Energy Prices and Competitiveness in Latin American Emerging Economies

Jorge Torres-Zorrilla[1], **Jorge B. Guillén**[2]

[1] *CENTRUM-Católica, Lima, Peru*

[2] *Universidad ESAN, Lima, Peru*

Abstract This paper presents an evaluation of the impact of international oil prices on the competitiveness of three emergent economies in Latin America. We use the methodology of input-output tables for: Peru, Chile and Colombia. Recent outstanding macroeconomic performance of these three emergent countries caused an increase in their demand for energy, which deepened their trade deficit of oil. The effects of high petroleum prices are divided into (a) the impact on costs of new energy prices and (b) the impact on competitiveness. The main conclusion is that energy inputs today constitute the most important cost for industries in Peru, Chile, and Colombia. We recommend some policies for energy efficiency that are consistent with the competitiveness of these three emerging market economies.

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JEL Classification H00, H20, H30, Q20, Q40.

Correspondence to: Jorge B. Guillén (e-mail: jguillen@pucp.edu.pe)

1. Introduction and Objectives

Our paper follows the green environmentalist approach[1] because we are looking for an efficient energy system that, at the same time, promotes a competitive industry for our sample of developing countries. However, we stress the necessity of a reduction of taxes without reducing the optimal social level of pollution[2] and, therefore, set up a competitive framework of industries in the emerging economies.

Decision makers are confronted today with the sustainability issue. Management decisions will always have impacts on energy efficiency, emissions and carbon footprints, impacts on ecosystems, and greenhouse gases. Increasingly, ecological impacts will be the criteria by which decisions will be judged in the future. This paper seeks to make a contribution to green management in emerging economies by focusing on the need for clean energy efficiency in the coming years.

According to DeCanio and Watkins (1998), investment in energy efficiency would encourage any project with positive net present value undertaken by a firm. This idea is in line with Bernanke (1983), Kester (1984), and Dixit and Pindick (1994).

Our study sheds light on a fair system of taxes by suggesting how oil taxes cause domestic firms to lose competitiveness. The public finance school proposes that optimal taxation must consider the inverse-elasticity rule which states that tax rates should be inversely proportional to their elasticity of demand; goods for which demand is inelastic (such as gas or oil) should have a high tax rate since changing their prices does not create much distortion[3] (Slemrod, 1990).

[1] For a detailed explanation of this approach, see Frohwein and Hansjürgens (2005).
[2] For instance, the excessive tax on oil in our sample of developing countries was not created for environmental purposes. The emission of gases within our sample countries is lower than that of industrialized economies which contrast with the tax system between these groups of countries.
[3] This is the Ramsey Rule.

Conversely, the government should set lower tax rates on price-elastic goods since small price changes may create large distortions in the quantity demanded.

Many critics of the latter point of view argue that Ramsey´s optimal rule of taxation brings efficiency instead of equity. According to opponents of Ramsey´s rule, governments may end up imposing a heavy tax on necessities such as food. In this way, a policymaker who relies on taxing oil will also sacrifice inequality for efficiency in the management of government income.

Diamond (1975) tried to solve the puzzle of inequality with a modified version of Ramsey's rule. He concluded that equity can be introduced into the optimal commodity tax system by having higher taxes on the goods consumed predominantly by the rich.

The latter model is very difficult to apply in practice and, specifically, for our study because oil is used by the rich and the poor. We are not attempting to study equity, but previous discussion in the literature reveals the impossibility of following the optimal tax approach.

When the aim is to combat pollution, Pigouvian taxes are very popular. Fullerton and Wolverton (2005) demonstrated the equivalence between the Pigouvian tax and the combination of a presumptive tax and an environmental subsidy (two-part instrument). However, in the case of car emissions, Fullerton and West (2000) proved that a Pigouvian tax does not improve welfare to the same extent as alternative instruments such as uniform taxes on gas, engine size, and the age of a car. Agostini *et al.* (1992) said that a uniform carbon tax was not optimal, and they argued that environmental policy should be designed taking into account the specific economic situation and technological choices of each country[4].

We may infer that there is no optimal instrument that can assure reduction of tax on gas and improved welfare. In our study, we focus attention on the impact

[4] The approach of Agostini *et al.* (1992) is similar to ours.

of taxes on competitiveness. Authors such as Knoll (2006) have described two models of competitiveness called the conduit or new money and the investor or old money models. For Knoll, a neutral tax system does not change the relative valuation of any investment. In a later analysis, Tannenwald (2004) emphasized the need to set up a tax system that promotes competitiveness in Massachussets.

We follow the latter idea because oil and energy prices have increased dramatically in recent years (IMF, 2008)[5]. As a result, analysts have observed that energy is becoming the most important and expensive input for all industries in emerging economies. The latter situation may affect competitiveness.

The primary objective of the paper is to estimate the present magnitude of energy inputs for industrial sectors of a group of economies in South America. To achieve this goal, we use the methodology of input-output tables (Miller and Blair, 1985) for three emerging economies in Latin America: Peru, Chile and Colombia. The methodology can receive many critics but there is not a unique estimation that may capture the effect of oil shock on industry cots or competitiveness.

