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Multisectoral Analysis of Electricity Price Increases in the Mexican Economy

Jaime Vaca,[a] Gaspar Núñez [b] and Antonio Kido [a]

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Abstract

This paper presents a multisectoral analysis of the increase in electricity prices in the Mexican economy, applying a pricing model and using the most recent input-output matrix. Increased in the manufacture of petroleum derivatives and coal, as electricity sources, are also analyzed. Additionally, increases in the generation, transmission and distribution of electricity are studied. The key findings obtained from this analysis show that a 40% increase has the most significant impact on the sectors such as air transport (7.76%); land passenger transportation (6.04%) –except rail--, tourist transport (6.04%) and on the generation, transmission and distribution of electricity (5.58%). This increase in turn impacts all subsectors of the national economy.

Keywords: Electricity; prices; energy transmission and distribution; multisectoral analysis; input-output matrix.

1. INTRODUCTION

Energy reform in Mexico represents a structural modification of the electricity sector. The recent creation of a wholesale electricity market aims to encourage the participation of private investors, to grant certainty, transparency and more competitive prices to all participants. Based on current international markets, an effort is being made to successfully participate in a global economic environment of stiff competition (KPMG, 2014, p. 4; SENER, 2016, p. 19).

The wholesale electricity market (WEM) started operations in 2016 and is currently a short-term energy market based on costs, with a daily market and a real-time market (Irastorza and Montalvo, 2018). In the last three years, 134 billion dollars were invested in the generation, transmission and distribution of electrical energy. This investment established a conjuncture to increase competition in the sector. The three long-term auctions carried out, account for 9 billion dollars of support for more than 19 states of the Mexican Republic; the program calls for the construction and commissioning of 70 power plants; 67 of which will produce clean energy (García, 2018).

However, the correct functioning of the wholesale electricity market must face the reality of keeping an industry that has a big impact as a strategic subsector under the protection of the State; therefore, it should be observed in detail if it is favorable to privilege the creation of the wholesale electricity market through increased investment from the private sector. Hence, the significant participation of the State in new investments in the electricity industry is of great importance, given that the purpose of the new Electric Industry Law is to promote sustainable development, guaranteeing that continuous, efficient and reliable actions are taken to benefit consumers.

The energy crisis of 1973 and the relevance of energy in economic development have generated, in many countries, numerous studies of the links between the energy sector and the economy. The realization of these studies in various contexts has had the objective of reducing each country's energy dependence, establishing more convenient energy policies, and studying the consequences of these on the economy. (Cardenete and Fuentes, 2009, p. 10)

In the same manner, the analysis of the electricity industry, including all the sectors that make up the economic system of a country, and encompassing all sources of electricity generation, favors the quantification of the interrelationships and economic ties of the branches of this industry with those of other economic sectors; as well as the evaluation of the multiplier effects in the economy due to its participation as both a supplier and participant of economic growth (Cámara *et al.*, 2011, p. 495). Therefore, studies such as these facilitate meaningful support in the decision-making processes involved in establishing public policies related to the economy and energy.

The objective of this text is to present the results of a multisectoral analysis on the increase of electricity prices in the Mexican economy, made through the price model and applying the most recent input-output model (IOM). By means of the simulation of scenarios in two endogenous variables, the results of a 40% increase in the petroleum and coal derivatives manufacturing subsector were obtained and shown, which in turn leads to an increase in the Generation sub-sector, transmission and distribution of electric power (5.58%); Likewise, the multiplier effect of this increase is evaluated, which impacts all subsectors of the economy.

In addition to this introduction, the work is divided as follows: point 2 presents the context of the electricity industry worldwide; point 3, the methodology applied; point 4, the database used, as well as the application of technology and the discussion of the results. Finally, the final results and conclusions of the policies derived from the research carried out are presented.

2. BACKGROUND AND CURRENT CONTEXT

Different sources and technology are present in the generation of electricity. At present, there are several options with different characteristics. The main classification in Mexico distinguishes conventional energies and clean energies. According to the Energy Regulatory Commission (CRE, 2014, page 8): "The new regulation aims to create an efficient, safe and clean electric sector with competitive prices". For this reason, it is important to promote competition in each of the activities in the process, and establish a wholesale electricity market (WEM), where large consumers of electricity can make their purchase directly from the generators of electricity.

