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Evaluation of the socio economic impacts in Ecuador due to refinery matrix change using General Equilibrium Model

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Abstract

In 2014, Ecuadorian oil exportation contributed 50.54% to its total exports, while the import of oil products – main diesel, gasoline and LPG – represented 24.20% of the total importation. Due to limited crude oil refinery capacities, Ecuador's domestic fuel production does not satisfy its internal demand. Within its policy *The 2013-2017 National Plan for Good Living*, the Ecuadorian Government outlines its planes to double crude oil refinery capacities by building a new refinery site. As an outcome, Ecuador would have a surplus of fuel.

In this context, this paper estimates the socio-economic impacts of the implementation of the Ecuadorian governmental policy using a General Equilibrium Model (GEM). Shocks in the exogenous variables: supply of factor capital, exports, imports of petroleum and refining sectors are defined according the policy's implications.

Results of the evaluation show a decrease for the Ecuadorian unemployment rate of 10.83% and an increase of 4.39% for the Ecuadorian Nominal GDP due to the fall of the price index, and revaluation factor work. However, at the same time foreign savings, governmental income as well as family income are estimated to decrease.

Keywords

Ecuadorian Refinery | Ecuadorian energy policies | Energy economic assessment

Introduction

In the 1970s, Ecuador began to produce oil. Consequently, the oil production became the largest source of primary energy available in the country, taking over the place of wood and biomass productions. It implied structural changes in the Ecuadorian economy and this period became called by local economists as the “Oil Boom” [1]. Since this period until nowadays, the Ecuadorian economy is depending on the oil production. The oil exportation plays a very important role in the income of the government and society.

The oil refining capacity installed has been gradually increased to a nominal capacity of 176,000 barrels per day. In addition, its electricity generation capacity extended to 4,664 MW of installed power – shared equally between thermoelectric and hydroelectric generation. Thus, the natural-gas processing and ethanol plants have marginal holdings in the transformed energy mix. The growth rate of the final energy consumption in Ecuador between 2000 and 2013 was 4.50% p.a. [2]. As a reference from the region, the growth rate during the same period for the Andean Community and Brazil the growth rate was at 3.00% p.a. respective 3.12% p.a. [3]. Although, the energy consumption is growing, domestic fuel production still does not satisfy the domestic demand. Hence, in 2010 the local energy production contributed only 58% to the total energy offer. This is leading to high levels of energy importation destined for transport sector. The predominantly oil products are highlighting that this sector represents the principal consumer of final energy in Ecuador.

The low local production is originated in Ecuador's limited refinery capacity. Even though Ecuador is possessing significant national oil reserves – 3.89 billion barrels in 2017 implying 15

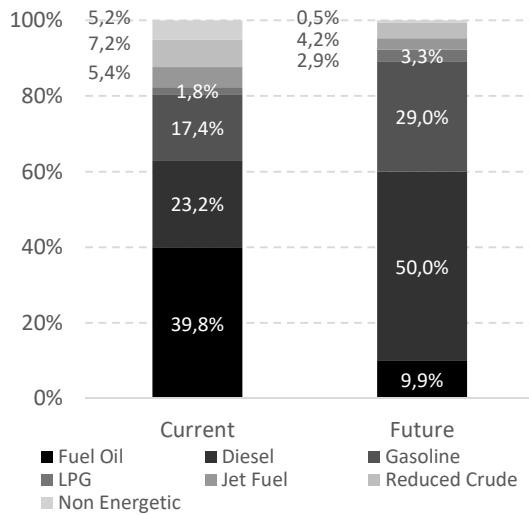
years self-sufficiency – this crude oil conversion rate causes the country a unfavorable situation [4], [5]. Furthermore, the major percentage of Ecuador's oil production (73% in 2014) was destined for exportation. Only the remains supply the refineries for domestic production. At the same time, Ecuador is importing big volumes of oil products. The imports – mainly diesel, gasoline and LPG – came up to 6.4 billion USD and represented 24.20% of Ecuador's total importation and 6.30% of its GDP for 2014. For the same year, the Ecuadorian oil exports represented a total value of 13 billion USD, equivalent 51% of its total exportations. Likewise for the same year, revenues from oil sales accounted for 18% of the general budget of the country [6]. Therefore, every energy-economic determining variable of the oil sector – production, transformation or consumption – for itself would imply significant impact on the Ecuadorian economy.