The increase in the price of oil also implies substantial increases in the price of all energy sources, including electricity. Some issues limit our input-output methodology to estimate impacts of international commodity prices, in general, and oil prices, in particular. Some authors argue that impacts in domestic process are not linearly related to changes in world commodity prices. Regarding the later issue, there is an interesting analysis in the literature, for instance, Bernanke, Gertler and Watson (1997) using a VAR methodology, conclude that the effect of oil shock prices in the economy comes from a tight of monetary policies instead of the shock per se. In addition to the later analysis, Hamilton (2003) examines the nonlinearity between oil price changes and GDP. For him, increasing oil prices

[5] In particular, in our sample of countries, the price has increased significantly because of the high taxes on oil.

affect more than its reduction. He claims that oil price increases disrupt spending of consumer and firms on certain sectors.

However, for Hamilton and Herrera (2004) the study of Bernanke, Gertler and Watson (1997) underestimates the effect of oil shock prices in their VAR analysis. An evidence of the last claim comes from prolonged effect of an oil shock after three or four quarters. Also, Huntington (2004) finds a significant relationship between the impacts of an oil shock specifically when the economy is operating to its full-employment level prior to the disruption.

By the other side, Hunt (2006)[6] captures both the supply of, and demand for, energy in a way to consider many of the major economic channels through which energy influences the economy. The simulation results suggest that the acceleration in energy prices alone cannot account for the stagflation experienced throughout the 1970s.

Like Hamilton (2003), Jimenez-Rodriguez and Sanchez (2005) find a non linear relationship between inflation and GDP. They also claim that oil importing countries have negative effect on the economy after a shock in oil prices. In a theoretical and empirical analysis, Jones, D.W., P.N. Leiby, and I.K. Paik (2004) show how asymmetric intra and intersectoral reallocations pops up in response to oil price shocks.

We intend to test the hypothesis that energy has become the most important input for industries today, especially for emerging economies.

The paper is organized as follows: the next sections evaluate the costs associated with new energy prices in Peru, Chile and Colombia and provide an analysis of the impact of those costs on competitiveness. The final section presents some conclusions and recommendations.

[6] He used a Global Economic Model (GEM).

2. Impact of New Energy Prices on Costs in Peru, Chile and Colombia

The section presents estimations of the impact of new energy prices, applying the input-output methodology[7]. We first evaluate the cost pressures on each country and then use this as a primary step to calculate the impact of new energy prices on these economies.

2.1. Cost Pressures in Peru

Unfortunately, the Peruvian input-output matrix was estimated by Instituto Nacional de Estadística e Informática for the base year 1994 (INEI, 2000). Some economists consider this matrix obsolete, 14 years later, especially because the oil price averaged only $16 per barrel in world markets in 1994 (IMF, 2008).

On the other hand, we have an updated input-output table for Peru for 2002 (MINCETUR, 2006). The average world price for oil in 2002 reached $25 a barrel (IMF, 2008), which is still low compared to today standards. Nevertheless, we use the 2002 input-output matrix to present calculations of the impact of oil price on costs[8].

To initiate the analysis, we follow the input-output model to state that an estimate of a new level of prices at the sector level is given by the following formula:

$$\triangle P_j = \triangle P_{energy} \cdot (I - A)^{-1} \quad (1)$$

[7] During 2007 and the first half of 2008, the World has witnessed a spectacular increase of oil prices that precede a significant decrease in the second half of 2008, variations caused by the international financial crisis. However, the real fact is that the fundamentals of the oil market are that supply is being reduced due to resource depletion. Within the next few years, we will see a constant oil prices increase. The return of $100-a-barrel-prices will be a consequence of the inevitability of oil depletion. The validity of this paper is guaranteed in spite of the actual low prices.

[8] The input-output model of economics is a matrix representation of a country's economy. It is used to estimate the effect of changes in one industry on others.

where $(I - A)^{-1}$ is the original inverse input-output matrix, $\triangle P_{energy}$ is a row-vector with the increase in the price of energy, and $\triangle P_j$ is a row-vector with the resultant increase in the prices of all sectors.

To make this model work for the Peruvian case, we assume that the new price of energy will be reflected on an initial 100%[9] increase in the oil price[10]. Then we compute the price variable. The sectors that will be most affected by this increase are given in Table 1.

Table 1: Impact of the oil price: first round. *Source: Estimations from input-output table, Peru 2002 (MINCETUR, 2006).*

Sector	**Impact %**
Refined petroleum	100
Fishing	8
Transport	8
Iron & steel	5
Non-metals	5
Fishmeal	4
Non-ferrous metals	4
Chemicals	4
Electricity & water	3

Table 1 shows that the sectors most affected are refined petroleum (gas & diesel) with 100% increase. The impact is also significant for sectors with a high fuel-component in their costs such as fishing (8%) and transport (8%), iron and steel (5%), and non-metal industries (5%). Electricity only increased by 3% because thermal electricity generation was not important in 2002.

However, oil prices have not increased by merely 100% from 2002 to today (2008). Prices have quadrupled from $25 a barrel to over $100 a barrel in 2008.

[9] To make this matrix comparable to today's prices and also to the matrices of other countries, we have to do some modifications.
[10] This is a step-by-step methodology.

This increase represents an increase of over 300%. A naive observation would be that we have to triple the values of Table 1, to go from a 100% effect to a 300% effect.