According to De la Cruz (2006, p.4), the experience of the first years of operation of the electricity markets organized in Chile, Australia, the United States of America and Europe, indicates that the liberalization of the electricity sector is a phenomenon that requires direct and continuous attention, since its development involves a long process of slow progress towards true competition, requiring constant adjustments and adaptations.

Erdogdu (2010, p.6) mentions that the cause leading to the modification of the structure of the electricity sector is different for each country, however, the main reason is commonly that reform improves the efficiency of the sector, reduces the price-cost margins and improve the quality in the service. An additional objective, in developed countries, may be to attract investments in the electricity sector.

In a comparative study of the five main electricity markets in the world, the United States of America (California), the United Kingdom, Australia, Norway and Chile, Srivastava *et al.* (2011, p.198) present as their main conclusion that the liberalization and restructuring process of the electricity sector in some countries, can be better designed if the experience of existing markets is taken into consideration. However, if the reforms are not carried out in an orderly and meticulous manner, the increase in costs could be manifested as a significant contingency.

3. METHODOLOGY

The structural analysis, based on the IOM, presents the interrelationship between the productive sectors of an economic system. The columns indicate the inputs coming from productive sectors required to manufacture their products and in the lines the quantity of products distributed by this sector to the other sectors; it is a model that quantifies this interrelationship and facilitates the analysis of the impacts presented in each of the elements of the productive system, in quantities or in prices, originated by variations in production and in the prices of goods and services. (Leontief, 1973, P. 156; 1993, P. 208).

The IOM is highly adaptable and has had an impressive development in multiple applications and theoretical aspects, although it has been criticized for its inflexibility related to the conjecture of the fixed technical coefficients (Aroche, 2013, pp. 250-254).

It is through an IOM that detailed studies can be carried out on the production and consumption of goods and services produced in a country or that are acquired from other countries, as well as the income obtained by said production through different production cycles. A general IOM is made up of the following matrices: supply, intermediate demand, final demand and a value-added table. It is created from the input-product registers, in an organized and structured manner in the form of a matrix, from which we obtain the GDP by method of production, type of expenditure, and type of income (Schuschny, 2005, p. 7).

Assuming that the economy can be categorized into n sectors, and x_i corresponds to the total production of the sector, and f_i is the final demand of the products of sector i, then through a simple accounting equation the form in which sector i distributes its products through sales to other sectors, and final demand of the products can be expressed (Miller and Blair, 2009, p.11):

$$x_i = z_{i1} + \dots + z_{ij} + \dots + z_{in} + f_i = \sum_{j=1}^{n} z_{ij} + f_i \quad (1)$$

The term z_{ij} indicates the inter-industry sales of sector i (also known as intermediate sales) to all sectors j (including itself, when $j = 1$). Equation (1) represents the distribution of the products of sector i, which are indicated in the lines of an IOM. There is one such equation to identify the sales of the products of each of the sectors n:

(2)

$$x_1 = z_{11} + \ldots + z_{1j} + \ldots + z_{1n} + f_1$$
$$x_i = z_{i1} + \ldots + z_{ij} + \ldots + z_{in} + f_i$$
$$x_n = z_{n1} + \ldots + z_{nj} + \ldots + z_{nn} + f_n$$

Where:

$$\underset{\text{Total Sector Production}}{X = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix}} \qquad \underset{\text{Inter-industry Sales by Sector}}{Z = \begin{bmatrix} z_{11} \cdots z_{1n} \\ \vdots \ \ddots \ \vdots \\ z_{n1} \cdots z_{nn} \end{bmatrix}} \qquad \underset{\text{Final Demand of the Sector}}{f = \begin{bmatrix} f_1 \\ \vdots \\ f_n \end{bmatrix}} \tag{3}$$

Therefore, the IOM can be described through the application of a system of linear equations, which represents for each sector the identity between the total production achieved and the production purchased and consumed by each of the other sectors of the system. In other words, everything produced by a sector is bought and consumed by others as inputs or by the consumer as final demand. In matrix notation this system of linear equations is represented using the following equation:

$$x = (I - A)^{-1} f \tag{4}$$

Where x is a column vector of production of order n; f is a column vector of final demand of order n; I represents an identity matrix and A is the matrix of technical coefficients. The term $(I - A)^{-1}$ is known as the *Leontief inverse matrix* (*L*), so the equation already stated is the solution equation for the input-output analysis and is expressed as:

$$x = Lf \tag{5}$$

The multiplier effects refer to the changes presented in one or several sectors of the economy, originated by impacts on a variable that is not part of inter-industry sales by sector (exogenous variable); For example, the final demand (Ramos *et al*., 2013, p.57) and according to the Center for Latin American Monetary Studies (2012, p.26). These effects "show the sum of all the chain reactions of the needs of both direct and indirect inputs, resulting from an increase in production motivated by an impact on final demand".