In this framework, the Ecuadorian government submits the 2013-2017 National Plan for Good Living. The policy stipulates to increase crude oil refinery capacities by building a new refinery site. The refinery, whose name translates as Pacific Refinery features 200 thousand B/D of installed nominal output capacity [7], [8]. As an outcome, Ecuador could satisfy its internal demand and offer a surplus of fuel to the global market. Hence, the objective of this study is to analyze the socio-economic impacts of the implementation of the Ecuadorian government policy The 2013-2017 National Plan for Good Living. Therefore, the study at hand introduces the consideration of all the interrelations of the Ecuadorian economy, intermediate consumption and productive chains. As its structure is appraised as most suitable for this application, a GEM is applied. Furthermore, the results get consulted to analyze the socio-economic impacts of the government policy on Ecuador.

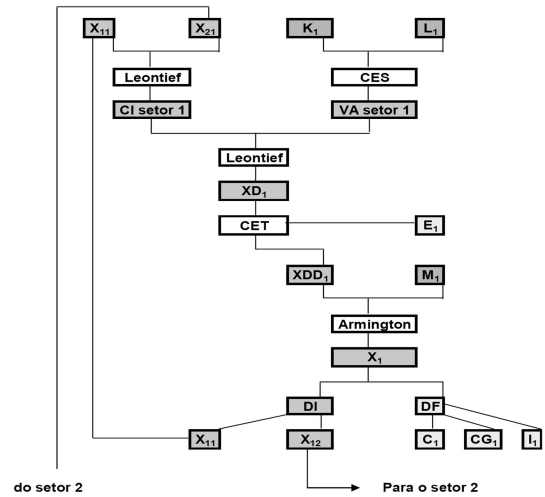
Methodology

The model is based on the equilibrium general theory developed by Leon Walras in 1874. The economic and energetic data on Ecuador was obtained from the Central Bank of Ecuador. The model was structured with the General Equilibrium Modelling Package (GEMPACK), a suite of economic modelling software developed by the Center of Policy Studies of the Victoria University, Australia.

The main hypothesis implemented by the authors specifies an increase of the current refinery capacity according to the governmental planning. It implies that the domestic fuel production will increase, primarily gasoline, diesel and LPG production, and the oil exportation will decrease due to the significantly increase of refinery oil supply as shown in *Figure 1a*. This change on the refinery structure implies a reduction of the fuel oil production, which is the main fuel in power plants. Nevertheless, the construction of the new hydropower plants will displace the existing power plants based on oil products as fuel.



(a)



(b)

Figure 1: Proportions of current and future refinery products (a); Structure of the GEM for Ecuador (b)

Since the new refinery structure implies that the majority of crude oil gets conveyed to local refineries, the Ecuadorian crude oil exports will decrease. Consequently, the local production of derivatives from Ecuador's disproportionately high crude oil reserves will be sufficient to satisfy the total domestic demand. Moreover, there would be significant amounts of derivate available for export. Without doubt, the reduction in crude oil exports, reduction in oil derivatives imports, and the available surplus of oil derivatives will have a high impact on the Ecuadorian economy. Especially, due to the fact that oil sector is the main in his economy.

Data selection and model structure

For the analysis at hand, the economy needs to be split into discrete sectors. Therefore, the authors use data provided by the Central Bank of Ecuador. In its social accounting matrix for 2010, the Bank structures the Ecuadorian economy into 25 sectors. Furthermore, the GEM requires data on the income and price elasticity of these sectors. Since it is, the authors use the weightage structure for Brazil developed by Almeida (2011) and link it to Moran et al.'s (2009) elasticity for gasoline products in the Ecuadorian market [9], [10].

