain management model supported by information technology tools designed from the perspective of supply companies.

2. Literature review

The topic to be investigated has received much attention in recent years due to its academic importance and relevance for the global economy. One of the important groups that has been publishing on this subject is located at Michigan State University. Dr. Tomas Hult, a member of the group, has published a book (Tomas Hult, 2014) in which he analyzes several points of the state of the art on the subject. Hult qualifies global supply chain management as "an area of increasing importance but understudied." He recognizes the limited literature on the subject and highlights the need to continue research with the following approach: "It is critical to integrate and coordinate efforts in logistics, operations, supply and marketing to maximize the management of the global supply chain." In one of the sections of his book, he presents a recent survey of American corporations in which he finds a lack of alignment between executives and officials on the vision, objectives and strategies for the globalization of their companies. In general, Hult's vision involves the integration of the areas of international business and supply chain management. He concludes that there is a need to align client requirements in the process of developing new products and

services with the strategic management of global operations and the geographical fragmentation characteristic of our time. Another professor at the University of Michigan, Dr. David Closs, has developed a framework to identify and analyze the competencies and capabilities of leading logistics and supply chain organizations (Closs, 2011). American, Australian and Argentine companies have used this framework. One important topic in the proposed research, namely, the relationship between public policies and the performance of supply chains, has been studied in the contexts of North America, Europe and the Pacific Basin. Finally, Dr. Ram Narasimhan, from the same university, has partially compiled the literature on decision models in supply chains and discussed their possible applications under globalization (Narasimhan, 2012). He concludes that these models can be developed using known analytical techniques but have not yet been adequately investigated.

The United Nations has published a study entitled "Global Supply Chains: Trade and Economic Policies for Developing Countries" (UNCTAD, Geneva, 2013). It recognizes the growing importance of global supply chains in achieving an adequate link between emerging countries and international markets. In turn, access to world markets as elaborated in current models requires greater supplier efficiency and competitiveness. These models emphasize that traditional foreign trade policies based on preferential access are no longer sufficient. Today, competitiveness requires consideration of a wide range of business factors such as those in the global supply chain model.

In related publications (Myerson, 2012) (Craig, 2019) from private consulting firms, the importance of the lean approach in global supply chains is highlighted. These works conclude that international logistics is a means of gaining a strategic competitive advantage and obtaining value. In both areas, the concept of leanness can help. Craig proposes a mapping of a typical international logistics movement that identifies areas where waste can be reduced.

In recent articles, the National Science Foundation has emphasized the need to focus on sustainability through operational research tools (National Science Foundation, 2015). Likewise, other authors highlight the relationship between analytics and agribusiness. They highlight the importance of making crop-related decisions in uncertain environments with changing climates and diverse soils with computational support from digitized information facilities. In another article, J. Byrum (2016) highlights the new strategy of combining advanced analytics and agricultural knowledge to find opportunities to increase the productivity of crops and optimize the process of plant breeding.

In a recent article, a group of academics address the social importance of the presence of global supply chains in the region of Murcia in Spain (Castro, C., Gadea, E., Pedreño, A., Ramirez, A., 2017). The article shows the political dimensions of the link between the region's productive areas and global supply chains over time. Craviotti conducts a qualitative analysis of Argentine citrus exporters' possibilities of leveraging synergies for more efficient insertion in global markets (Craviotti, C., Palacios, P., Soleno, R., 2010).

Another important article (Weintraub, 2006) highlights advances in operations research in agriculture and forestry, concluding that although some findings have helped improve

understanding and management of agricultural resources, more research and applications are needed, especially due to global economic growth, which demands greater efficiency from such firms. There have also been some successes with applications with similar objectives, such as those achieved in northeastern China (Zhi-Qiang, 2010). These involve the development and use of an agricultural decision support system that has partially met needs in an environment of growing demand. The system is based on spatial information technologies and simulation methods. It consists of three parts: (1) a spatial data warehouse of agricultural resources; (2) crop monitoring with a simulation package; and (3) decision support for the supply of food. Parker demonstrates the effectiveness in another part of the world—India—of the use of mobile telephony as a means of communication by creating a text message service with current daily prices for market participants. This initiative achieved an average reduction of 12% in the geographic dispersion of prices in rural communities.

3. Method

3.1. SKU identification

The first step in the structuring of global supply chains is to identify the stock keeping units (SKUs) of the chosen product. SKUs identify exportable elements and all the intermediate products in their production back to the raw materials. In cases where the number of SKUs is manageable (in the tens), these can be modeled individually. In cases where there are hundreds or thousands of SKUs, families of products must be considered, with an eye to the concern that this grouping should continue to allow reasonable measurement of demand, prices, costs and capacity consumption.

3.2. Identification of supply chains

The domestic supply chain participants that allow each exportable SKU to reach the port of exit have to be identified. The capabilities, transformation times and flexibilities and costs of each are then investigated. For transfers between different participants, transport modalities, capacities, times and costs were investigated. In short, all the supply chains for a selected product need to be highlighted in as much detail as possible.