The study of the direct and multiplier effects of a specific sector on the remaining sectors that make up an economic system, is done through the matrix of coefficients of direct needs or technical coefficients, called A in equation (4). This matrix, which is the core of the study, explains the immediate link among sectors and is calculated by dividing the elements of the intermediate demand of each sector by their corresponding production value (Figueroa, 2015, p.51). A study broken down by branches of activity of the circulation and distribution of inputs, products, goods and services, makes it possible to determine the overall impact of each element in each sector and subsector of the total economy (Spanish Energy Club, 2014, p 188). This global impact is made up of direct and indirect impacts.

The present work uses the domestic IOM for 2013, applied to 79 subsectors of the North American Industrial Classification System (NAICS), which is the most recent published by the National Institute of Statistics and Geography (INEGI, 2017). Table 1 presents a summary of this model for three large sectors. It shows the interrelationship among these large productive sectors of Mexico. The inputs necessary for the manufacture of the products corresponding to the primary activities sector are indicated in the corresponding column (called j), which require inputs in the amount of \$273.353 billion Mexican pesos to satisfy the need for the production of the industrial activities, an amount that is the sum of the amounts of \$64.515 billion Mexican pesos for the primary sector, \$117.098 billion Mexican pesos from the industrial sector, and \$55.740 billion Mexican pesos from the service sector.

If the line corresponding to the primary sector (denominated i) is taken, its production is distributed in each sector as follows: \$64.515 billion pesos in the same primary sector; \$421.732 billion pesos in the industrial sector and \$5.710 billion pesos in the services sector, so that the total of the intermediate demand is \$491.417 billion pesos for the primary sector. The shaded part of Table 1 shows the matrix of intermediate demands, which is constructed from the flows of inputs and products that are made in each of the three basic sectors of an economy.

The additional columns, called Final Demand, record the sales of each sector to the final markets for their production, such as: private consumption, government consumption, gross capital formation, stock variation, and exports. For example, electricity is sold to companies in other sectors as an input to production (inter-industry transaction) and also to residential consumers (sale of final demand). The additional rows, called Value Added, represent the other non-produced inputs, such as: imports, taxes, labor, and depreciation of capital.

One of the aspects of greatest practical interest of these studies is the evaluation of the various multiplier effects that can occur in the economy as a result of impacts on production and on the costs of inputs produced directly by the subsectors of the economy (endogenous variables), and effects on the monetary values of taxes, imports and value added (exogenous variables) (Casares *et al*., 2017, p.121).

Table 1 indicates that the industrial sector consumes $421.732 billion Mexican pesos at basic prices in 2013 from the primary sector. Second, it is essential to understand that not all the product of sector i will be destined to the rest of the sectors, given that a part of it is used in the final demand f, which is made up of the following: 1) Individual or private expenditure, $146.023 billion of weights; 2) Public expenditure, does not consume products from the primary sector; 3) Gross production of fixed capital, $7.841 billion pesos; 4) Change in stocks and purchases minus the disposal of valuable objects, $24.058 billion pesos.

(SEE TABLE 1)

It is important to note that the inclusion of exports ($110.404 billion pesos in the example), and imports in the boxes of input products lead to the Leontief extended model, also called open economy (Chraki, 2016, p.58).

A Price Model

The original IOM developed by Leontief was based on physical units (tons of grain, meters of cloth, and man-hours of labor force, among others). The technical input coefficients (matrix A) were based on physical quantities of inputs divided by physical quantities of products. This information was structured as a table of exchanges in a base year, in terms of value using unit prices of the base year for the aforementioned units. Usually, the information of the IOM is expressed in monetary units, in the same way the respective analyses are carried out in units of value. However, models with mixed units have been developed, mainly for the analysis of energy and environmental problems, in which ecological and energy exchanges are recorded in physical terms (Miller and Blair, 2009, page 41).

It is widely known that the dual version of the regular input-output model is applied in the simulation of cost push inflationary processes. Of course, this double-priced version of the Leontief model is based on the same strict assumptions and standards of the quantitative version and on some heavy and additional assumptions made for the price version (Oosterhaven, 1996, p.75).