The consumer behavior is defined as a Liner Expenditure System, considering minimum levels of subsistence linked to the budget constraint. Although, the production behavior of goods and services is defined, like a Constant Elasticity Substitution. This implies a minimization of production cost which are linked to availability and exchange of the production factors: capital and labor.

The relationship between intermediate sectors is defined as Leontief function, which means there is no sensitivity to the relative price variation between sectors. Furthermore, there are two functions considered to determine the interaction of the domestic economy with external economies. First, a Constant Elasticity of Transformation is considered to define a local production target, meaning that the local production goes for internal consumption or

exportation. The second consideration is the Armington function, which is use to define a quantity of goods and services that are imported by the Ecuadorian society (*Figure 1b*).

The model consists of 1,112 variables – five exogenous variables and 1,107 endogenous variables – linked to 1,107 equations. The definition of these variables is based on the established hypotheses. These variables refer to the export, import, production and supply of the oil, and refinery sectors. To get the five exogenous variables, the export, import, and production equations associated with these variables are removed. Thus, three subsectors are created: oil crude, oil derivate, and other fossil sources. In the GEMPACK software logic, equations do not consider the equations of subsectors. Consequently, these variables become exogenous for the model.

Exogenous variables closure

The aim of the Ecuadorian government policy is the construction of a new refinery, which implies high investments for Ecuadorian economy. Therefore, a greater supply of the factor capital is archived. Hence, this variable is defined as exogenous. According to government figures, the construction of the new refinery would require an investment of 12.5 billion USD [11]. In addition, as mentioned earlier, oil products imports and exports would change. In the first case, a significant drop is expected and in the second case an increase in exports would be expected.

Table 1: Closure selection

Sector	Variable	Description
S2	E	Export of oil and similar
S2	X _d	Oil domestic production
S2	X _{dd}	Oil offer
S8	E	Export of oil products
S8	M	Import of oil products
K	Oft.	Factor capital offer

Table 1 illustrates the closure selection specified by imports and exports as sectors 2 and 8. The refining sector is defined according to the implications from the policy. Therefore, the GEM considers factor capital offer, exports and imports of petroleum as exogenous variables. The shock level is based on official information [7], [12].

For Ecuador, domestic selling and export prices for oil are remarkably different. In 2010, the selling price for export oil was 69.80 USD / barrel and for domestic refinery supply was 13.86 USD / barrel. The currency translation effect concerning the oil prices are taken into consideration by the model. However, there is no difference in physical units.

Exogenous variables shock

The total supply of the factor capital equates to 43 billion USD. The refining sector (S8) contributes 610 million USD, equivalent to 1.42% of the total value. Hence, if the proposal is to double the current refining capacity, it would imply increasing the total supply of capital by 1.42%. It is expected that the refining sector (S8) will absorb the predominate share in this capital increase. This increase would guarantee the availability of resources for the refinery construction. Subject to these limitations, sales prices for export, import and domestic production are different for each product. As a first step, the increases or reductions in physical quantities are calculated. In the second step, these physical quantities are illustrated in monetary units. Hence, oil exports would decrease of from 128 to 26 million barrels, implying a reduction of 79% in exports for this sector (S2). According to Guillín (2013), the reduction of oil exports due to the new refinery would be -74% [13]. Exports of oil products, which are mainly fuel oil, sum up to 10 million barrels. The new refinery structure implies a surplus of 66 million Bbl. of derivatives would be available for export, therefrom 34% gasoline and 66% diesel. Oil products have a higher market price than fuel oil. The resulting price variation would imply a shock of 375% in exports of derivatives (S8). Complementarily, according to Guillín (2013), the volume available for exports would be 64 million barrels [13].