3.3. Identification of demand chains

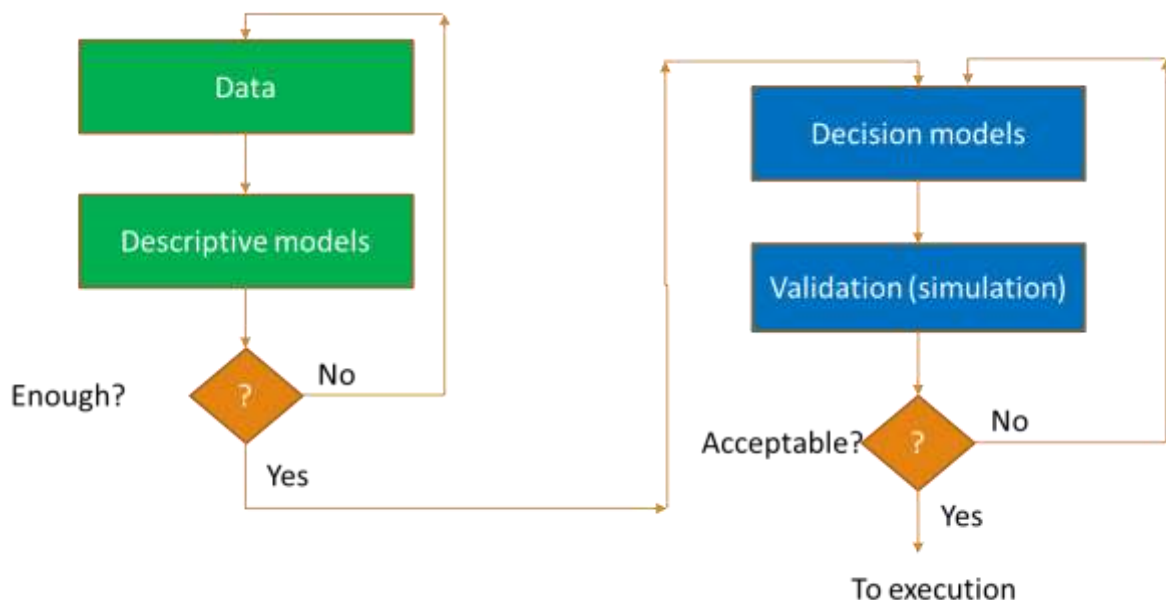
On the other side of the business, outside the country, all participants in the distribution and marketing of the selected product must be identified. At the end points of these demand chains, it is necessary to estimate possible demands and the corresponding prices. In the previous points, participants' capacities, times and costs were investigated. Likewise, for links between two participants, possible transport modalities, capacities, times and costs must be analyzed.

3.4. Study framework

The growing importance of global supply chains management has been driven by the current trend of so-called big data. The progressive liberalization of international transactions and improvements in logistics and services have coincided with the facilitation of enormous amounts of commercial information worldwide. The ability of both private companies and public sectors to analyze and take advantage of this information has quickly reached its limit, and although encouraging results have emerged, this has occurred only in specific and simple cases. The new knowledge area that has arisen in this context is known as analytics. The greatest development in this field is found in descriptive analytics (descriptive models), which has seen great advances from the digitalization of data and allowed for structuring that facilitates the analysis of both numerical and textual data. The state of the art is now leaning, as a logical consequence, towards two higher-level fields: predictive analytics and prescriptive analytics (decision models). The possibility of using large amounts of data to predict the future by looking for behavior patterns that often hide within a tangle of numbers and texts has been a concern of data mining for several years and is currently incorporated within the more general concept of predictive analytics. On the other hand, and perhaps more ambitiously, knowledge is moving towards the development of decision support tools based on these large amounts of data to lead organizations towards better results. This is prescriptive analytics, which is the line of work used in this research.

Figure 1

Development framework



Source: Own elaboration.

As explained above, the research project involves applying and adapting knowledge of supply chain management models to develop a global model supported by a computer system that exploits the large amount of information available with the aim of maximizing sustainable objectives over time. This model will be oriented towards providing support in decision making. The feasibility of the proposals will be tested in the context of the Peruvian coffee export chain, which is integrated into the global market. The corresponding design of strategic and tactical planning systems for global export chains will aim to foster more sustainable development in the country. Coordination of these global chains across all their functions and activities in supply, operations, distribution, market channels and sales involves finding opportunities to share decisions, integrate operations, create collaborative processes and share information systems with the integrated models proposed. To do all this, information was used to decide which global supply chain to use in the test and information applications to model both supply and demand. The data were structured in descriptive models that allowed us to feed a mathematical analytical model that serves as the foundation for the constructed tactical planning system. This search had to be fed back more than once to obtain a sufficiently descriptive model for the decision model. Validation is done in the final part of the work, which estimates whether the decisions recommended by the analytical model will have the estimated effect and whether they are appropriate for future planning. Figure 1 shows the framework followed in the project.

4. Analysis of global supply chains

Global supply chains have been widely studied by corporations that do business internationally, but they have not been studied by emerging countries whose products are marketed in these global chains. This research uses the forms of analysis of international corporations to understand the criteria used, but the ultimate goal is to model these chains from the perspective of exporting countries, taking coffee as an example.

4.1 Global corporate focus

The main criteria extracted from the strategies of global business chains are the following, with each explained in terms of how they affect our objectives:

- a. Added value for global chains. The most important criterion of a supply chain management model is integration, that is, the analysis of an entire business as a single system. A global perspective on corporate supply chains continues with the same concept: they must be managed as a true global chain, without bias towards any of the processes or corresponding functions, whether these are related to supply, transport, storage, production or marketing. Global chains must be managed on the basis of a fundamentally integral

strategy. Understanding this point is very important in a country's analysis of its international positioning. A country regularly participates in one of the processes: it supplies a particular input or manufactures a particular product. The message to keep in mind is that corporations value this participation based on its contribution to the global model. This is what must be understood; participation must add value. It is not enough to have a certain price or a certain quality. What must be analyzed is the role that this participation plays in the international chain of the international buyer and how it helps the final product obtain a higher market value.