Unfortunately, the input-output model assumes constant technical coefficients. Therefore, the model should only be applied to estimate marginal changes in all variables. However, increases of 100%, 200%, or 300% of a key input, such as petroleum, definitely change the technical coefficients. Therefore, impact analysis of a second 100% increase will require a previous adjustment of all input-output coefficients, which is far beyond the scope of our study.

What we can do here is to make an assumption for a second-round impact analysis. Note that this means a re-estimation of the new effects of oil prices, *over and above the values in Table 1.*

In this case, we assume that only the fuel coefficients change for every sector of the input-output matrix, and they approximately double their value. This means an increase in total costs without changing other coefficients, assuming that profits (or other items) decrease by the same amount. This new technical coefficients matrix is used for the second round.

An estimate of a new level of the coefficient of the energy input at the sector level is given by the following formula:

$$A_{ij} = a_{ij} \frac{P_{energy}}{P_{product}} \tag{2}$$

Where a_{ij} is the original input-output energy coefficient, A_{ij} is the new input-output energy coefficient, P_{energy} is the new price of energy, and $P_{product}$ is the new price of the sector j being analyzed.

Table 2 provides the impact on prices of a second-round 100% oil price increase, estimated with the adjusted matrix. Note that oil prices grow from 1 to 2 in round one and from 2 to 4 in round two. This is equivalent to the increase from \$25 to \$100 per barrel. Table 2 reviews the effects of this increase.

Table 2: Impact of the oil price: second round. *Source: Estimations from input-output table, Peru 2002 (MINCETUR, 2006).*

Sector	**Impact 1**	**Impact 2**	**Accumulated**
Refined petroleum	100	100	300
Fishing	8	16	25
Transport	8	15	24
Iron & steel	5	11	16
Non-metals	5	10	15
Fishmeal	4	7	11
Non-ferrous metals	4	7	11
Chemicals	4	7	11
Electricity & water	3	7	10

In summary, for the second round, we increase coefficients to approximately double, leaving unchanged all other coefficients; then, we estimate a second impact of 100% increase in oil prices; and finally, we accumulate the two rounds.

The sector affected most is refined petroleum (300%). Then we have fishing (25%), transport (24%), iron and steel (16%), non-metals (15%), and electricity (10%). Note that these estimates assume a full impact on domestic fuel prices and the removal of all subsidies that are still present in the Peruvian domestic market.

2.2. Magnitude of the Energy Input in Peru

Now we are ready to estimate the present level of energy inputs in the Peruvian economy. Note that the high oil price also implies substantial increases in the price of all energy sources, including electricity. The thesis is that energy has become the most important input for all industries, especially in emerging economies. We define energy inputs as the sum of fuels + electricity[11] (sectors 22 & 32 of

[11] The methodology of the United Nations is used to label the sectors. The same sectors apply to each country.

the Peruvian input-output matrix). Remember that the new coefficient of energy input A_{ij} is estimated from the formula:

$$A_{ij} = a_{ij} \frac{P_{fuels}}{P_{product}} \quad (3)$$

After round two, a second 100% increase in oil price, the magnitude of the energy input for all sectors is presented in Table 3.

Table 3: (Peru) Magnitude of energy input after 300% increase in oil prices[12].

Sectors	Original fuel input	New fuel price	New output price	New fuel input	New energy input	New energy input (% of costs)
1 Agriculture	0.0018	4.00	1.0233	0.0070	0.0077	0.0229
2 Fishing	0.0798	4.00	1.2624	0.2529	0.2529	0.5916
3 Petroleum, crude	0.0121	4.00	1.0690	0.0452	0.0532	0.1335
4 Mining	0.0175	4.00	1.0924	0.0642	0.1049	0.2731
5 Dairy products	0.0075	4.00	1.0700	0.0281	0.0325	0.0443
6 Fish, prepared	0.0057	4.00	1.0863	0.0209	0.0259	0.0520
7 Fishmeal	0.0077	4.00	1.1071	0.0278	0.0337	0.0788
8 Cereal grains, milled	0.0068	4.00	1.0571	0.0256	0.0390	0.0580
9 Sugar	0.0174	4.00	1.0842	0.0643	0.0710	0.0950
10 Other food	0.0029	4.00	1.0472	0.0110	0.0174	0.0229
11 Beverages, tobacco	0.0101	4.00	1.0894	0.0371	0.0596	0.0942
12 Textiles	0.0039	4.00	1.0477	0.0148	0.0308	0.0464
13 Wearing apparel	0.0014	4.00	1.0388	0.0052	0.0126	0.0226
14 Leather products	0.0052	4.00	1.0676	0.0195	0.0346	0.0423
15 Footwear	0.0028	4.00	1.0544	0.0106	0.0167	0.0263
16 Wood products	0.0070	4.00	1.0820	0.0258	0.0431	0.0602
17 Paper products	0.0110	4.00	1.0828	0.0406	0.0859	0.1342
18 Publishing	0.0043	4.00	1.0560	0.0161	0.0320	0.0551
19 Chemicals	0.0213	4.00	1.1108	0.0767	0.1352	0.2504
20 Pharmaceuticals	0.0011	4.00	1.0485	0.0041	0.0088	0.0183
21 Other chemicals	0.0042	4.00	1.0597	0.0160	0.0285	0.0494
22 Petroleum, refined	0.0015	4.00	4.1087	0.0015	0.0022	0.0029
23 Rubber, plastics	0.0082	4.00	1.0763	0.0305	0.0566	0.0864

[12] The labels of each sector follow the methodology of United Nations, and this applies to each country.