Table 2: Shock on exogenous variables¹

Sector	Variable	Shock	End Value
S2	E	-79.00%	1,917
S2	X_d	-32.00%	7,483
S2	X_{dd}	163.00%	5,566
S8	E	375.00%	4,063
S8	M	-89.00%	350
K	Oft.	1.42%	610

Another effect of the new refining capacity would be a derivate import reduction. There would not be imports of gasoline and diesel anymore, but an import of LPG. This shift in Ecuador's oil product acquisition implies a shock of -89% in imports in this sector M8. In physical units, the produced amount of oil does not change, but its monetary value would decrease since the domestic selling price is lower than the export price. This implies a shock of -32% in the production of this sector (X_{d2}). A similar logic applies in the oil supply (X_{dd2}): In physical terms, there would not be a change, but considering local and external prices implies a shock of 163%.

Results and interpretation

Initially, the predictable impacts on specifics variables will be evaluated by doing a reliability testing of the model and its results. Based on Ecuadorian Central Bank data, considering a non-importation of derivatives implies a reduction of about 18% in total imports (M). According to the

¹ All unspecified values are in million USD

model results, the total import reduction is estimated at 15%. In monetary units, this reduction would be equivalent to 3.4 Billion USD. Hence, this value lies close to the estimation of 4.5 billion USD by the Planning Secretariat of Ecuador [7].

A priori, the total exports would be increased, due to the increase in exports of derivatives. Nevertheless, given the high share of oil in Ecuadorian exports, the model reflects that total exports (E) would decrease by 14%. According to Castro and Cunha (2016), the new refining structure would imply a reduction of 9% in total exports. However, this study is not considering the price effect and factors replacement, in other words, a Leontief model [14]. Nevertheless, the trade balance would be improved by reducing the difference between exports and imports by 18%, equivalent to 778 million USD. According to Castro and Cunha (2016) this reduction would be 301 million USD under the same assumptions. In addition, studies by Guillín (2013) and Díaz and Novillo (2013) conclude that the new refining structure would improve Ecuador's trade balance [15].

Table 3: Result on predictable variable¹

Sector	Variable	Variation	End Value
Imports	M	15 %	19,133
Exports	E	14 %	15,807
S8	X _d	70 %	4,987
S8	X _{dd}	46 %	3,033

A priori, the value of local production of derivatives (X_{d8}) has to increase at least to double its value. Nevertheless, the local production of derivatives would be increased by 70% according to the model. This particularity is due to the price difference between imported fuel and domestic fuel. Therefore, the latter has a lower sale value. The same effect but only due to the price variation of oil products occurs concerning the local supply of derivatives. Thus, the model shows an increase by 46%. Currently most fuels are imported, but in the alternative scenario they would be produced locally and at a lower cost than the imported ones. Table 4 presents the main variables to evaluate the development or growth of a society: GDP growth, the unemployment rate and the price index. Hence, the variation would imply a nominal GDP increase of 4.39%. In 2010, GDP was 9.5 billion USD, which would be 72.6 billion USD. This increase would imply an increase in GDP per capita from 4,636 USD to 4,839 USD. In addition, considering a new refinery investment of 12.5 billion USD and a GDP growth of 3 billion USD, implies a payback of 4.16 years.

Table 4: Result on main variables¹

Variable	Variation	End value
GDP	4.39%	72,609
Purchase Families	5.00%	16,039
Unemployment rate	-10.83%	4.10%
Price index	-7.97%	3.06%

