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COFFEECONOMICS

Scientific research paper

Dr. Mario Arturo Ruiz Estrada

University of Malaya, 50603 Kuala Lumpur, Malaysia

Email: marioruiz@um.edu.my

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Abstract

Coffeeconomics is an alternative field of economic research that can be used to evaluate coffee market structure behaviour from microeconomic and macroeconomic perspectives. The coffee market structure consists of the interaction of four large players: coffee producers (small, large and cooperatives), coffee brokers, coffee sellers (large, medium and small) and coffee consumers. The main objective of this study is to evaluate the vulnerabilities of the coffee market structure as a whole through the application of the National Coffee Production Function (NCP-Function). Finally, the NCP-Function of Guatemala was calculated in order to evaluate the risk and vulnerability of its coffee market structure between 1928 and 2018.

Keywords: coffee, Guatemala, coffee market structure, Economics research, Econographicology

1. A general brief of coffee

The origin of coffee goes back to Ethiopia, Africa. Henceforward, coffee has a long history with different transcendental events happening as of the 15th century. This prolonged history of coffee involves dynamic transformations in the production, trading and consumption of coffee until the present day. The history of coffee trading can be divided into three large periods: (i) Coffee arrives from Ethiopia to the Middle East (Arabian Peninsula) in the 15th century. (ii) From the Arabian Peninsula, coffee trading to Europe starts in the 17th century. (iii) Finally, coffee production and trading moves from Europe to America in the 18th century. The mechanism applied by all the European empires for the production and trading of coffee in different parts of the American continent was based on the policy of invasion of new territories (conquered colonies) through the use of force, violence and repression of native peoples, and through the exploitation of its natural resources. The most powerful and largest European empires of the 17th and 18th centuries were the British, Spanish, Portuguese, French and Dutch empires. The production of coffee in America was based on the use of large coffee plantations together with the use of intensive slave labour (both indigenous and from Africa) for many centuries. The coffee-producing colonies conquered by the Europeans in the American, Asian and African continents can be divided into the following zones: North America (today's southern Mexico), controlled by the Spanish empire; Central America (Guatemala, El Salvador, Honduras, Nicaragua and Costa Rica) controlled by the Spanish empire; Caribbean (Jamaica, ruled by the British empire; Haiti, ruled by the French empire; Trinidad and Tobago; ruled by the British empire); South East Asia (Vietnam, ruled by the French; Indonesia, ruled by the Dutch; Laos, ruled by the French, and Papua New Guinea, ruled by the British and Dutch empires); India, ruled by the British; South America (Colombia, Brazil, Peru, Ecuador, and Bolivia) ruled by the Spanish empires.

The fast global expansion of the coffee market in different places around the world requires a deep evaluation of its four main players, that is, the producers, brokers, sellers, and consumers (buyers) as a whole, whose interaction in the coffee market structure was evaluated in the present paper by a mechanism based on the creation of different indicators and analytical tools to assess the risk and performance of the coffee market structure.

The first players in the coffee market structure are the coffee producers. This research study presents a list of the top coffee producers by country, continent and participation percentage in global coffee production. The American continent (Brazil, Colombia, Mexico, Honduras, Guatemala, Peru, Nicaragua, Costa Rica, El

Salvador, Ecuador, Venezuela, Dominic Republican, Haiti, Cuba, Panama, Bolivia, Puerto Rico, Paraguay, and Trinidad and Tobago) is responsible for 59 % of the world's production, followed by Asia (Vietnam, Indonesia, India, Laos, Thailand, Philippines, Timor Leste) with 25 %; Africa (Ethiopia, Uganda, Ivory Coast, Kenya, Tanzania, Cameroon, Madagascar, Gabon, Democratic Republic of Congo, Rwanda, Burundi, Togo, Nigeria, Ghana, Sierra Leone, Angola, Zimbabwe, Liberia) with 15 %; and finally Oceania (Australia and New Zealand) with only 1 %. In fact, the top ten players of coffee production worldwide follow this order: Brazil, Vietnam, Colombia, Indonesia, Ethiopia, Honduras, India, Uganda, Mexico, and Guatemala.

The two general types of coffee beans are known as Robusta, with a strong or harsher taste, and Arabica, with a sweeter and softer taste. According to different statistical sources from the International Coffee Organization (ICO), 60 % of the coffee produced worldwide is Arabica, while 40 % is Robusta. On the other hand, the genus Coffea is divided into three large groups: Arabica, Dewevrei, and Stenophylla (Seudieu, 2008). When studying the special conditions needed in the production of coffee, this paper established that (i) the location of major producers of coffee is in the equatorial belt; (ii) coffee is very vulnerable to climate change, weather and natural disasters; (iii) the optimum temperature for coffee production is between 64ºF and 72ºF.

All these factors make it possible to establish the high vulnerability of coffee producers. This study determined that in a good harvest the profit that producers can obtain from coffee brokers is between 15 % and 20 %. Some recent statistics from ICO show that many producers suffer large losses and bankruptcy. These losses are due to sudden climate change, unpredicted weather changes, and disease (fungal, parasitic, viral). At the same time, if these losses suffered by coffee producers lead to a reduced coffee supply, then the margin of profit for coffee brokers is also less than the profit margin originally predicted.

Within the structure of coffee production, producers can be classified as large producers, cooperatives, and small producers. According to recent statistics from ICO, coffee producers share the following percentages of participation in the global production of coffee: large producers, 55 %; cooperatives, 31 %; and small producers, 14 % of the total worldwide production. Therefore, the margins of profit are directly related to the size of the producer. Large producers are getting bigger margins of profit and small producers are obtaining smaller margins.