Table 3: (continuation).

24 Non-metals	0.0301	4.00	1.1487	0.1048	0.1687	0.2769
25 Iron & steel	0.0348	4.00	1.1742	0.1187	0.1596	0.2303
26 Non-ferrous metals	0.0091	4.00	1.1132	0.0327	0.0683	0.0805
27 Metal products	0.0054	4.00	1.0840	0.0201	0.0324	0.0592
28 Machinery n.e.d	0.0119	4.00	1.1010	0.0434	0.0550	0.0853
29 Machinery E.	0.0077	4.00	1.0818	0.0285	0.0445	0.0680
30 Transport equipment	0.0061	4.00	1.0906	0.0222	0.0399	0.0553
31 Other manufactures	0.0059	4.00	1.0708	0.0222	0.0400	0.0683
32 Electricity & water	0.0265	4.00	1.1021	0.0960	0.1175	0.4014
33 Construction	0.0098	4.00	1.0843	0.0361	0.0375	0.0713
34 Commerce	0.0027	4.00	1.0493	0.0102	0.0224	0.0767
35 Transports	0.0688	4.00	1.2488	0.2204	0.2259	0.4139
36 Services, financial	0.0012	4.00	1.0273	0.0046	0.0206	0.0658
37 Insurance	0.0012	4.00	1.0175	0.0047	0.0064	0.0115
38 Rental	0.0000	4.00	1.0055	0.0000	0.0000	0.0000
39 Services, enterprises	0.0035	4.00	1.0303	0.0134	0.0246	0.0702
40 Restaurants, hotels	0.0039	4.00	1.0435	0.0149	0.0234	0.0513
41 Services, households	0.0013	4.00	1.0231	0.0051	0.0110	0.0369
42 Services, households	0.0048	4.00	1.0633	0.0179	0.0277	0.0415
43 Health, private	0.0016	4.00	1.0259	0.0062	0.0199	0.0521
44 Education, private	0.0061	4.00	1.0353	0.0234	0.0373	0.1546
45 Government	0.0096	4.00	1.0489	0.0367	0.0485	0.1677

The first column is the original energy input as a percentage of the gross value of output of every sector (the original input-output coefficient). The second and third columns are the price index of fuels and the price indexes of the different sectors (accumulated for first and second rounds). The fourth column is the new input-output coefficient after second round. This new coefficient A_{ij} is our objective and is estimated from the formula above. Note that the oil price index is now 4.00. That is, in round one, it goes from 1 to 2, and in round two, from 2 to 4.

The final result is that the simple average of the new energy input is 6% for the goods-producing sectors 1 to 32. Note that this figure is a percentage of gross value of output (GVO). In order to express this as a percentage of production costs, we must discount value added (VA) from the GVO. Since the average

VA coefficient is about 50%, the energy input is about 12% of total costs of production.

Of course, for some sectors, the new energy input reaches a greater level as a percentage of costs (see seventh column of Table 3). The highest values are for fishing (59% of costs), transport (41%), electricity (40%), mining (27%), non-metal products (28%), chemicals (25%), and iron and steel (23%). The final result is that the simple average of the new energy input is 12% for all goods-producing sectors.

A conclusion of the above analysis is that energy inputs today constitute the most important cost for industries in Peru. This may be asserted because the total sales of energy (sum of the "fuels and electricity" rows from the input-output matrix) are greater that intermediate sales of other sectors of the matrix.

2.3. Cost Pressures in Chile

The input-output matrix for Chile was estimated by Banco Central de Chile (2008) for the base year 2003. Remember that oil prices averaged $29 per barrel in world markets in the year 2003 (IMF, 2008) and that this price was still low compared to standards of today. We use this 2003 input-output matrix to present calculations of impact of price increases on costs in Chile.

To initiate the analysis, we use the previously presented formula 1 to estimate a new level of prices at the sector level.

We apply the model to Chile in two steps as we did in the calculations for Peru. We assume that the new price of energy will be reflected on an initial 100% increase in the oil price. Then, we compute the price effects. The ranking of sectors most affected by this increase is given in Table 4.

However, again, as in the Peruvian case, oil prices have not increased by merely 100% from 2003 to 2008. Prices have more than tripled from $29 a barrel to over $100 a barrel in 2008. This increase represents an increase of about 250%.

Table 4: Impact of the oil price: first round. *Source: Estimations from input-output table, Chile 2003 (Banco Central de Chile, 2008.*

Sector	**Impact %**
Fuels	100
Passenger transport	15
Truncking	13
Rail transport	9
Agriculture	8
Sugar	6
Air transport	6
Fruits	5
Coal	4
Milling	3

As before, a naive observation would be that we have to multiply the values of Table 1 by 2.5 to go from a 100% effect to a 250% effect.