- b. Incorporation of the country in the configuration of global chains. Another aspect to take into account is the fact that the global supply chain strategy is part of the global strategy of multinational corporations. These corporations require that the management of their supply chains be integrated into their plans to achieve business effectiveness and efficiency. Supply chain analysis and planning have transcended their traditional operational position to become crucial at the tactical and strategic levels. The supply chain has to be defined simultaneously with the products and services that the corporation wishes to develop and, from the global perspective, with the marketing strategy, the countries in which the business will expand and the tactics for facing competition in each market. On the other hand, countries participating in these global chains must be aware that they not only compete based on their products or services but also based on all the infrastructure required to join the chains. Transports, ports, procedures, technology and taxes are part of this competition.
- c. Creation of a global integration policy. In the definition of supply chain management, the key concept is the integration of the complete system in all its aspects. This integration must cover materials, information, money and decisions. Therefore, it is vital to review what integration is and discuss how this characteristic can be achieved in the operation of a company and a multinational corporation. Efficiently achieving the goal of integration is basically the reason why the supply chain must be managed. Thinking comprehensively is not a natural process. From the time we learn to reason, life teaches us to divide the whole; it is believed that if a large job is divided into parts and each of these is done efficiently, a good solution to the problem has been secured. In routine tasks at home and in school, the idea of dividing up activities and solving each one in a focused and efficient way is highlighted. In terms of management, we are taught to conduct basic operations. There is no approach that is more wrong, especially in business. While each person responsible for the processes and functions into which a supply chain can be divided may independently perform their work in the best way, this approach will soon lead the organization to a state of inefficiency and lack of coordination. This simplistic approach neglects the tactics and strategy of systems. The aim is to ensure that the actions of any company operator automatically respond to the policies that the general manager has laid out and that the decisions of intermediate officers are integrated into the company strategy. This is a difficult task that must be planned and managed specifically. People have to learn to think about integration. Just as a company has to integrate the decisions of all its personnel, a country must also think about the integration of the decisions of all participants in its export

chains. The participating country is part of a global chain, and the value of this participation depends on the contribution that each participant makes to the total system. This value creation involves working in coordination to ensure the success of the global chain rather than to maximize the success of each individual element. Pursuing individual success—the object of intense focus of many business policies—will bring only provisional satisfaction that sooner or later will end in the exclusion of the local chain from international chains. This fact is demonstrated with the developed model. The free competition approach applies to business chains, not individual companies. In future markets, competition among isolated companies will no longer be seen but rather will be between supply chains formed by groups of companies coordinated to satisfy the needs of their final customers.

4.2 Local business approach

To incorporate these criteria, a change in the mentality of local companies and governments is necessary. It has already been explained that the existence of global supply chains formed by many companies with geographical locations across the world is increasingly important in the field of foreign trade. This development must be based on the following aspects of the local business sector and government policies.

- A changing orientation within companies: To join the new integrated management models, companies participating in the chain must move from a product orientation to a market orientation. This means that the "in the product" approach, whereby many companies care only about the products that they can offer and their capabilities without thinking about the consumer market, must move to the "product market" approach, analyzing the needs of final customers and the corresponding production levels. Thus, instead of maximizing production, companies should focus on maximizing sustainable profitability over time; that is, operational planning should move to strategic and tactical planning.
- A change of objective within companies: Planning objectives must shift from the immediate profitability of the company to the sustainable development of the business chain. The reference model has as its objective the profit and sustainable development of the global chain and not that of a particular company. A general optimum must be found that involves all relevant dimensions—economic, social and environmental—and that goes beyond optimization of particular dimensions. In the application to the coffee export chain, the global profitability of the chain is maximized, but the SKUs are defined in terms of social and environmental aspects.
- Own perspective in the model: The approach must take the perspective of local supply companies. All published analyses of global supply chains are typical of the large markets of the developed world. In the provider-buyer relationship, the focus has been on the perspective of the buyer. The analysis conducted here takes the other perspective, and some recommendations that emerge from it are very different.

- Integrated supply and demand planning: In the business environment, the great shift from supply planning to integrated supply and demand planning is already underway. The advantages of this approach are very clear, and it must be extended to global chains. It is clear that what cannot be sold must not be produced, but it must also be understood that there are tools, such as the price factor, to manage demand for the producer's benefit. These aspects are highlighted in the explanation of the developed tactical planning system.
- Use of analytical tools: The complexity of corporate supply chains is such that supply chain models have to be implemented through the use of properly designed computerized tools. In the case of global supply chains, there is the same need, and it is essential to create a computer system to support sustainable development models by taking advantage of the large amount of information currently available. The framework in which the plan is developed explains this relationship between information and processing.
- Capacity for integrated decisions: One of the anticipated disadvantages in reaching the proposed goals is the difficulty in coming to global decisions in the group of companies that belong to an export chain. This is a cultural change in which the catalytic medium must be facilitated by business associations or by the government. Regulatory policies should be oriented towards this goal, which will support the country's sustainable progress in export markets.