According to INEC (2014), 6.1 million employees were employed, directly or indirectly in the secondary sector of Ecuador in 2010. The unemployment rate was at 5%, implying 323 thousand unemployed [16]. The model reflects that the unemployment rate would decrease by 10.83% with the new refining structure. This would imply the creation of 34 thousand new jobs in total to the economy. More precisely, 36% of these new jobs would be linked to the secondary sector and 50% to the tertiary sector [14]. Furthermore, there would be a reduction in the price index as the model confirms a decrease of 7.97%. According to INEC, the price index for December 2010 was 3.33% [17]. Hence, the model foresees that the correspondent price index would shift to 3.06%. For the households, this would mean a greater purchasing power in relative terms from the same absolute wages. Hence, there would be a real gain in the economy for the households. Consequently, the prices of 23 sectors would decrease. The main reductions would lie in the sectors: minerals, electricity, and transport with -13%, -20%, and 16%, respectively. Therefore, based on these three socio-economic variables, it could be concluded that the change in the refining structure in Ecuador would imply a real economic growth and improvements in the quality of life for families. However, there would be sectors with negative effects.

Table 5: Income and revenue results¹

Variable	Initial Value	End Value	Variation
Income tax	10,115	9,701	-414
Households income	67,433	64,674	-2,758
Households expenditure	45,568	43,704	-1,864
Government income	13,454	12,933	-520
Government revenue	9,181	9,003	-178
Savings	18,910	17,408	-1,502
External savings	4,104	3,326	-778
Households savings	11,750	11,269	-481
Government savings	3,057	2,813	-244

According to *Table 6*, all savings in the economy would be reduced. The largest reduction would be in external savings with 18.96%, which is consistent with the increase in the trade balance due to the decrease in imports of derivatives presented previously. The reduction in total savings would be 7.96%, equivalent to 1.5 billion USD. This decrease would imply a reduction in the investment of the same amount. However, the main impact would be in the construction sector (S20) with a reduction of the investment of 2.60%. Consequently, the Gross Fixed Capital Formation would decrease in many sectors since it is investment related. Nevertheless, there would be a view exceptions. One exception builds the oil refining sector (S8) which would increase its investment by 153%. In fact, the electric power sector (18) would also increase its investment by 13%. This is due to the growth of the thermoelectric power plants which is directly related to the supply of fuels. Family income and expenses would both reveal the same reduction with 4.09%. However, in absolute values the income would decrease more than the expenses. These shifts imply that families would spend less. Nevertheless, because relative

prices would have a further decrease (7.97%), the demand for products in 24 sectors would increase, especially in the transportation sector.

The government's income and revenue would decrease by 1.94% and 3.87%, respectively. The reason of the reduction is the collection of taxes and the export of oil. Given that there would be a decrease in household expenditures, a decrease in consumption tax revenue would be implied. Likewise, the decrease in household income would imply a decrease of 4.09% in the income tax revenue. In fact, given that oil has a 17% share of fiscal revenues, the export reduction would imply a noticeable reduction in government revenues. Nevertheless, there would be an increase in the public health services, defense, education and other public services. This is due to a greater decrease in the price index than in the government income. The price index reduction is reflected in the falling prices of many goods in relation to *numéraire*, which is the remuneration of the factor labor in this model. Nevertheless, the oil production sector (S2) would have a price increase of 15.78%. The sectors with a major falling price are: Non-metallic minerals (S12), electric services (S18), and transportation (S22) with 13%, 20%, and 16%, respectively. Consequently, the consumption in the oil sector (S2) would decrease, which would be the only sector with a decrease in consumption. Hence, all other sectors would have increases in consumption (*Figure 2a*), implying a real consumption increase in the Ecuadorian economy. The refining sector (S8) would have the highest growth in consumption with an increase of 81%. Other sectors which would have significant increases in consumption are: Non-metallic minerals (12), electric energy (18), and transportation (22) with increases of 6%, 8%, and 13%, respectively. The results are consistent with the fall in prices in the same sectors (*Figure 2a*).