The input-output model assumes constant technical coefficients, and therefore, the model should only be applied to estimate marginal changes in all variables. An oil price increase of 250% definitely changes the technical coefficients. Therefore, impact analysis of a second increase will require a previous adjustment of all input-output coefficients, which is far beyond the scope of this preliminary study.

What we do here is to make the same assumption as before for a second-round impact analysis. Note that this means a new estimate of the effect of oil prices, over and above the values in Table 4. We assume that only the fuel coefficients change, for every sector of the input-output matrix, and they approximately double their value. This means an increase in total costs without changing other coefficients, assuming that profits or other items decrease by the same amount. This new technical coefficients matrix is used for the second round.

We use the same formula (2) to estimate a new coefficient of the fuel-energy input at the sector level as in the previous case.

Table 5 provides the impact on prices of a second-round 75% oil price increase. Note that oil prices increased from 1 to 2 in round one and from 2 to 3.5 in round two. This is equivalent to the increase from $29 to $102 per barrel[13].

Table 5: Impact of oil price: second round. *Source: Estimations from input-output table, Chile 2003 (Banco Central de Chile, 2008).*

Sector	**Impact 1**	**Impact 2**	**Accumulated**
Fuels	100	75	250
Passenger transport	15	22	40
Trucking	13	20	36
Rail transport	9	13	23
Agriculture	8	12	21
Sugar	6	9	16
Air transport	6	9	16
Fruits	5	7	12
Coal	4	6	10
Milling	3	4	7

In summary, for round two, we increase coefficients to approximately double, leaving unchanged all other coefficients; then, we estimate a second impact of 75% in oil prices; and finally, we accumulate the two rounds.

The sector most affected is again refined petroleum (250%), followed by passenger transport (40%), trucking (36%), rail transport (23%), agriculture (21%), sugar (16%), and air transport (16%). Electricity only increased by 2% (see Table 5).

2.4. Magnitude of the Energy Input in Chile

Now, we are ready to estimate the present level of energy inputs in the Chilean economy. Note that, in the case of Chile, the high oil price does not imply substan-

[13] For the Peruvian case, this factor is higher because the input-output matrix for the Chilean case refers to the year after the Peruvian one.

tial increases in the price of electricity. Nevertheless, we add fuel and electricity inputs to estimate total energy inputs.

The new coefficient A_{ij} is again estimated from the formula (3) used before. After round two, a second increase in oil price, the magnitude of the energy input for all sectors is presented in Table 6.

Table 6: Chile: Magnitude of energy input after 250% increase in oil prices.

	Sectors	**Original fuel input**	**New fuel price**	**New output price**	**New fuel input**	**New energy input**	**New energy input** (% of costs)
1	Agriculture	0.0353	3.50	1.1054	0.1118	0.1263	0.3110
2	Fruits	0.0294	3.50	1.0846	0.0949	0.1005	0.3426
3	Livestock	0.0086	3.50	1.0484	0.0287	0.0446	0.0854
4	Forestry	0.0173	3.50	1.0495	0.0577	0.0598	0.3267
5	Fishing	0.0372	3.50	1.1147	0.1168	0.1198	0.2847
6	Coal mining	0.0023	3.50	1.0388	0.0077	0.0910	0.1384
7	Crude petroleum	0.0092	3.50	1.0323	0.0312	0.0314	0.0925
8	Ferrous mining	0.023	3.50	1.0677	0.0754	0.1574	0.3697
9	Copper mining	0.0143	3.50	1.0496	0.0477	0.1026	0.2689
10	Other mining	0.0152	3.50	1.0566	0.0503	0.0807	0.2072
11	Meat industry	0.0018	3.50	1.0338	0.0061	0.0112	0.0170
12	Fishing industry	0.0215	3.50	1.0995	0.0684	0.0779	0.1367
13	Fish, prepared	0.0055	3.50	1.0502	0.0183	0.0266	0.0438
14	Edible oils	0.0091	3.50	1.0500	0.0303	0.0398	0.0857
15	Dairy	0.0035	3.50	1.0356	0.0118	0.0210	0.0334
16	Milling	0.0005	3.50	1.0424	0.0017	0.0131	0.0242
17	Animal feed	0.0018	3.50	1.0490	0.0060	0.0118	0.0187
18	Bread industry	0.0108	3.50	1.0475	0.0361	0.0496	0.0910
19	Sugar	0.0007	3.50	1.0483	0.0023	0.0073	0.0138
20	Food products, diverse	0.0022	3.50	1.0226	0.0075	0.0143	0.0325
21	Alcohol & spirits	0.0039	3.50	1.0449	0.0131	0.0189	0.0308
22	Wine	0.0013	3.50	1.0323	0.0044	0.0085	0.0151
23	Beer	0.0041	3.50	1.0258	0.0140	0.0270	0.0509
24	Non-alcoholic beverages	0.0012	3.50	1.0208	0.0041	0.0246	0.0441
25	Tobacco	0.0043	3.50	1.0296	0.0146	0.0182	0.0356
26	Textile products	0.0042	3.50	1.0178	0.0144	0.0322	0.0979
27	Wearing apparel	0.002	3.50	1.0135	0.0069	0.0192	0.0483
28	Leather	0.0038	3.50	1.0201	0.0130	0.0247	0.0631
29	Footwear	0.0012	3.50	1.0119	0.0042	0.0123	0.0306

Table 6: continuation.