5. Structure of the global coffee export chain

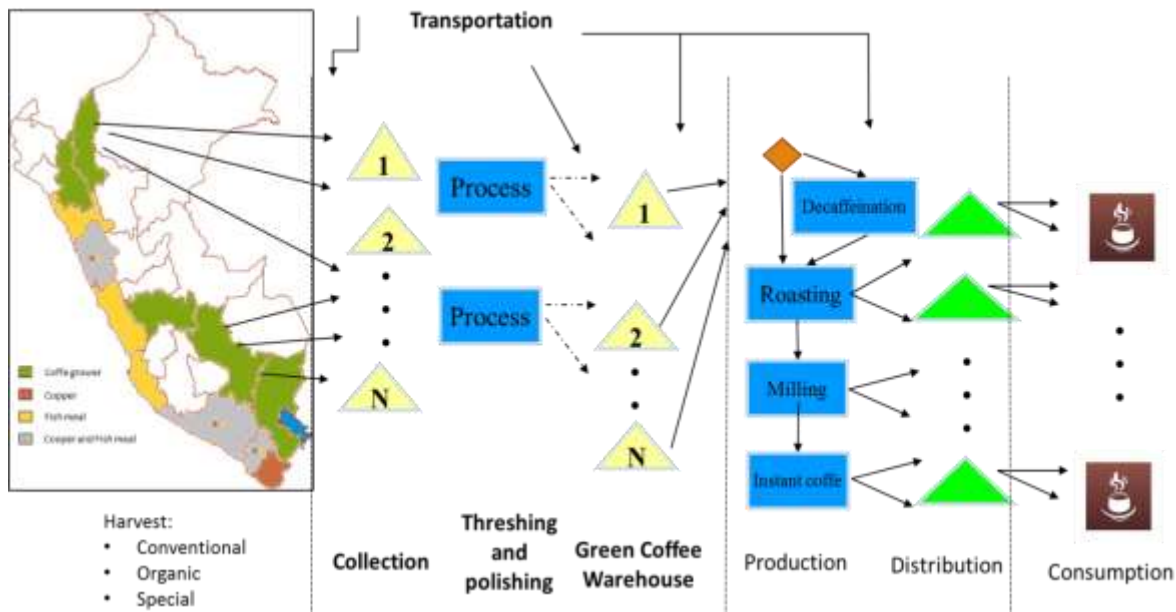
To demonstrate the feasibility of our approach, the insertion of Peruvian coffee export chains into global supply chains is modeled. Figure 2 shows a graphic summary of the global coffee supply chain. Peruvian coffee areas are shown on the map in green, with highlights of the northern, central, Cuzco and Puno clusters.

The type of coffee is defined in the agricultural stage of the chain based on a series of conditions of fertilizer type and care in the preharvest, harvest and postharvest phases. These types have been simplified into three categories: standard or conventional, organic and special. Collection is carried out by farmers' cooperatives or by private companies competing to acquire the corresponding harvests based on price or financing, which is so necessary for small farmers. Contracts are often elaborated that may help farmers with liquidity but may commit them to prices that are not always favorable. Threshing and polishing are the main processes that prepare the green coffee bean, which is the main SKU, for export. These processes are carried out by cooperative plants, by private companies themselves or by specialized companies through outsourcing. The green bean is a commodity and is valued at the New York price. Organic status yields a premium over the international value, and there are a variety of certifications recognizing the quality of the coffee. Certifications from Fairtrade Labelling Organizations International impose universal standards for environmental protection that have become quite widespread, allowing some Peruvian producers to obtain clear advantages with special prizes for their organic beans.

Prices of coffees categorized as special are not determined by the commodity price and are subject to direct negotiation with the buyer.

Figure 2

Structure of the global coffee supply chain



Source: Own elaboration.

Before roasting the coffee to produce the SKU for mass consumption, the producer has to decide whether to use the decaffeination process. Demand for decaffeinated coffee is growing worldwide. Regular or decaffeinated green beans are roasted, a process in which the coffee acquires all its recognized characteristics of taste and smell. After roasting, the coffee can be packed and sold in whole bean or ground form to satisfy the taste of the consumer. An SKU that requires an additional process and for which demand is also increasing is soluble or instant coffee. Currently, there is no capacity for this process in Peru, although the technology is relatively simple and the literature on this specialty is widely disseminated.

More than 99% of Peruvian exports are green coffee beans in bags and are aimed at producers on all continents, especially the United States and Europe. There are very few exports of roasted and packaged coffee. The incursion of Peruvian companies into roasting and packaging has been directed almost entirely at the domestic market. The reasons for this are not entirely clear. Some arguments purport that because of technology and economies of scale, the costs of roasting and packaging in Peru are very high, although this can be debated, taking into account that the technology required is not advanced. It is qualitatively held that the future prospects for exporting roasted and packaged coffee from Peru will center on high-quality grains and Latin American export destinations. Identification of the participants and the mapping of the green coffee export

chain, in terms of both supply and demand, with the associated costs and average prices, is shown below so that results that corroborate or contradict these hypotheses can be evaluated quantitatively. It was impossible to include the export chain of roasted coffees in our model: given the almost negligible export of these products in Peru, it was not possible to find sufficient information.

5.1 Information sources

Three data-generating agents, which guarantee a permanent flow of information to the model, are identified:

- The Ministry of Agriculture and Irrigation
- Customs
- Various institutions

The Ministry of Agriculture and Irrigation is one of the institutions that provides the most information in the agricultural stage. The project takes as a reference the agrarian census of 2012 as well as other statistics generated by this ministry.

The customs agency is another of the institutions that generates relevant information that is used in the model in the distribution and consumption stage. The researchers obtained access to the customs database through Veritrade, an export and import data administrative system that is available in the library of the University of Lima.