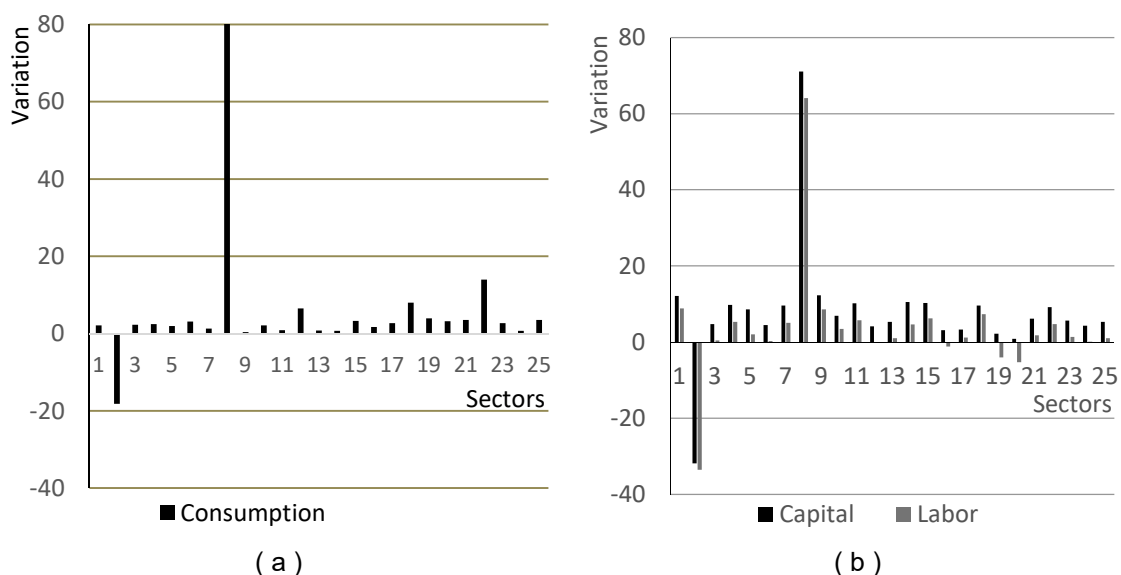


Figure 2: Variation per sector (a); Demand of primary factors Capital and Labor (b)

The primary factors of production would denote an increase in the demand for almost all sectors (*Figure 2b*). The biggest increase would be in the oil refining sector (S8) and the biggest decrease in the oil production sector (S2). Significant reductions in the factor labor would also arise in the water, waste, and sewage sector (S19) and the construction sector (S20) with 4%

and 5%, respectively. An explanation for these reductions is a deduction of workers by the other sectors. The construction sector (S20) is generally abundant of informal employment. In this context, the paper at hand supports the hypothesis that the workers migrate into more formal and stable employments. Thus, the sectors agriculture (S1), transport equipment (S15) and energy (S18) suggest itself as new fields of activity for these workers since they denote the greatest increases in the factor labor. In the end, the factor capital appears more abundant than the factor labor. Therefore, the result of the model implies a fall of 8% in the labor price. Consequently, the factor capital becomes scarcer in relation to the factor labor and therefore the remuneration increases. Finally, the revaluation of that labor leads to a reduction of the unemployment rate.

Conclusions

- The results of the GEM applied concerning the main – variables imports, exports, and domestic production – are consistent with the target of refinery matrix change and in line with official estimates. The study at hand is introducing the first appraised analysis of the Ecuadorian governmental policy which is considering all relevant actors of the Ecuadorian economy.
- The change in the refining structure of Ecuador would imply a reduction in the unemployment rate, GDP growth and a decrease in the price index. Hence, there is real economic growth.
- In nominal terms, the income of households and government would decrease. Nevertheless, since prices of goods and services would have a greater reduction than the incomes, in relative terms they do not. Therefore, in the Ecuadorian economy would denote a greater consumption by the households.
- Given that, there is a fall in the price of the factor capital in comparison to the factor labor, labor would be revalued and consequently, there would be an improvement in the quality of life for the workers.
- Purchasing power of the families would increase, but a significant part of this growth would go to the transport sector. Hence, it would be advisable for the government to establish policies to encourage consumption in sectors that generate greater added value, for example in the industrial sector.

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