The Leontief price model is recognized as a model of production prices, and finds prices as a solution, but the solution to that model actually reflects price indices. Replacing prices with price indices implies that there is a "base period of time" 2 that serves as a common reference for all price indices for the definition of monetary tables in order to eliminate the effects of prices (De Mesnard, 2012, p.2).

In the quantitative version of the Leontief model, the mathematical expression on which the development of the model is based, the elements of the MIP are considered by line, that is, the products demanded by the sectors that constitute the economic set. Consequently, said model expresses a vector of final demands (vector x), which originates the push of the model. For this reason, the Leontief model is named as the push model on the demand side, in order to differentiate it from the model of prices (Chávez, 2017, p.6).

The price model enables us to know the variations in prices of the different goods produced in the economy, resulting from an increase in the prices of primary inputs (Dietzenbacher, 1997, p.630). Thus, the Leontief model is also known as the push model with respect to costs. As already mentioned, the price model follows the methodology applied by Leontief in the product input analysis, and for reasons of simplicity in its registration, monetary interrelationships are organized in this model assuming that all the added value is represented by the labor force.

Table 1 will be taken as an example for the application of the model. As was mentioned, the rows describe the distribution of the production of a sector in the whole economy and the columns express the composition of the inputs required by a particular industry to obtain production, that is, the total disbursements incurred by each industry. Then, when all the inputs are accounted for in the processing and payment sectors, the total sum of the column (total disbursements) is equal to the total sum of the row (total production).

Application of the Pricing Model for an Endogenous Variable

To apply the price model from the MIP used, the elements of the matrix (see Table 1) that do not belong to the inputs produced directly by the subsectors of the economy (exogenous variables) are added in a single line. The lines corresponding to Imports, Taxes on Net Products and Value Added for each subsector were added, as presented in Table 2, calling the line of this sum Value Added.

Table 2. The Aggregate Table for Three Sectors, Prices in Millions of Mexican Pesos at Basic Prices for 2013

Activities	1	2	3	f_1	Total Production
1	64 515	421 732	5 170	288 325	779 742
2	117 098	3 021 320	746 758	9 753 926	13 639 102
3	55 740	1 853 896	1 805 456	9 508 711	13 223 804
Added Value	542 389	8 342 154	10 666 420	2 009 673	21 560 636
Production	779 742	13 639102	13 223 804	21 560 636	

Source: Created by the authors based on the Input-Output Matrix for Mexico at Basic Prices for 2013 with data from The National Institute of Statistics and Geography (INEGI, 2017)

Considering the example corresponding to three large sectors, an increase in one of the inputs corresponding to sector 2 is contemplated, that is, the increase in the price of a raw material corresponding to an endogenous sector is assumed. For example, the increase in the subsector Manufacture of Petroleum Products and Coal since it represents the largest input of the Electricity Generation, Transmission and Distribution subsector, which will be applied later in this work. This increase will have to be converted into an exogenous sector in order to simulate the impact that would generate the increase in the price of this input.

As already mentioned, it is considered that the sector of activities 2 includes the production of some input whose price increases and represents an input of great significance, then, the conversion of this sector from endogenous to exogenous modifies the structure by incorporating this line in the part corresponding to expenses (activity sector 2 becomes a payment sector) and the value-added line will be made up of this line plus one corresponding to payments to other sectors. On the other hand, consumption in 2 becomes part of the final demand (see Table 3).

Table 3. The Aggregate Table for Two Sectors, Prices in Millions of Mexican Pesos at Basic Prices for 2013

Activities/ Sectors	Sectores		Demanda final		Producción total
	1	3	Consumo en 2	Consumo final	
1	64 515	5 170	421 732	288 325	779 742
3	55 740	1 805 456	1 853 896	9 508 711	13 223 804
Expenses in 2	117 098	746 758	3 021 320	9 753 926	13 639 102
Payment to Other Sectors	542 389	10 666 420	8 342 154	2 009 673	21 560 636
Added Value	659 487	11 413 178	11 363 473	11 763 599	
Total Payments	779 742	13 223 804	13 639 102	21 560 636	

Source: Created by the authors based on the Input-Output Matrix for Mexico at Basic Prices for 2013 with data from The National Institute of Statistics and Geography (INEGI, 2017)