Various institutions, such as the National Coffee Board and second-tier cooperatives, among others, have studies providing cross-cutting information that contributes to some information requirements of the model.

The information must enter the model in a structured manner, so it is important to make some changes to the original data, considering that the source must be stable and constantly updated to guarantee the flow of reliable information, which contributes to the decision support capability of the model.

6. Tactical planning system

Supply chain management (SCM) and pricing and revenue management (PRM) systems are the pillars of business management models developed in recent years. The successes achieved are countless, and the academic and commercial development put into them has been abundant. In a very summarized way, SCM systems allow management of the distribution, manufacture and supply of a company with the objective of satisfying demand at a desired service level and at the lowest possible operating cost. Demand is considered exogenous to the system. PRM systems maximize profitability based on available capacity through market segmentation by optimizing prices and the allocation of the products that each segment must receive. Capacity is taken as given

and known. SCM systems are the responsibility of the operations area and PRM systems of the commercial and marketing areas. The proposal simultaneously integrates optimization of the supply side with that of the demand side to achieve greater profitability growth. This is the conceptual basis on which the tactical planning system is developed for the integration of the coffee export chain into global supply chains. The developed model is basically tactical, but through the use of scenarios, it also allows us to respond to strategic objectives. The extension of these concepts to the global chain allows the behavior of each participating company in the export chains to be observed according to the overall objective of the system. The optimal links between suppliers and demand markets are identified to maximize the marginal contribution of the entire export chain for each of the products.

This snapshot of the uses of the tactical planning system will allow governments or business associations to prioritize production based on the profitability of the product or client. Supply can be segmented into categories according to distribution and market channels. If demand exceeds capacity, PRM techniques can determine the optimal mix of prices and market shares to fill this demand with maximum profitability. When demand does not occupy the full capacity, these same techniques can suggest ways to stimulate demand (promotions) to achieve a more efficient relation with supply. Permanent adjustments can be made to prices, market shares and capacity assignments to ensure the highest possible return on capacity. Although these benefits can be tested from a quantitative point of view, achieving them can be difficult to accept from the organizational perspective. The companies that make up export chains are used to making individual decisions aimed at maximizing profits. It will not be easy for the chain to focus on its profits as a whole. Among other ideas, we propose implementing incentives and motivation policies based on key results of the tactical planning system. We think that the various government agencies should play an active role in this regard. On the other hand, government investments must be supported by strategic decisions recommended by the tactical planner after the corresponding analysis is conducted.

The proposed system demonstrates that the existing techniques for optimizing supply given demand (SCM) or manipulating demand given a supply capacity (PRM) seem to have a better destination if they are integrated and price decisions are incorporated in the presence of limited capacity, economies of scale, demand seasonality, etc.

6.1. Analytical model

We construct a mathematical analytical model of the described global green coffee supply chain. Below is a detailed description of the mathematical model and, most importantly, an analysis of the results of its application. The solution of the mathematical model is obtained with open-source resources provided by the Technical University of Wildau in Germany and the University of Auckland in New Zealand. The adjustments that the model required to be solved were kindly provided by professors at both institutions. Thanks to this, the framework proposed in the present

project does not require any commercial license and is free to access for both public and private entities.

The most direct purpose of the model when applied to a global supply chain is to optimize the marginal contribution of supply chain partners by means of demand and capacity utilization decisions. The objective is to decide in which market to commercialize each of the products of an export chain and simultaneously decide how to assign producer capacity among those products to maximize the marginal contribution of all products and all markets in the set. The planning system is supported by a nonlinear mathematical model, but for reasons of lack of data representing price elasticities, we have worked with a linear model in which prices are taken as input data. The purpose is to use this model to support tactical chain decisions in export chains in their static, current version. Among these decisions are the following:

- Which suppliers (farmers) tend to supply each product and in what quantities?
- Which plants fulfill the requirements of each distribution structure?
- What market share maximizes the profitability of the export chain in each segment of the market?
- What average prices should be implemented in each segment? Due to data limitations, this function has not been implemented.
- What distribution structure should each segment address?

All these decisions are made in monthly periods and for a horizon of one or more years. The runs shown for the export chain of coffee consider a twelve-month horizon, but there are no limitations in extending it.

Strategic decisions are usually made at the level of projected outcomes, and the developed model supports them through the construction of scenarios. Each scenario reflects a strategic project, and through comparison of the results with the status quo, it can be determined whether the project in question is profitable. Examples of strategic decisions include the following:

- What would be the effect on profitability and market attention if an additional productive resource (for example, a new agricultural area for the product) were implemented?
- What is the best market incentive plan among the alternatives presented regarding the profitability of the export chain?
- What would be the effect on profitability and market share if the operation were extended to a new country or offered a new export product?
- What potential achievements can be required of an export chain under the given or proposed conditions?

The model incorporates the following concepts:

- The demand of each zone or market segment for each product is calculated based on a potential market, with the possibility of including a price elasticity formula as described in the previous section. In the absence of these formulas, we work with given prices. The idea is that the model can be adapted to any elasticity relationship that develops. If there is no

formula, as is the case with coffee, the model is still valid, with the prices changing from being decision variables to being data.