The second main player in the coffee market structure is the coffee broker, who plays a crucial role in the worldwide price of coffee. According to the findings of this study, the price of coffee always rises considerably in the stage of commercialization involving the producer and broker. The possibility and risk of constant speculation is always there because brokers usually push to obtain lower prices from the producers and higher prices from the sellers. The main role of brokers is to link

coffee producers and coffee sellers. This study found that at the end of the process, coffee brokers earn a profit that can range from 25 % to 35 %.

The third main group of players in the coffee market structure are the coffee sellers, likewise classified as large, medium or small. The main role of coffee sellers is to fix the final price for whole coffee consumers in any given market. The profit margin of sellers is between 15 % to 25 % during good selling seasons. The success of coffee sellers depends highly on the good quality of coffee, broker prices, marketing strategies, channels of distribution (domestic and international), diversity and creativity of new coffee beverages, and good customer service. Sellers always play an important role in keeping the demand of coffee active and sustainable in the short and long run. Seizing 62 % of the global coffee market, currently these large sellers are Starbucks, Coffee Bean, Gloria Jeans Coffee, Caribou Coffee, Dunkin' Donuts, McCafe (McDonald's), Tully's Coffee, Costa Coffee, Lavazza Coffee, and Nestle. On the other hand, medium coffee sellers embrace 28 % of the world coffee market, whereas small coffee sellers are left with the remaining 10 % of the market.

Last but not least, the fourth player in the coffee market structure is the coffee consumer. Basically, it was found that the consumption of coffee is directly connected to the following main factors: (i) the fast expansion of income-per-capita (economic growth); (ii) accessible prices amongst coffee producers and coffee brokers; (iii) new young consumers (new ways to attract potential coffee buyers); (iv) fast changes of preference and taste in coffee consumers worldwide (especially in the Chinese and Asian markets); (v) strong and sustainable marketing strategies. According to recent indicators, coffee consumption has had an exponential growth rate of 35 % per year since 2001. This increase is largely the result of the official incorporation of China into the World Trade Organization (WTO, 2019). Additionally, several markets in Asia have been increasing considerably their consumption of coffee; such is the case of Malaysia, whose growth rate of coffee consumers is 23 % per year; Singapore, with a 35 % annual consumer growth rate; Indonesia, with a growth rate of 27 %; Thailand, of 23 %; Taiwan, of 15 %; South Korea, of 33 %; Japan, with a 21 % growth rate and finally the Philippines, whose growth rate of coffee consumers is 12 % per year.

2. An introduction to Coffeeconomics

"Coffeeconomics" can be defined as

> a new field of economic research in charge of evaluating all issues related to coffee market structures by means of exhaustive investigation of the behaviour of producers, brokers, sellers and consumers of coffee, both in the short and the long term. Coffeeconomics is supported by the use of different quantitative and qualitative research tools in order to evaluate analytically the truthfulness and reliability of different coffee markets around the world, anywhere and anytime.

As an integral part of this definition, "Coffee Market Structure" is defined as the dynamic interaction among producers, brokers, sellers, and consumers, the four large players in the coffee trading process, all of whom pursue a diversity of benefits or gains, from profits to maximum consumer satisfaction. Under the Omnia Mobilis Assumption (Ruiz Estrada, 2011), it is assumed that the coffee market structure will always have failures and will continuously be in a dynamic imbalance state (DIS) (Ruiz Estrada, 2013).

The main objective of Coffeeconomics is to generate specific economic research in order to evaluate qualitatively and quantitatively the coffee market structure and all its different players from an economic point of view, something that hardly existed in the past. The study of coffee market structures involves a series of difficulties, such as (i) limited information from producers; (ii) high speculation, especially from brokers and sellers; (iii) income inequality and coffee consumer preferences.

The fast expansion of worldwide coffee consumption makes the study of Coffeeconomics essential. According to statistics from the World Trade Organization (WTO, 2019), the consumption from 1999 to 2019 increased 21 % (after China had access to the WTO). In fact, coffee has opened new opportunities for producers and consumers to obtain large benefits in the short and long run. The main problem in Coffeeconomics is access to the coffee market prices database and documents, something that has become more complex nowadays. A lot of information about coffee is limited. Additionally, high speculation and unknown distribution channels make it impossible to obtain trading routes and prices (price negotiations between producers and brokers). Speculation of coffee prices generates inconsistency when attempting to do trustworthy economic research that evaluates coffee market structure problems. Possible future changes in the collection of coffee costs and in access to databases and price documents are expected. These possible future changes face three key

challenges: (i) search and collection of primary data and costs from producers (large and small national coffee producers); (ii) monitoring coffee brokers around the world; and (iii) monitoring prices and quality of coffee among sellers and consumers. The future of the coffee market structure highly depends on being able to follow its microeconomic and macroeconomic behaviour in the short and long run. Likewise, Coffeeconomics is interested in following all new technologies and innovative products and services that this great industry generates.

The primary objective of Coffeeconomics involves evaluating and generating policies that benefit all players in the coffee market structure by means of doing specialized research and considering possible scenarios under varying risk levels, as well as potential policies to solve problems occurring in the coffee market structure. The main challenge of Coffeeconomics is to move from the traditional cost-benefit model to more dynamic and applicable economic simulations that follow closely the coffee market structure behaviour. The second challenge of Coffeeconomics is the use of artificial intelligence (AI), also known as the neural networks approach. The use of AI can help to evaluate the behaviour of producers, brokers, sellers, and consumers simultaneously. Neural networks provide a powerful analytical tool to evaluate the costs, prices, technological changes and market trends of coffee. The primary objective of neural networks is to select this information from databases and documents as well as to propose the most suitable solutions to failures in the coffee market structure, anytime and anywhere.

Therefore, the adaptation of AI to solve coffee market structure failures is directly connected to mathematical models, such as the theory of chaos, mathematical logic, and neural networks. Finally, a simulator to evaluate coffee market structure failures was introduced. This new tool is called the "National Coffee Production Function (NCP-Function)". The next section provides a detailed explanation of the NCP-Function.