The matrix of technical coefficients A is obtained for the two sectors (1 and 3) indicated with the shaded area in Table 3, that is, the proportion that each one has within the total sum of payments per column, so:

$$Matriz\ A = \begin{bmatrix} 0.0827 & 0.0004 \\ 0.0715 & 0.1365 \end{bmatrix}$$

Since we want to obtain the price variation through Leontief's pricing model, which is given by:

$$\bar{p}' = (I - A)^{-1} v_c = L' v_c \qquad (6)$$

Where, $\bar{p}'$ is the vector of total payments, L' is the inverse matrix of Leontief and v_c is the value added vector made up of expenses in 2 plus payments to other sectors, so we get the transposed matrix

$$Matriz\ A' = \begin{bmatrix} 0.0827 & 0.0715 \\ 0.0004 & 0.1365 \end{bmatrix}$$

Now, the Leontief matrix for the base year base is: $(L^{\circ})' = (I - A')^{-1}$ for both sectors indicated in the previous matrix, then:

$$(L^{\circ})' = (I - A')^{-1} = \begin{bmatrix} 1.0902 & 0.0903 \\ 0\,0005 & 1.1582 \end{bmatrix}$$

From the base year 2013 data, considering the values of expenses in 2 and payments to other sectors, that is, the vector of the total expenses of added value v_c^0 used to denote the proportion of value added for the base year with respect to production it would be composed in the following way, transposing the corresponding data:

$$v_c^0 = \begin{bmatrix} 0.1502 \\ 0.0565 \end{bmatrix} + \begin{bmatrix} 0.6956 \\ 0.8066 \end{bmatrix} = \begin{bmatrix} 0.8458 \\ 0.8631 \end{bmatrix}$$

So the price model for the base year is given by:

$$\bar{p}^0 = (L^0)' v_c^0 = \begin{bmatrix} 1.0902 & 0.0903 \\ 0.0005 & 1.1582 \end{bmatrix} * \begin{bmatrix} 0.8458 \\ 0.8631 \end{bmatrix} = \begin{bmatrix} 1.0000 \\ 1.0000 \end{bmatrix}$$

According to data from the Energy Information Agency of the United States (US Energy Information Administration, 2017) the international price of natural gas could suffer an increase of 40% in 2017, which implies a multiplier effect in the manufacturing sector and in the electricity industry in Mexico. This increase in the price of some inputs of sector 2 (for example the subsector Manufacture of petroleum products and coal) was therefore considered as an exercise. We want to know the impact that would be generated in the price of the goods produced in sectors 1 and 3, given that the original condition in which the price of the input is contemplated in sector 2 (now converted into exogenous to part of the value added) is a unit value. We will now know the impact that the price of 2 would have to be 1.4, which increases the added value induced by the input of sector 2 in the same proportion (from 0.1502 to 0.2102 and from 0.0565 to 0.791). The new vector v_c^1 *v1c* would therefore have the following value:

$$v_c^1 = \begin{bmatrix} 0.2102 \\ 0.0791 \end{bmatrix} + \begin{bmatrix} 0.6956 \\ 0.8066 \end{bmatrix} + \begin{bmatrix} 0.9058 \\ 0.8857 \end{bmatrix}$$

Therefore:

$$\bar{p}^{\circ} = (L^{\circ})' v_c^1 = \begin{bmatrix} 1.0902 & 0.0903 \\ 0.0005 & 1.1582 \end{bmatrix} * \begin{bmatrix} 0.9058 \\ 0.8857 \end{bmatrix} = \begin{bmatrix} 1.0675 \\ 1.0262 \end{bmatrix}$$

In relation to prices of the original index, the price of sector 1 increased to 1.0675 (increase of 6.75%), the price of sector 3 increased to 1.0262 (2.62%).

4. DATABASE AND RESULTS

The paper used the most recent IOM in Mexico published by INEGI for 2013, specifically the domestic symmetric matrix product x product, disaggregated to 79 subsectors of the NAICS.

A descriptive statistical analysis is needed for more detailed knowledge of the economic structure of the sector or sub-sector under study. A table of the inputs (or consumption taken from each sub-sector) for the subsector Generation, Transmission and Distribution of Electric Power will show the relative importance of the inputs and, therefore, the magnitudes of the backward linkages, as well as those corresponding to added value and generation of employment (see Table 4).