- If prices respond to an elasticity formula, their possible values fall between a minimum and a maximum.
- Sales are defined based on the share of potential market demand corresponding to each area.
- The material balances for the three inventories in the model are incorporated: materials in plants, finished products in plants and finished products in distributors.
- Each of the three stores corresponding to the three inventories is restricted based on space capacities.
- The quantity of purchases for each supplier and material is restricted based on monthly capacity (this refers to the hectares sown, as used by the planner, and is restricted based on the total hectares available in the agricultural area).
- The hours used for each resource in each month are restricted based on available hours.
- The total amount to be distributed in each area is restricted based on unit capacity.

The objective of the model is to maximize the present value of the flow of monthly marginal contributions. The monthly marginal contribution is calculated as the difference between income from sales and total costs, that is, purchases (farm cost), transport costs, manufacturing (threshing), distribution and inventories.

6.2. Prototype data for the coffee export chain

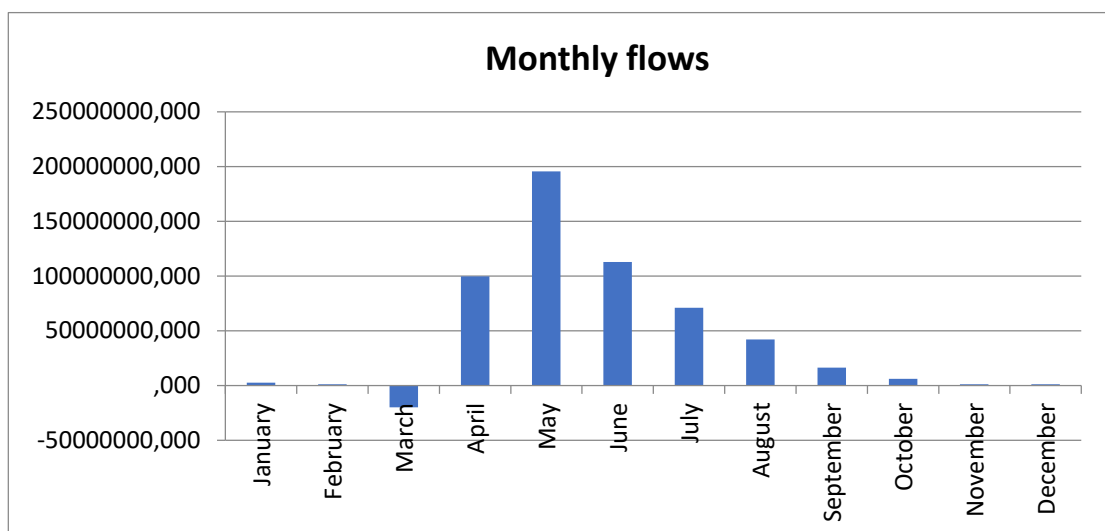
The choice of the coffee export chain was made after a complete analysis of all export chains in Peru. The selection criteria were industry maturity, representativeness and scope. Coffee is a mature export product with clear representativeness of the agricultural sector (it is the agricultural product that makes the highest contribution to GDP) and with a national scope. The data considered in the planning system for the green coffee export chain are basically those explained in the previous sections, except for some small variations. The exporters were summed up to the thirty with the highest market shares. The types of coffee were simplified into three categories: standard or conventional, organic and special. Potential demand was estimated based on the exports in each category and qualitative aspects of each importing country. Annual exports were estimated at 177,788 tons of coffee, mainly of the conventional and organic varieties. Special coffees have a very small market share and will be left out of the next analysis. The sale prices were estimated as average prices of all exports and converted into local currency (*soles*). The cost per hectare was derived based on the farm price of each agricultural area multiplied by the corresponding yield. Finally, the capacity of each agricultural area was estimated based on the reported data and the corresponding potential. With all these data plus those discussed in the previous sections, the inputs of the tactical planning system were loaded and the mathematical model run to obtain the results that are described and explained below.

6.3. Results of the planning system for the coffee export chain

The objective function of the tactical planning system is to maximize the present value of the marginal contribution of all the periods, which yields an amount of S / . 505,371,000. The monthly values shown in Figure 3 clearly show the seasonal behavior of this product and the need for financing, which is typical of agricultural products.

Figure 3

Optimal marginal contribution



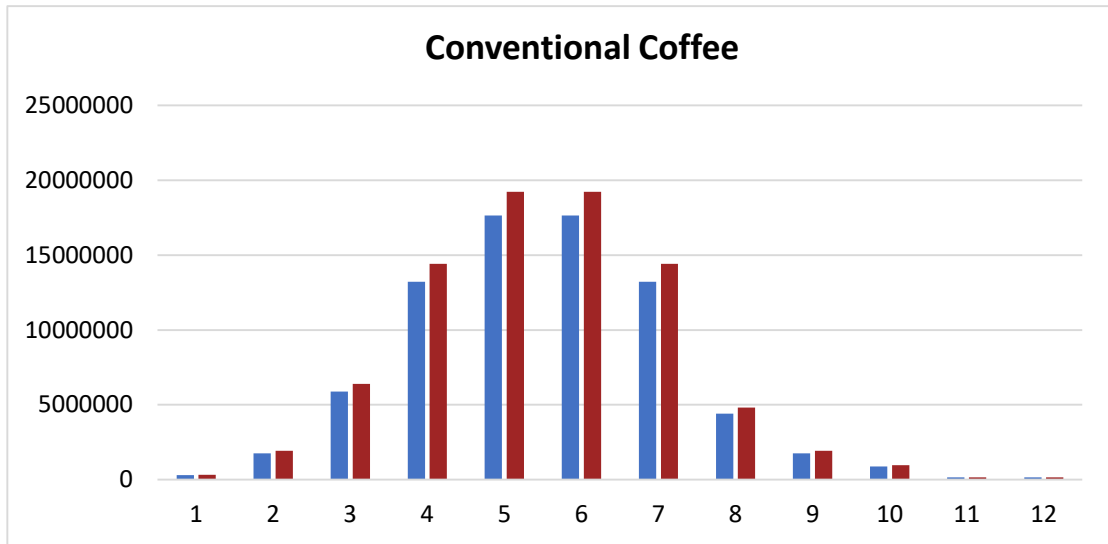
Source: Own elaboration.