30	Wood products	0.0047	3.50	1.0396	0.0158	0.0350	0.0690
31	Paper products	0.0103	3.50	1.0499	0.0343	0.0576	0.1148
32	Printing	0.0011	3.50	1.0146	0.0038	0.0116	0.0318
33	Fuels	0.002	3.50	3.5200	0.0020	0.0056	0.0341
34	Basic chemicals	0.0082	3.50	1.0309	0.0278	0.0514	0.1552
35	Other chemicals	0.0033	3.50	1.0163	0.0114	0.0156	0.0513
36	Rubber products	0.0038	3.50	1.0160	0.0131	0.0278	0.0824
37	Plastics	0.0023	3.50	1.0145	0.0079	0.0276	0.0806
38	Glass products	0.0277	3.50	1.0770	0.0900	0.1159	0.4240
39	Other non-metal products	0.0233	3.50	1.0810	0.0754	0.0985	0.2303
40	Iron & steel	0.0049	3.50	1.0231	0.0168	0.0587	0.1963
41	Non-ferrous metals	0.0042	3.50	1.0269	0.0143	0.0296	0.0722
42	Metal products	0.0039	3.50	1.0184	0.0134	0.0275	0.0855
43	Non-electric machinery	0.0033	3.50	1.0168	0.0114	0.0243	0.0641
44	Electric machinery	0.0036	3.50	1.0214	0.0123	0.0312	0.0713
45	Transport equipment	0.0035	3.50	1.0145	0.0121	0.0182	0.0650
46	Furnitures	0.0026	3.50	1.0206	0.0089	0.0205	0.0472
47	Other manufacturing	0.0023	3.50	1.0139	0.0079	0.0182	0.0542
48	Electricity	0.0102	3.50	1.0420	0.0343	0.3573	0.7821
49	Gas	0.0718	3.50	1.1922	0.2108	0.2207	0.4345
50	Water	0.0028	3.50	1.0129	0.0097	0.0438	0.1682
51	Construction	0.0085	3.50	1.0350	0.0287	0.0314	0.0829
52	Trade	0.0016	3.50	1.0214	0.0055	0.0198	0.0453
53	Hotels	0.0073	3.50	1.0324	0.0247	0.0409	0.1027
54	Restaurants	0.0028	3.50	1.0292	0.0095	0.0212	0.0398
55	Rail transport	0.0725	3.50	1.1981	0.2118	0.2694	0.5010
56	Passenger transport	0.1424	3.50	1.3636	0.3655	0.3683	0.9334
57	Truck transport	0.1213	3.50	1.3132	0.3233	0.3257	0.7703
58	Sea transport	0.0091	3.50	1.0339	0.0308	0.0315	0.1169
59	Air transport	0.0367	3.50	1.0999	0.1168	0.1195	0.4351
60	Other transport activities	0.0056	3.50	1.0286	0.0191	0.0312	0.0740
61	Communications	0.0008	3.50	1.0113	0.0028	0.0096	0.0293
62	Finance	0.001	3.50	1.0124	0.0035	0.0105	0.0369
63	Insurance	0.0002	3.50	1.0064	0.0007	0.0049	0.0148
64	Real estate activities	0.002	3.50	1.0119	0.0069	0.0266	0.1359
65	Services to firms	0.0056	3.50	1.0241	0.0191	0.0353	0.1156
66	Property, housing	0.0004	3.50	1.0043	0.0014	0.0036	0.0375
67	Public administration	0.0039	3.50	1.0198	0.0134	0.0315	0.1148
68	Public education	0.0018	3.50	1.0082	0.0062	0.0134	0.1315
69	Private education	0.0014	3.50	1.0093	0.0049	0.0108	0.0536

Table 6: continuation.

70	Public health	0.0023	3.50	1.0111	0.0080	0.0131	0.0671
71	Private health	0.0008	3.50	1.0053	0.0028	0.0064	0.0423
72	Entertainment activities	0.0014	3.50	1.0163	0.0048	0.0191	0.0508
73	Other services	0.0086	3.50	1.0327	0.0291	0.0370	0.1280

The first column is the original fuel input as a percentage of gross value of output of every sector (the original input-output coefficient). The second and third columns are the price index of fuels and the price indexes of the different sectors (accumulated for first and second rounds). The fourth column is the new input-output coefficient after second round. This new coefficient A_{ij} is our objective, and it is estimated from the formula above. Note that the oil price index is now 3.5. That is, in round one, it increased from 1 to 2 and in round two, from 2 to 3.5.

The final result is that the simple average of the new energy input is 6% for all goods-producing sectors 1 to 51 (as a percentage of GVO). To express this as a percentage of costs, we discount value added from the GVO.

Of course, for some sectors, the new energy input reaches a greater level as a percentage of costs (see seventh column of Table 6). The higher values are for passenger transport (93% of costs), truck transport (77%), electricity (78%), rail transport (50%), air transport (44%), and Gas (44%). The final result is that the simple average of the new energy input is 13% for all goods-producing sectors 1 to 51.