3. Introduction to the National Coffee Production Function (NCP-Function)

The following section describes the National Coffee Production Function (NCP-Function). Initially, it consists of four sub-production functions: (1) Coffee Producers; (2) Coffee Brokers; (3) Coffee Sellers; (4) Coffee Consumers. Each sub-production function has its respective quadrant. Each quadrant shows a single dependent variable (βij) represented with a vertical line at the quadrant's centre; and "n" number of independent variables (αij) represented with horizontal lines at the bottom of the quadrant. Finally, all αji were join to the dependent variable βij using the linkage of axes application "$\top\!\!\top$". All axes in each quadrant run real-time under the application of dynamic growth rates (see Expression 1.5). Therefore, there are four quadrants or four sub-production functions, and each quadrant has its dependent variable "βij" by "n" number of independent variables "αij". In this case, there are four outputs from producers ($\beta 0$), brokers ($\beta 1$), sellers ($\beta 2$) and consumers ($\beta 3$), originating at each sub-production function. Finally, among the four quadrants there is a single axis that it´s all the final coffee national output "$\beta *$". It joins the output of each of the four sub-production functions by means of the linkage application "$\perp\!\!\!\perp$" which links the quadrants by straight lines (see Figure 1). The idea is to build a single surface by linking together in the same physical space the four outputs of each sub-production function.

The objective of the NCP-Function is to build a large and single surface that is moving in real time in the same physical space. In fact, the application of the Omnia Mobilis assumption (Ruiz Estrada, 2011) is a basic condition to generate the real-time effect of the NP-Function. Hence, the final national output "$\beta *$" always displays a dynamic and multi-dimensional behaviour (Ruiz Estrada & Park, 2018) in real time into its multi-dimensional space. The analysis of the final results of the NCP-Function depends on the position of the surface and it can determine the situation of an economy highly dependent on the production, commercialization, and consumption of coffee. If the acreage is at a positive level, then the stability of the coffee market will be observed. If the surface remains at zero level, a stagnation of the coffee market is observed. If the acreage jumps between negative and positive levels, it can be established that the coffee market is highly vulnerable. Finally, if the acreage is below the negative level, then the coffee market is in constant crisis (see Figure 1).

4. The National Coffee Production Function model

The NCP-Function offers an alternative graphic and mathematical model to analyze from a multi-dimensional perspective the final national output by country. In fact, the NCP-Function offers policy makers, academics and central banks an alternative methodological approach that allows them to measure the final output of any country.

The NCP-Function is built by four sub-production functions as follows:

Sub-Production Function 0: Coffee Producers

$$☼\beta 0 = f\,(☼\Delta\alpha 00, ☼\Delta\alpha 01, ☼\Delta\alpha 02, \ldots, ☼\Delta\alpha 0\infty \ldots) \quad (1)$$

Sub-Production Function 1: Coffee Brokers

$$☼\beta 1 = f\,(☼\Delta\alpha 10, ☼\Delta\alpha 11, ☼\Delta\alpha 12, \ldots, ☼\Delta\alpha 1\infty \ldots) \quad (2)$$

Sub-Production Function 2: Sellers

$$☼\beta 2 = f\,(☼\Delta\alpha 20, ☼\Delta\alpha 21, ☼\Delta\alpha 22, \ldots, ☼\Delta\alpha 2\infty \ldots) \quad (3)$$

Sub-Production Function 3: Coffee Consumers

$$☼\beta 3 = f\,(☼\Delta\alpha 30, ☼\Delta\alpha 31, ☼\Delta\alpha 32, \ldots, ☼\Delta\alpha 3\infty \ldots) \quad (4)$$

$☼$ = Real Time $\quad \beta i$ = Output $\quad \Delta$ = Dynamic Growth Rate

All variables in each sub-production function require the application of the dynamic growth rate, as follows:

$$☼\Delta\alpha ij = ☼\Delta\alpha ij\,\langle t+1\rangle - ☼\Delta\alpha ij\langle t0\rangle / ☼\Delta\alpha ij\,\langle t+1\rangle \times 100\% \quad (5)$$

$$☼\Delta\alpha ij\langle t0\rangle \; i = \{1,2,\ldots,\infty\} \text{ and } j = \{1,2,\ldots\infty\}$$

$\langle t+1\rangle$ = Future time period $\quad \langle to\rangle$ = Initial time period

Therefore, the final mathematical structure to build the NCP-Function is based on Expression 6:

$$☼\beta^* \equiv ☼\pm\beta 0 \,╬\, ☼\pm\beta 1 \,╬\, ☼\pm\beta 2 \,╬\, ☼\pm\beta 3 \quad (6)$$

$╬$ = linkage of quadrants

The Sub-Production Function 0 Specialization (Coffee Producer) shows a large number of factors and functions that affect its behaviour simultaneously, according to expressions 7, 8, 9, and 10.

Sub-Production Function 0 – Coffee Producer "A":

$$☼\beta A\text{-}0{:}0i = f\,(☼\Delta\alpha A\text{-}0{:}00, ☼\Delta\alpha\ A\text{-}0{:}01, ☼\Delta\alpha\ A\text{-}0{:}02,\ldots,☼\Delta X\ \alpha\text{-}0{:}0\infty\ldots) \quad (7)$$

Sub-Production Function 0 – Coffee Producer "B":

$$☼\beta B\text{-}0{:}1i = f\,(☼\Delta\alpha B\text{-}0{:}10, ☼\Delta\alpha B\text{-}0{:}11, ☼\Delta\alpha B\text{-}0{:}12,\ldots,☼\Delta\alpha B\text{-}0{:}1\infty\ldots) \quad (8)$$