Table 4. Inputs for the Generation, Transmission and Distribution of Electricity
(Millions of Mexican Pesos at Basic Prices for 2013)

Number	*NAICS Class Code*	*Subsector*	*Amount*	*Percentage*
1	324	Petroleum and Coal Products Manufacturing	82 496.779	46.05
2	325	Chemical Manufacturing	25 923.949	14.47
3	335	Electrical Equipment, Appliances, and Component Manufacturing	16 715.085	9.33
4	212	Mining (Except Oil and Gas)	13 323.771	7.44
5	431	Grocery and Related Products Wholesalers	12 427.325	6.94
6	484	Truck Transportation	2 949.752	1.65
7	541	Professional, Scientific, and Technical Services	2 945.092	1.64
8	461	Grocery and Related Products Retailers	2 743.212	1.53
9	561	Administrative Support Services	2 539.884	1.42
10	238	Specialty Trade Contractors	2 465.597	1.38
			Subtotal	91.85

Source: Created by the authors based on the Input-Output Matrix for Mexico at Basic Prices for 2013 with data from The National Institute of Statistics and Geography (INEGI, 2017).

Similarly, the preparation of a table with the way in which electricity is distributed (consumed) by the productive sectors, allows us to identify the relative importance of the use of electricity, as well as the magnitude of the dispersion. Table 5 shows the distribution of electricity to the 16 main subsectors that consume it.

Table 5. Inputs for the Generation, Transmission and Distribution of Electricity
(Millions of Mexican Pesos at Basic Prices for 2013)

Number	NAICS Class Code	Subsector	Amount	Percentage
1	461	Grocery and Related Product Merchant Retailers	29 322.635	10.35
2	311	Food Manufacturing	23 311.831	8.23
3	327	Nonmetallic Mineral Product Manufacturing	17 591.178	6.21
4	222	Natural Gas Distribution	16 929.603	5.97
5	331	Primary Metal Manufacturing	15 069.998	5.32
6	931	Executive, Legislative and Other Governmental Support	13 352.441	4.71
7	336	Transportation Equipment Manufacturing	13 132.050	4.63
8	212	Mining (except Oil and Gas)	11 405.036	4.02
9	326	Plastics and Rubber Products Manufacturing	10 892.679	3.84
10	332	Fabricated Metal Product Manufacturing	9 629.321	3.40
11	325	Chemical Manufacturing	8 366.669	2.95
12	611	Educational Services	8 085.265	2.85
13	431	Grocery and Related Products Wholesalers	6 774.388	2.39
14	334	Computer and Electronic Product Manufacturing	6 340.890	2.24
15	335	Electrical Equipment, Appliances, and Component Manufacturing	5,782.485	2.04
16	111	Agriculture, Grain Farming	5,713.938	2.02
			Subtotal	71.17

Source: Created by the authors based on the Input-Output Matrix for Mexico at Basic Prices for 2013 with data from The National Institute of Statistics and Geography (INEGI, 2017).

Application of the Price Model in Electricity Price Increase in Mexico

The increase in the inputs corresponding to the subsector Petroleum and Coal Products Manufacturing, supposes the increase in the price of the raw materials corresponding to an endogenous sector. This will have to become an exogenous sector in order to simulate the impact that would generate the increase in the price of this input. Following the methodology applied and in order to know the multiplier effects of the subsector under study, an assumed increase of 40% is considered, which is due to the increase registered in the price of natural gas in January 2017. So, the column corresponding to the expenses in this sub-sector is multiplied by 1.4 and added to the column of payments to other sectors. By multiplying the multiplier matrix by the modified column of expenditure in the electric power transmission, control and distribution subsector, the impact of this increase is obtained for each of the subsectors of the national economy (see Table 6).

Table 6. Impact of a 40% Increase in prices in prices of an endogenous variable, such as Petroleum and Coal Products Manufacturing on the prices in productive subsectors of the economy.