In the analysis of this solution, the following observations can be highlighted:

- The revenues correspond to total sales of 91,286 tons per year, leaving 86,502 tons of the estimated demand not met. A deeper analysis of this unmet demand reveals that for conventional coffee, almost all of the demand is filled, as shown in Figure 4. Colombia's demand, at 6,915 tons, should not be filled, given the lack of profitability due to the very low price. For organic coffee, most of the estimated demand, 79,587 tons, is not filled, as shown in Figure 6. The reasons are explained in the following points.

Figure 4

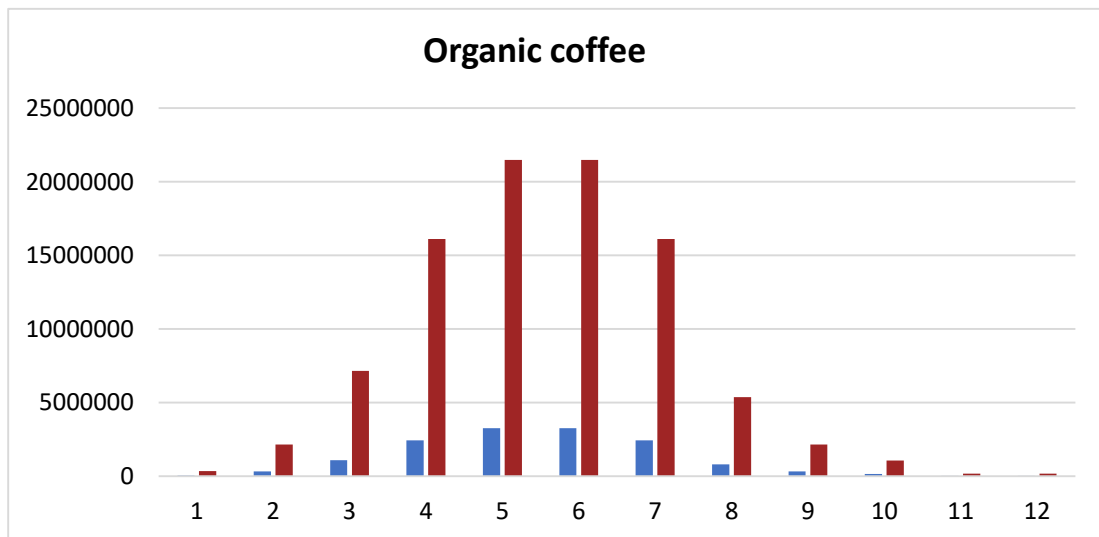
Sales vs Demand for Conventional Coffee



Source: Own elaboration.

Figure 5

Sales vs Demand for Organic Coffee

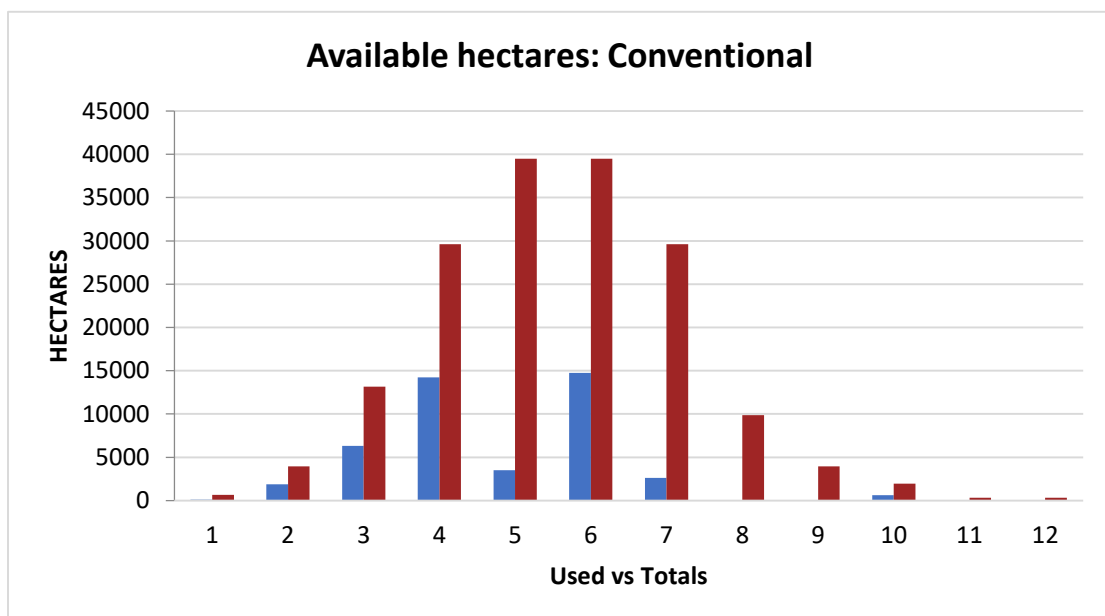


Source: Own elaboration.