Sub-Production Function 0 – Coffee Producer "C":

$$☼\beta c\text{-}0{:}2i = f\,(☼\Delta\alpha C\text{-}0{:}20, ☼\Delta\alpha C\text{-}0{:}21, ☼\Delta\alpha c\text{-}0{:}22,\ldots,☼\Delta\alpha C\text{-}0{:}2\infty\ldots) \quad (9)$$

Sub-Production Function 0 – Coffee Producer "Z":

$$☼\beta Z\text{-}0{:}4\infty = f\,(☼\Delta\alpha Z\text{-}0{:}\infty 0, ☼\Delta\alpha Z\text{-}0{:}\infty 1, ☼\Delta\alpha Z\text{-}0{:}\infty 2,\ldots, ☼\Delta\alpha Z\text{-}0{:}\infty\infty\ldots) \quad (10)$$

If any coffee producer in the same country displays the largest output from the sub-production function zero, followed by ($☼\beta A\text{-}0{:}0i$) v ($☼\beta B\text{-}0{:}1i$) v ($☼\beta c\text{-}0{:}2i$) v ($☼\beta Z\text{-}0{:}4\infty$), then this coffee producer needs to establish the main market price for the rest of coffee producers on the sub-production function zero.

Sub-Production Function 1 Specialization (Coffee Brokers) presents a large number of factors and functions that affect its behaviour simultaneously, according to expressions 11, 12, 13, and 14 respectively.

Sub-Production Function 1 – Coffee Brokers "A":

$$☼\beta A\text{-}1{:}0i = f\,(☼\Delta\alpha A\text{-}1{:}00, ☼\Delta\alpha A\text{-}1{:}01, ☼\Delta\alpha\ A\text{-}1{:}02,\ldots,☼\Delta\alpha A\text{-}1{:}0\infty\ldots) \quad (11)$$

Sub-Production Function 1 – Coffee Brokers "B":

$$☼\beta B\text{-}1{:}1i = f\,(☼\Delta\alpha B\text{-}1{:}10, ☼\Delta\alpha B\text{-}1{:}11, ☼\ \Delta\alpha B\text{-}1{:}12,\ldots,☼\Delta\alpha B\text{-}1{:}1\infty\ldots) \quad (12)$$

Sub-Production Function 1 – Coffee Brokers "C":

$$☼\beta c\text{-}1{:}2i = f\,(☼\Delta\alpha C\text{-}1{:}20, ☼\Delta\alpha C\text{-}1{:}21, ☼\ \Delta\alpha c\text{-}1{:}22,\ldots,☼\Delta\alpha C\text{-}1{:}2\infty\ldots) \quad (13)$$

Sub-Production Function 1 – Coffee Brokers "Z":

$$☼\beta Z\text{-}1{:}4\infty = f\,(☼\Delta\alpha Z\text{-}1{:}\infty 0, ☼\Delta\alpha Z\text{-}1{:}\infty 1, ☼\Delta\alpha Z\text{-}1{:}\infty 2,\ldots, ☼\Delta\alpha Z\text{-}1{:}\infty\infty\ldots) \quad (14)$$

If any domestic or overseas coffee broker displays the largest output in sub-production function 1, followed by ($☼\beta A\text{-}1{:}0i$) v ($☼\beta B\text{-}1{:}1i$) v ($☼\beta c\text{-}1{:}2i$) v ($☼\beta Z\text{-}1{:}4\infty$) then this coffee broker can find the best price of sub-production function 1.

Sub-Production Function 2 Specialization (Coffee Sellers) have a large number of factors and functions that affect the final price behaviour simultaneously, according to expressions 15, 16, 17 and 18 respectively.

Sub-Production Function 2 – Coffee Sellers "A":

$$☼\beta A\text{-}2{:}0i = f\,(☼\Delta\alpha A\text{-}2{:}00, ☼\Delta\alpha A\text{-}2{:}01, ☼\Delta\alpha A\text{-}2{:}02,\ldots,☼\Delta\alpha A\text{-}2{:}0\infty\ldots) \quad (15)$$

Sub-Production Function 2 – Coffee Sellers "B":

$$☼\beta B\text{-}2{:}1i = f\,(☼\Delta\alpha B\text{-}2{:}10, ☼\Delta\alpha B\text{-}2{:}11, ☼\Delta\alpha B\text{-}2{:}12,\ldots,☼\Delta\alpha B\text{-}2{:}1\infty\ldots) \quad (16)$$

Sub-Production Function 2 – Coffee Sellers "C":

$$☼\beta c\text{-}2{:}2i = f\,(☼\Delta\alpha C\text{-}2{:}20, ☼\Delta\alpha C\text{-}2{:}21, ☼\Delta\alpha c\text{-}2{:}22,\ldots,☼\Delta\alpha C\text{-}2{:}2\infty\ldots) \quad (17)$$

Sub-Production Function 2 – Coffee Sellers "Z":

$$☼\beta Z\text{-}2{:}4\infty = f\,(☼\Delta\alpha Z\text{-}2{:}\infty 0, ☼\Delta\alpha Z\text{-}2{:}\infty 1, ☼\Delta\alpha Z\text{-}2{:}\infty 2,\ldots,☼\Delta\alpha Z\text{-}2{:}\infty\infty\ldots) \quad (18)$$

If any coffee seller in the same coffee market displays the largest output in sub-production function 2 followed by ($☼\beta A\text{-}2{:}0i$) v ($☼\beta B\text{-}2{:}1i$) v ($☼\beta c\text{-}2{:}2i$) v ($☼\beta Z\text{-}2{:}4\infty$) then this coffee seller can get the biggest profit margin of sub-production function 2.

Sub-Production Function 3 Specialization (Coffee Consumers) shows a large number of factors and functions that affect the final satisfaction in coffee consumer behaviour simultaneously, according to expressions 19, 20, 21, and 22 respectively.