Number	NAICS Class Code - Subsector	Percentage
1	481 - Air Transportation	7.76
2	485 - Transit and Ground Passenger Transportation	6.04
3	487 - Scenic and Sightseeing Transportation	6.04
4	221 - Electric Power Generation, Transmission and Distribution	5.58
5	482 - Rail Transportation	4.78
6	114 - Fishing, Hunting and Trapping	4.73
7	492 - Couriers and Messengers	3.67
8	484 - Truck Transportation	3.54
9	213 - Support Activities for Mining	2.81
10	212 - Mining (except Oil and Gas)	1.89
11	115 - Support Activities for Agriculture and Forestry	1.67
12	111 - Agriculture, Grain Farming	1.67
13	222 - Distribution of Water or Gas via ducts	1.58
14	325 - Chemical Manufacturing	1.50
15	327 - Nonmetallic Mineral Product Manufacturing	1.37
16	562 - Waste Management and Remediation Services	1.35

Source: Created by the authors based on the Input-Output Matrix for Mexico at Basic Prices for 2013 with data from The National Institute of Statistics and Geography (INEGI, 2017).

This example shows the backward linkage of any of the subsectors that have been impacted by the price increase in the Petroleum and Coal Products Manufacturing subsector, which will address a forward chaining exercise in relation to the subsector Electric Power Transmission, Control and Distribution, which is of interest.

Similar to the exercise corresponding to the previous subsector, from the IOM to 79 sub-sectors, an increase in the inputs corresponding to the Electric Power Transmission, Control and Distribution subsector will be considered, that is, it will have to be converted into an exogenous sector in order to simulate the impact that the increase in the price of this input would generate across sectors. To know the multiplier effects of this subsector caused by the increase in prices of the subsector, Petroleum and Coal Products Manufacturing, an increase of 5.58% is applied in the analysis, which obeys the value obtained (see Table 6). So, the column corresponding to the expense in Electric Power Transmission, Control, and Distribution is multiplied by 1.0558 and added to the column of payments to other sectors and after multiplying the multiplier matrix by the modified column of the expense in Electric Power Transmission, Control and Distribution, the impact of this increase (forward chaining) is obtained in each of the subsectors of the national economy (see Table 7).

Table 7. Impact of a 5.58% Increase in prices in prices of an endogenous variable, such as Petroleum and Coal Products Manufacturing on the prices in productive subsectors of the economy.

Number	NAICS Class Code - Subsector	Percentage
1	222 - Distribution of Water or Gas Via Ducts	1.09
2	327 - Nonmetallic Mineral Product Manufacturing	0.55
3	313 - Textile Mills	0.36
4	212 - Mining (except Oil and Gas)	0.26
5	326 - Plastics and Rubber Products Manufacturing	0.25
6	331 - Primary Metal Manufacturing	0.24
7	332 - Fabricated Metal Product Manufacturing	0.24
8	323 - Printing and Related Support Activities	0.21
9	337 - Furniture and Related Product Manufacturing	0.20
10	322 - Paper Manufacturing	0.19
11	314 - Textile Product Mills	0.18
12	321 - Wood Product Manufacturing	0.18
13	512 - Motion Picture and Sound Recording Industries	0.15
14	339 - Miscellaneous Manufacturing	0.15
15	316 - Leather and Allied Product Manufacturing	0.15
16	315 - Apparel Manufacturing	0.15

Source: Created by the authors based on the Input-Output Matrix for Mexico at Basic Prices for 2013 with data from The National Institute of Statistics and Geography (INEGI, 2017).

5. ANALYSIS OF THE RESULTS AND CONCULSIONS

The domestic symmetric input-output matrix for 2013, published by the INEGI, was used as a database in this work. According to the data the production corresponding to the Electric Power Transmission, Control, and Distribution subsector represents 1.31% of the total production at basic prices for 2013 and GDP corresponds to 1.13% of the national total.

Based on this matrix, a descriptive analysis was carried out that shows that the electricity generation, transmission and distribution subsector is supplied with inputs from 47 sub-sectors, of which the largest percentage corresponds to the Petroleum and Coal Products Manufacturing subsector with 46.05%, which is due to the fact that the use of natural gas, fuel oil and coal prevails in electric power generation, which in turn demonstrates a high dependence on fossil fuels, and suggests the need to establish generation of electricity with alternative sources of energy.

Similarly, the analysis of the 2013 input-output matrix indicates that the Electric Power Transmission, Control, and Distribution, subsector supplies or distributes its production to 78 of the 79 sub-sectors, that is, all those that are dedicated to the production of electricity, goods and services in the Mexican economy. The Grocery and Related Products Retail subsector stands out with a consumption of $29,322.635 million pesos at basic prices for 2013 which corresponds to 10.34% of the demand for electric power.