- The reason why demand for organic coffee is not met is that there is no capacity in the agricultural areas for this product. Looking at Figure 6, we can see that 360,216 hectares of conventional green coffee are not used for the proposed solution because there is no market for this product other than the Colombian market, whose demand is not profitable for any export chain participants to fill at the price offered and thus should not be filled (although in fact it is). As supply is greater than demand, the planner chooses to deploy conventional coffee suppliers for the markets that offer the highest profitability. Less profitable agricultural areas are not used.

Figure 6

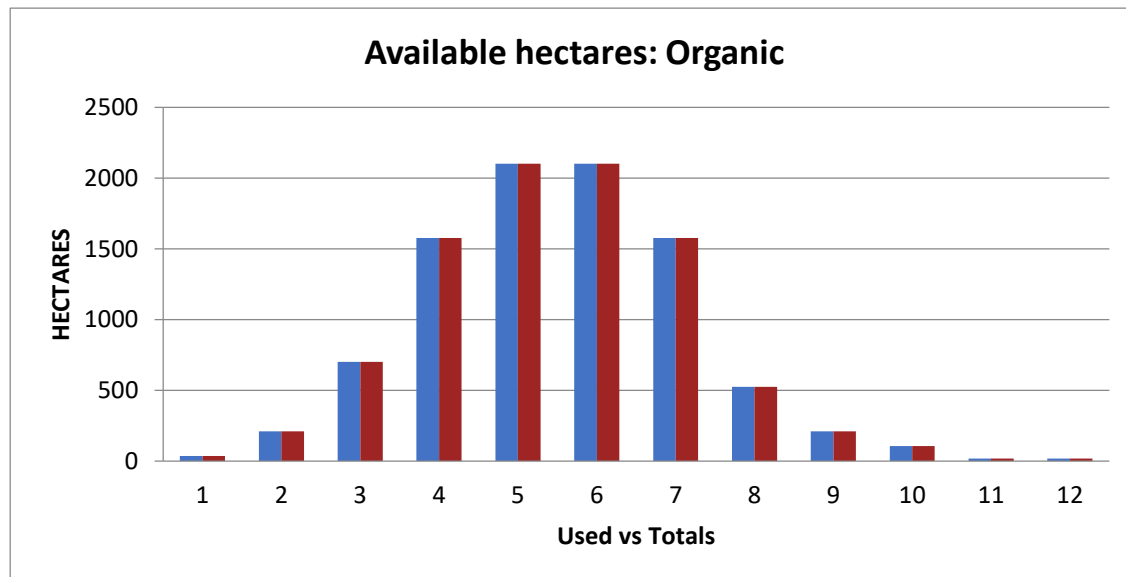
Hectares Used vs Total Available Area for Conventional Coffee



Source: Own elaboration.

- For organic coffee, the opposite occurs. Demand is greater than the total supply of agricultural areas. All the hectares offered are used, as shown in Figure 7, and only 15% of the demand is met. The planner selects the markets and the producers that generate the highest profitability.

Figure 7

Hectares Used vs Totals for Organic Coffee

Source: Own elaboration.

7. Conclusions

The main conclusions obtained during the investigation are as follows:

- We construct a decision model that, through information processing, allows us to support the decisions required within a tactical planning system that integrates the export chains of an emerging country into global supply chains.
- It is possible to find and structure the data required by the decision model with information available from various sources.
- A framework is developed so that the coffee export chain prototype can be replicated in any other export or local consumption chain.
- From the application of the tactical planning system to the coffee export chain of Peru, the following conclusions are obtained:
 - The hectares dedicated to conventional coffee are excessive for the corresponding market; conversely, those dedicated to organic coffee are scarce, and the estimated demand cannot be covered despite the market segment being profitable.
 - Some demand, specifically that of Colombia, is at purchase prices so low that it is not profitable to fill.

- Some agricultural areas must migrate to organic coffee since with the current yields on conventional coffee, the areas are out of market.
- These conclusions may require further analysis due to the rust plague that is affecting many agricultural areas. The plantations that are most resistant to rust are those of robusta coffee, which is related to conventional rather than organic coffee. The opinion of agricultural experts is required in this aspect.

8. Recommendations

The recommendations that can be drawn from the project are as follows:

- A body of entrepreneurs knowledgeable about the supply chain is required to analyze its definition and sizing. This analysis required considerable effort to complete in the case of coffee.
- The structuring and modeling of a new chain (or chains) must be done by the research team to quickly obtain valid results since adjustments to the model and data structure may be required.
- In the case of Peru, it is possible to extend the export chain prototypes to the fish meal and copper sectors to fully demonstrate that the proposed framework is feasible and is a modern, effective and efficient tool for governments to use for the productive planning of the country.
- Team collaborations should be conducted between researchers and entrepreneurs to draw conclusions and recommendations based on the results. Validation, as the last stage of the framework, requires the participation of experts from each modeled chain.
- Agricultural factors such as the rotation of plantations can be modeled when alternative products that allow greater yields from agricultural land are integrated. In the coffee sector, some of the areas in Peru are reaching the limit of 20 years of planting and producing yields well below those of some competing countries such as Korea.
- International demand should be the subject of a larger study that incorporates relevant data to allow a better estimation of potential demand and a possible estimation of price elasticity.
- These conclusions and recommendations should be used in sectoral policymaking since this type of work provides the public sector with academic support. The suggested evolution in the country's planning processes can only become a reality if the public bodies in charge take the required leadership and sponsor future research.

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