Sub-Production Function 3 – Coffee Consumer "A":

$$☼\beta A\text{-}3{:}0i = f\,(☼\Delta\alpha A\text{-}3{:}00, ☼\Delta\alpha\, A\text{-}3{:}01, ☼\Delta\alpha\, A\text{-}3{:}02,\ldots,☼\Delta\alpha\, A\text{-}3{:}0\infty\ldots) \quad (19)$$

Sub-Production Function 3 – Coffee Consumer "B":

$$☼\beta B\text{-}3{:}1i = f\,(☼\Delta\alpha B\text{-}3{:}10, ☼\Delta\alpha B\text{-}3{:}11, ☼\Delta\alpha B\text{-}3{:}12,\ldots,☼\Delta\alpha B\text{-}3{:}1\infty\ldots) \quad (20)$$

Sub-Production Function 3 – Coffee Consumer "C":

$$☼\beta c\text{-}3{:}2i = f\,(☼\Delta\alpha C\text{-}3{:}20, ☼\Delta\alpha C\text{-}3{:}21, ☼\Delta\alpha c\text{-}3{:}22,\ldots,☼\Delta\alpha C\text{-}3{:}2\infty\ldots) \quad (21)$$

Sub-Production Function 3 – Coffee Consumer "Z":

$$☼\beta Z\text{-}3{:}4\infty = f\,(☼\Delta\alpha Z\text{-}3{:}\infty 0, ☼\Delta\alpha Z\text{-}3{:}\infty 1, ☼\Delta\alpha Z\text{-}3{:}\infty 2,\ldots,☼\Delta\alpha Z\text{-}3{:}\infty\infty\ldots) \quad (22)$$

If any coffee consumer displays the largest output in the sub-production function 3 followed by (☼βA-3:0i) v (☼βB-3:1i) v (☼βc-3:2i) v (☼βZ-3:4∞), then this coffee consumer can get the best price; in this case, measured by maximum coffee consumer satisfaction.

The third step is to build the NCP-Function by joining by straight lines the output of all national coffee production functions from producers, brokers, sellers and consumers, until a single surface could be drawn (see Figure 3). The NCP-Function is interested in verifying performance and effects among all of the coffee

market actors before and after implementing coffee prices. The NCP-Function performance depends on the location of the surface. The location of this NCP-Function can show four possible performance results: coffee market stability (see Expression 23), coffee market stagnation (see Expression 24), coffee market with high vulnerability (see Expression 25), and coffee market in constant crisis (see Expression 26):

$$☼\beta^{*}╬☼ +\beta a╬☼ +\beta b╬☼ +\beta c╬☼ +\beta z \ (23)$$

{if $\Delta+\beta^{*}$╬ R+ then the surface ╬ the coffee market stability performance}

$$☼\beta^{*}╬☼ +\beta o = 0╬☼ +\beta 1 = 0╬☼ +\beta 2 = 0╬☼ +\beta 3 = 0 \ (24)$$

{ if $\Delta\ Y^{*}$╬ o then the surface ╬ the coffee market stagnation performance}

$$☼\beta^{*}╬☼ \pm\beta o╬☼ \pm\beta 1╬☼ \pm\beta 2╬☼ \pm\beta 3 \ (25)$$

{if ΔY^{*}╬ R+/- then the surface ╬ the coffee market stagnation performance}

$$☼\text{-}\beta^{*}╬☼ \text{-}\beta o╬☼ \text{-}\beta 1╬☼ \text{-}\beta 2╬☼ \text{-}\beta 3 \ (26)$$

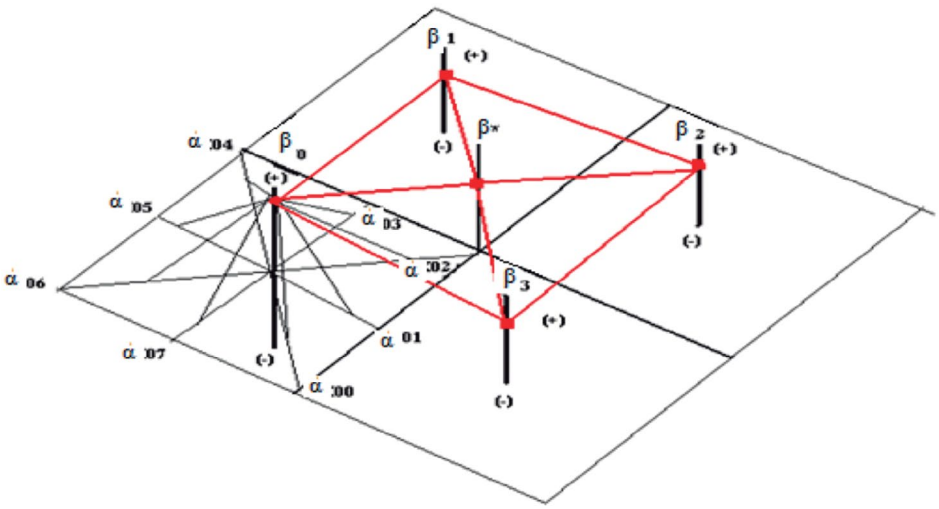
{if $\Delta\beta^{*}$ ╬ R- then the surface ╬ the coffee market with high vulnerability performance}

5. How to calculate the National Coffee Production Function (NCP-Function)

The application of the National Coffee Production Function (NCP-Function) can fundamentally be divided into three basic steps. The first step is to build the national production function of producers, brokers, sellers and consumers of coffee by measuring the four sub-production functions. The second step is to compare the same sub-production function in each producer, broker, seller, and consumer of the same coffee market, in order to find which producer, broker, seller and consumer is going to get more benefits on a specific sub-production function. Finally, the third step is to build the NCP-Function through a surface. The NCP-Function is made up of the final national outputs of all coffee producers, brokers, sellers, and consumers in the same coffee market, as it monitors their behaviour.