In the corresponding application of an increase in the prices of 2 endogenous variables, to know the multiplying effects of the Electric Power Transmission, Control, and Distribution, subsector, an increase of 40% in the Petroleum and Coal Products Manufacturing subsector was first considered, assuming an increase in the price of inputs corresponding to an endogenous sector. The results indicate that the corresponding subsectors with the greatest impact were the following: Air Transportation (7.76%); Transit and Ground Passenger Transportation (6.04%); Scenic and Sightseeing Transportation (6.04%); Electric Power Transmission, Control, and Distribution (5.58%); and Rail Transportation (4.78%). This example shows the backward linkage of any of the subsectors that have been impacted by the price increase in the subsector Petroleum and Coal Products Manufacturing.

In accordance to the application of the price model and considering the 2013 IOM, it appears that a considerable increase in prices in the subsector Petroleum and Coal Products Manufacturing, in this case 40%, does not significantly impact the electricity industry and its consumers (5.58%). It is worth mentioning that the price increase in Petroleum and Coal Products Manufacturing is just one of several elements that make up the price increase in electricity. According to the report "The Impact of Oil Price on EU Energy Prices"(Albrecht *et al*., 2014) the most important factors influencing electricity prices are the following:

- The combination of sources of electricity generation, including the participation of renewable energies: different technologies and different fuels impact the marginal costs of electricity generation, which through the order of merit curve are the basis for the mechanism for fixing electricity prices. (The "order of merit" refers to the order in which the power plants enter the electric system, from the cheapest to the most expensive);
- Supply/demand balance: the price is established where the supply/demand curve intersects the order of merit curve of the generation of electricity;
- The prices of fossil fuels for the generation of electricity, particularly the prices of coal and gas, but also oil, where its use plays a significant part in the combination of national electricity generation, impact the order of merit curve;
- The capacity for interconnection with other member states: interconnections allow the importation of electricity from lower cost sources; the influence on domestic prices will depend on interconnectivity with and generation capacity in neighboring countries;
- Price of CO2 emission rights (EUAs).

In Mexico, the model for obtaining electricity prices takes into account the following: the cost of generation linked to the increase in the prices of inputs, interruptions in the supply of natural gas, the fall in hydroelectric generation, maintenance costs, expansion of the national electricity grid, and losses in the system (Sigler, 2018). It is important to emphasize that it would be enriching to develop future research with alternative methodologies, which contrast with the results presented.

In order to analyze the forward linkage, an impact of 5.58% was applied to Electric Power Transmission, Control, and Distribution subsector; obtaining impacts in all subsectors of the national economy, among which the following stand out: Distribution of Water or Gas Via Ducts to the final consumer, Nonmetallic Mineral Product Manufacturing, Textile Mills and Textile Product Mills, Mining (except Oil and Gas) and Plastics and Rubber Products Manufacturing. Although the subsector corresponding to Groceries and Related Products Merchant Retailers has the largest electricity consumption in millions of pesos at basic prices in 2013 (10.34% of the total demand for electricity) the impact of this increase only represents 0.04%.

The electricity industry in Mexico is important as it supplies 78 of the 79 subsectors of the national economy and over time has been a significant source of employment, as well as an important element for economic development. According to the expected growing demand for electric power, one of the main objectives of the energy reform is to promote mechanisms that meet this demand efficiently with low costs. A greater private participation in the sector will result in the incorporation of private generation plants, which would demand less labor and would also substitute unproductive or inefficient State generation plants. This would generate greater efficiency, but would indirectly result in increased in unemployment, which would have to be met in other ways, such as the investment in basic infrastructure.

Considering the high impact that the electrical industry has as a strategic sub-sector, it is not advisable to favor the creation of the wholesale electricity market through investment by the private sector, given that the purpose of the new Electric Industry Law is to promote its sustainable development, guaranteeing its action continuously, efficiently, and reliably for the benefit of consumers. Therefore, the participation of the State in new investments in the field is of great importance. On the other hand, if the dependence on prices and the international availability of natural gas, which at the beginning of 2017 showed an increase of 40%, is maintained, it is very likely that there will also be an increase in average prices of electricity.

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[a] The Michoacan University of Saint Nicholas of Hidalgo, Mexico [b] The College of Mexico (COLMEX). E-mail addresses:jaimevaka@hotmail.com, gaspar.nunez@colmex.mx and akido42@hotmail.com, respectively. This work was completed thanks to the support from the National Council of Science and Technology) (CONACYT in Spanish) through the Registry of Quality Graduate Programs (PNPC in Spanish).

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