This result goes along the line of De Miguel, O'Ryan, Pereira and Carriquiri (2006) who studied in a General Equilibrium Model how oil price increase and the restrictions to natural gas imports from Argentina affect negatively the Chilean economy. They analyze quantitatively the direct and indirect effects of these international shocks. They also claim that policies that promote alternative use of energy will offset the negative effects on high oil prices. However, they also explain how their methodology has the problem of ignoring the consumer preferences, transmission channels that cannot be captured.

As in the Peruvian case, the conclusion of our above analysis is that fuels and energy inputs today constitute the most important cost for industries in Chile. That is, the total sales of energy are greater that intermediate sales of other sectors of the matrix.

2.5. Cost Pressures in Colombia

The input-output matrix for Colombia was estimated by Departamento Administrativo Nacional de Estadísticas for the base year 2006 (DANE, 2008). The oil price averaged $64 per barrel in world markets in the year 2006 (IMF, 2008). Although this price is less than the standard price as of today, the case is different from the cases for Peru and Chile. In this case, we do not need to re-estimate new energy coefficients to refine cost-price estimations, and we directly use the 2006 input-output matrix to make calculations.

To initiate the analysis, we use the previously presented formula (1) to estimate a new level of prices at the sector level.

As observed, we apply the model to Colombia in one step, contrary to the cases for Peru and Chile[14]. We assume that the new price of energy will be based on a final 60% increase of the oil price. Then, we compute the price effects. The ranking of sectors most affected by this increase is given in Table 7.

The sectors for which the impact is greatest would be fuels with a 60% increase and other sectors with a high fuel-component in their costs. These are sea transport (28%), air transport (16%), and road and rail transport (16%). The impact is also significant for fishing (9%), metal mining (9%), non-metal mineral products (7%), coal (7%), and sugar (4%). Note that electricity increases by

[14] This is because the input-output matrix for the Colombian case uses the base year 2006.

Table 7: Impact of oil price. *Source: Estimations from input-output table, Colombia 2006 (DANE, 2008).*

Sector	**Impact %**
Refined petroleum	60
Sea & water transport	28
Air transport	16
Road & rail transport	16
Fishing	9
Metal mining	9
Miscellaneous manufacturing	7
Non-metal mineral products	7
Coal	7
Sugar	4

less than 1%; this reflects the fact that thermal generation is not important in Colombia.

Remember that the input-output model assumes constant technical coefficients, and therefore, the model should only be applied to estimate marginal changes in all variables. However, the oil price increased 60%, and this is not a marginal change. Nonetheless, we assume that changes in the technical coefficients are not as high as that, and we do not make an adjustment of the input-output coefficients.

2.6. Magnitude of the Energy Input in Colombia

Now, we are ready to estimate the present level of energy inputs in the Colombian economy. In this case, we also add fuel and electricity inputs to estimate total energy inputs.

The new coefficient A_{ij} is again estimated from the formula (3) presented previously. The magnitude of the energy input for all sectors is presented in Table 8.

Table 8: Colombia: Magnitude of energy input after 60% increase in oil prices.

	Sectors	Original fuel input	New fuel price	New output price	New fuel input	New energy input	New energy input (% of costs)
1	Coffee	0.0044	1.6	1.0101	0.0070	0.0087	0.0431
2	Other agricultural products	0.0098	1.6	1.0160	0.0154	0.0172	0.0565
3	Live animals & products	0.0088	1.6	1.0130	0.0139	0.0167	0.0565
4	Forestry products	0.0065	1.6	1.0212	0.0102	0.0177	0.0742
5	Fishing	0.1051	1.6	1.0760	0.1563	0.1630	0.5402
6	Coal	0.0808	1.6	1.0649	0.1214	0.1300	0.3018
7	Crude petroleum & Gas	0.0000	1.6	1.0091	0.0000	0.0017	0.0085
8	Metal mining	0.1098	1.6	1.0761	0.1633	0.1926	0.6168
9	Non-metal mining	0.0249	1.6	1.0195	0.0390	0.0472	0.3079
10	Meat & fish	0.0042	1.6	1.0188	0.0066	0.0127	0.0159
11	Vegetable oils	0.0201	1.6	1.0353	0.0311	0.0417	0.0523
12	Dairy products	0.0036	1.6	1.0187	0.0056	0.0165	0.0214
13	Grain milling	0.0088	1.6	1.0232	0.0137	0.0221	0.0300
14	Coffee products	0.0062	1.6	1.0161	0.0098	0.0133	0.0145
15	Sugar	0.0369	1.6	1.0429	0.0566	0.0611	0.0823
16	Cocoa products	0.0089	1.6	1.0278	0.0139	0.0258	0.0375
17	Food products, diverse	0.0178	1.6	1.0357	0.0275	0.0398	0.0540
18	Beverages	0.0154	1.6	1.0321	0.0239	0.0331	0.0568
19	Tobacco products	0.0122	1.6	1.0252	0.0190	0.0229	0.0376
20	Textile fibers & fabrics	0.0197	1.6	1.0366	0.0305	0.0555	0.0772
21	Textile products, except apparel	0.0106	1.6	1.0295	0.0164	0.0326	0.0514
22	Apparel & special textiles	0.0068	1.6	1.0263	0.0106	0.0219	0.0344
23	Leather & products	0.0078	1.6	1.0257	0.0122	0.0248	0.0364
24	Wood products	0.0096	1.6	1.0234	0.0150	0.0316	0.0501
25	Paper products	0.0231	1.6	1.0380	0.0356	0.0517	0.0736
26	Printing & editing	0.0089	1.6	1.0270	0.0138	0.0198	0.0321
27	Refined petroleum	0.0300	1.6	1.6262	0.0295	0.0300	0.0546
28	Chemicals	0.0250	1.6	1.0420	0.0385	0.0488	0.0701
29	Rubber & plastic products	0.0122	1.6	1.0350	0.0188	0.0455	0.0632
30	Non-metal mineral products	0.0777	1.6	1.0708	0.1161	0.1421	0.2408
31	Metal products	0.0146	1.6	1.0385	0.0225	0.0436	0.0647
32	Machinery & equipment	0.0077	1.6	1.0274	0.0119	0.0215	0.0337
33	Other machinery & electric products	0.0114	1.6	1.0288	0.0177	0.0262	0.0441
34	Transport equipment	0.0077	1.6	1.0272	0.0120	0.0157	0.0219
35	Furniture	0.0064	1.6	1.0256	0.0100	0.0188	0.0288
36	Miscellaneous manufacturing	0.0891	1.6	1.0724	0.1330	0.1430	0.2605