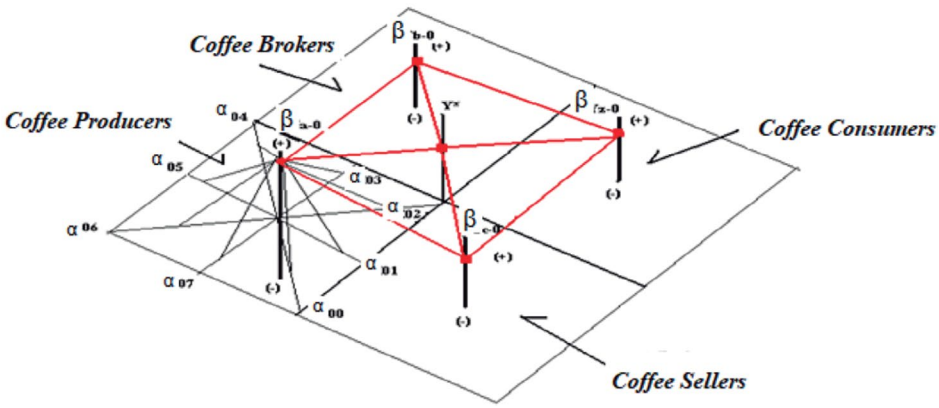
The first step will establish the final national output by means of the NCP-Function, depending on the results of each sub-production function, represented by all producers, brokers, sellers, and consumers (see expressions 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22). The NCP-Function will then join all four sub-production functions in a common axis shared by the four quadrants of the NCP-Function (figures 1 and 2). The second step is to compare the same sub-production function in different coffee markets interested in getting higher benefits in profits or levels of satisfaction. The second step can help to determine which actor (coffee producer, broker, seller and consumer) is more competitive and to establish better prices (see Expression 23, 24, 25, 26 & Figure 2 and 3).

Figure 1. The National Coffee Production Function (NCP-Function) Surface



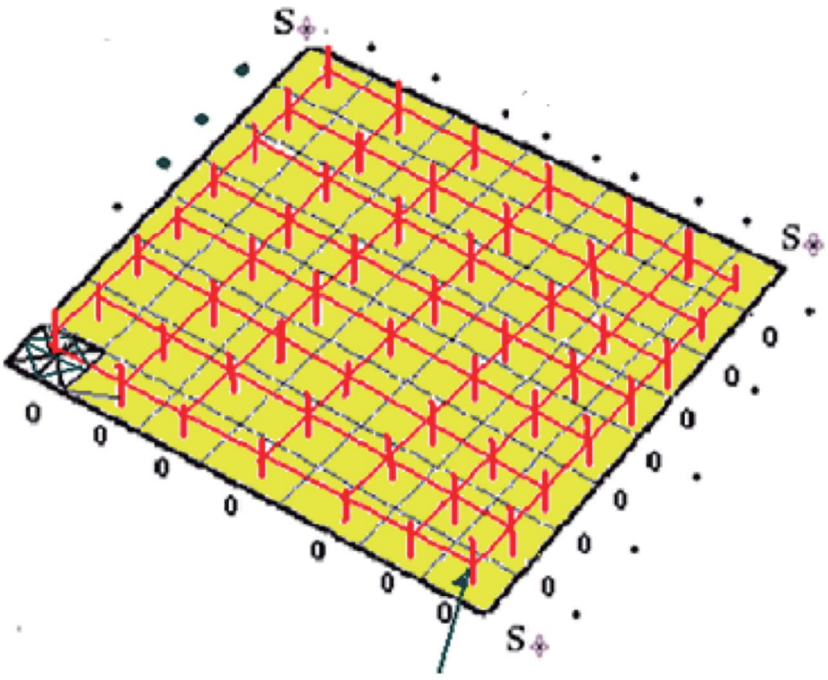
Fuente: Source: Ruiz Estrada (2017)

Figure 2. NCP-Function Surface by Sub-Production Function



Fuente: Source: Ruiz Estrada (2017)

Figure 3. NCP-Function Surface



Fuente: Source: Ruiz Estrada (2017)

6. The application of the National Coffee Production Function (NCP-Function) in the case of Guatemala

The national coffee production function (NCP-Function) of Guatemala was studied, covering the time period 1928 to 2018 and using secondary data from different coffee related databases and institutions. The NCP-Function is part of what is commonly known as cost-benefit analysis. It focuses primarily on performance and risks in the coffee market structure based on a new set of indicators and analytical tools. The NCP-Function has an important role supporting the performance of the four main players in the coffee market structure: producers, brokers, sellers, and consumers (buyers). The analysis of this structure concentrates heavily on evaluating the vulnerability of its four main players, both in the short and in the long run. The coffee market structure operates with common problems and conditions that share common characteristics: (i) producer adversities, (ii) higher broker speculation, and (iii) aggressive competition among coffee sellers to extend traditional and potential markets. The NCP-Function varies considerably in the spheres of producer, broker, seller and consumer behaviour, both in the short term and in the long term. However, they do exhibit a strong linkage in the four sub-functions.

The NCP-Function for Guatemala was higher (0.67) between 1928-1958 (see Figure 4). Guatemala's high NCP-Function rates are related to its long trajectory in the production of coffee. More specifically, the NCP-Function for Guatemala shows that between 1960-1985 it reached 0.71 (see Figure 5). Subsequently, the NCP-Function rate increased to 0.81 between 1985-2005 (see figure 6). During recent years (2006-2018) the NCP-Function rate has been 0.68 (see Figure 7). This decrease responds mainly to the following circumstances: (i) the strong competition from neighbours such as Costa Rica, Honduras and El Salvador, (ii) the vulnerability of the international coffee prices, (iii) the surge of new producers in the international arena, specially from Southeast Asia, such as Vietnam and Indonesia, (iv) high broker speculation, and (v) the fast expansion of large sellers. On the other hand, the lack of trade with the Popular Republic of China decreed by Guatemalan authorities make it impossible to find potential niches in this large market.

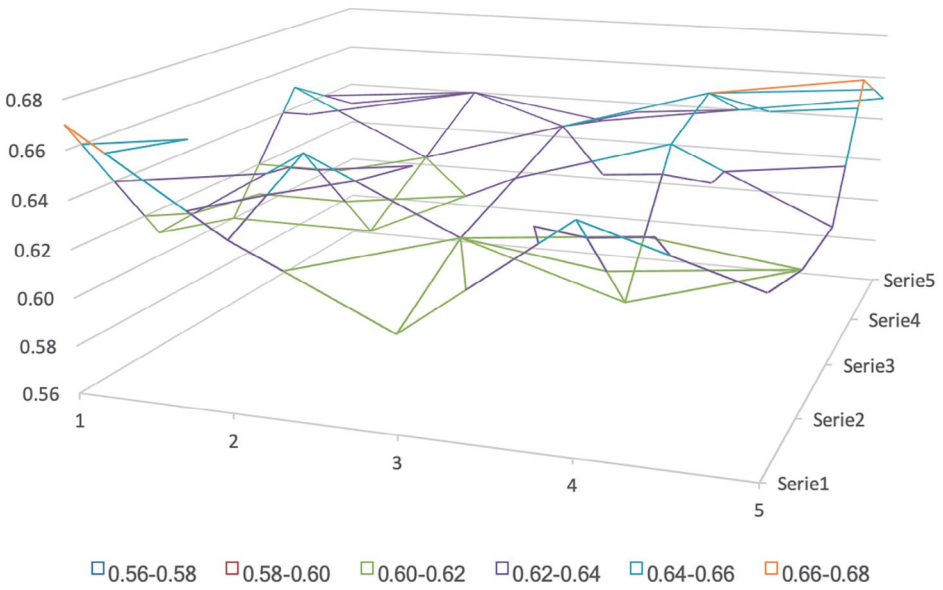
The NCP-Function applied to Guatemala shows that, of the total output of coffee grown by national producers, 38 % is grown by large producers, 42 % by cooperatives and only 12 % by small producers (Villain, Hernández & Anzueto, 2008). Not surprisingly, responsible for the high degrees of speculation in coffee prices, American and European coffee brokers have been replaced by new mechanisms of negotiation at the different levels of coffee production (large, cooperatives and small producers). Indeed, the role of brokers in the coffee business considerably

affects the level of profits of large producers, whose profit margin is between 25 % and 35 %; cooperatives, whose margin is between 18 % and 25 %; and small producers, whose margin is between 12 % and 18 %.

The NCP-Function applied to Guatemala shows the quota of coffee exports to the rest of the world is equal to 65 % of its total national production. This translates into a domestic consumption rate of approximately 35 %. Guatemala's coffee market structure is unique due to a favorable ranking among the world's largest coffee producers, having positioned itself in the tenth place internationally as a result of its long history in the global coffee market and to the quality of the coffee the different regions of the country produce.

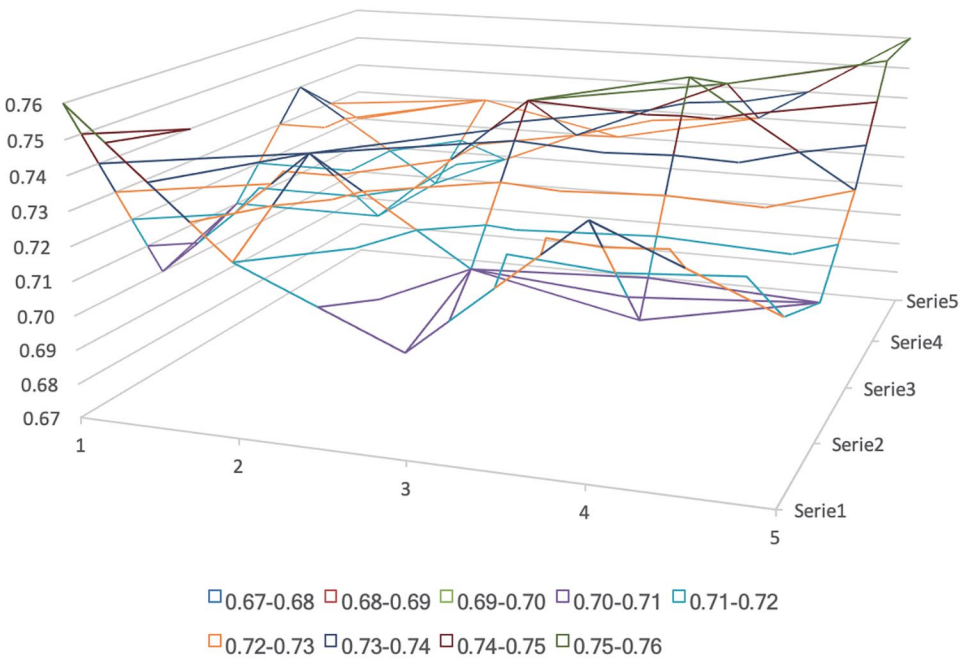
The NCP-Function of Guatemala is experiencing fast changes and adaptations according to the equally fast changes occurring in coffee market behaviour at a global level. The reduction of small producers directly affects its coffee market structure, which is rapidly moving towards production by large cooperatives in order to survive in today's competitive coffee market. Despite the fact that the Guatemalan coffee market structure has experienced a small growth in the previous years, the moderate increase in the NCP-Function of Guatemala is not enough to generate a competitive coffee market structure able to compete with large players around the world who can satisfy the needs of large consumers, such as Europe and the U. S., by providing huge amounts of coffee. Similarly, the coverage of local coffee consumers tends to decrease, according to the performance of the NCP-Function in Guatemala. Given the producers' weak position and the high speculation by coffee brokers, the gap between producer and broker profits considerably affects the performance of Guatemala's NCP-Function in the short and long run.

Figure 4. The NCP-Function for Guatemala (1928-1958)



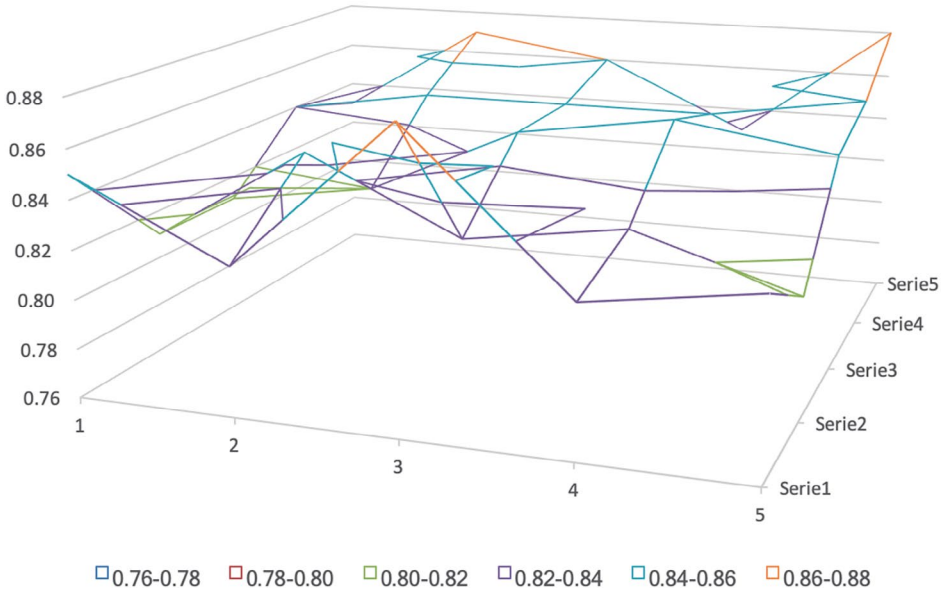
Fuente: Source: International Coffee Organization (ICO) (2017)

Figure 5.



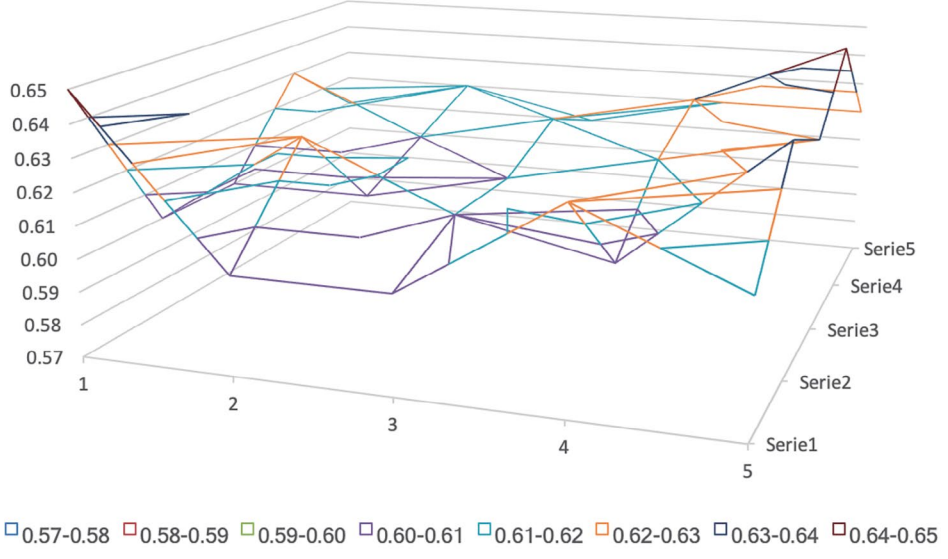
Fuente: Source: International Coffee Organization (ICO) (2017)

Figure 6. The NCP-Function of Guatemala (1985-2005)



Fuente: Source: International Coffee Organization (ICO) (2017)

Figure 7. The NCP-Funtion of Guatemala (2006-2018)



Fuente: Source: International Coffee Organization (ICO) (2017)

7. Conclusion

A new field of economic research is proposed, Coffeeconomics; a new economic analytical method that can be used to evaluate the performance, development and progress of the coffee market structure. At the same time, its corresponding analytical tool is presented, called National Coffee Production Function (NCP-Function), based on the use of a set of four sub-functions: (i) Sub-Function 0: Coffee producers, (ii) Sub-Function 1: Coffee brokers, (iii) Sub-Function 2: Coffee sellers, and (iv) Sub-Function 3: Coffee consumers. The underlying intuition is that coffee market structure depends on the good performance of these four sub-functions. The NCP-Function could contribute to a better and more in-depth understanding of coffee market structure performance as a whole.

A more useful measurement of the NCP-Function is conducive to the generation of appropriate policies for dealing both with negative factors such as low productivity, climate change, price discrimination, and with the constant speculation between coffee producers and coffee brokers. With more suitable and realistic planning, with better measures that seek to lessen the impact of adverse factors on the coffee market structure, it is possible to avoid collapse before it occurs. On the one hand, estimating the negative factors that can affect the coffee market structure may lead to small coffee producers and cooperatives to allocate more efficiently financial and human resources for the generation of a sustainable coffee market structure. Furthermore, and at a broader level, the results confirm that a stronger NCP-Function could have a significant impact on the coffee market structure, even in small coffee producing countries. The final conclusion is that the NCP-Function offers an alternative graphic and analytical approach to risk and vulnerability in the coffee market structure.

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