Table 8: continuation.

37	Waste	0.0256	1.6	1.0165	0.0402	0.0418	0.9533
38	Electricity	0.0009	1.6	1.0075	0.0014	0.3384	0.6426
39	Gas, homes	0.0300	1.6	1.0291	0.0466	0.0537	0.0848
40	Water	0.0044	1.6	1.0080	0.0069	0.0290	0.1018
41	Construction works, buildings	0.0008	1.6	1.0239	0.0013	0.0013	0.0025
42	Construction works, roads & other	0.0045	1.6	1.0258	0.0070	0.0070	0.0125
43	Trade	0.0057	1.6	1.0160	0.0090	0.0239	0.0712
44	Repare services:automobiles & other	0.0040	1.6	1.0192	0.0062	0.0201	0.0351
45	Hotels & restaurants	0.0043	1.6	1.0175	0.0067	0.0127	0.0220
46	Road & rail transport	0.1988	1.6	1.1321	0.2809	0.2818	0.5534
47	Sea transport	0.4302	1.6	1.2732	0.5406	0.5445	0.8013
48	Air transport	0.2137	1.6	1.1463	0.2983	0.2993	0.4618
49	Services complementary to transport	0.0288	1.6	1.0316	0.0447	0.0671	0.1070
50	Mail & communications	0.0379	1.6	1.0342	0.0587	0.0778	0.1494
51	Financial services	0.0002	1.6	1.0099	0.0003	0.0155	0.0363
52	Real estate services	0.0000	1.6	1.0020	0.0000	0.0001	0.0007
53	Services to firms	0.0067	1.6	1.0134	0.0106	0.0225	0.0676
54	Public administration	0.0123	1.6	1.0156	0.0194	0.0244	0.0646
55	Education services	0.0025	1.6	1.0056	0.0039	0.0104	0.0764
56	Social & health services	0.0166	1.6	1.0260	0.0260	0.0472	0.0916
57	Drainage services	0.0163	1.6	1.0178	0.0256	0.0342	0.0860
58	Entertainment services	0.0058	1.6	1.0110	0.0091	0.0270	0.0607
59	Domestic services	0.0000	1.6	1.0000	0.0000	0.0000	0.0000

The final result is that the simple average of the new energy input is only 5% for all goods-producing sectors 1 to 36. Note that this is a percentage of GVO. In order to express this as a percentage of production costs, we must discount value added (VA) from the GVO. Since the average VA coefficient equals 50%, the energy input is about 10% of total costs of production.

Of course, for some sectors, the new energy input reaches a greater level as a percentage of costs (see eight column of Table 8). The higher values are for sea transport (80% of costs), road-rail transport (55%), air transport (46%), electricity (64%), metal mining (61%), and fishing (54%). The final result is that the simple average of the new energy input is 10% for all goods-producing sectors 1 to 36.

A conclusion of the above analysis is that fuels and energy inputs today constitute the most important cost for industries in Colombia. That is, the total sales of energy are greater that intermediate sales of other sectors of the input-output matrix.

3. Impact on Competitiveness (Costs)

The effects on costs of high petroleum prices on new energy prices were presented in the previous section. The impact of these effects on the competitiveness of the three countries of our sample is discussed here.

First, we have to mention that regarding substitution effects, we explicitly made the assumption that there are no direct substitutes for energy in the industries of the surveyed emerging economies, in the medium term. That is to say, it is not viable to replace other factors instead of energy in response to relative price changes. In fact, other studies demonstrate that the elasticity of substitution between energy and other inputs is low and close to zero in most industries of emerging economies as today. A World Bank study reports that an estimate of the elasticity of substitution between energy and other inputs equals about 0.25 for a three region model of energy international trade (Martin R. and Selowsky M., 1981)

Solving the problem of the last effect, we have to argue that to be competitive[15] in this new age of globalization, whenever energy costs increase and if energy becomes the most important input in manufacturing industries, we worry about the net effects on competitiveness. If we already have competitive advan-

[15] Competitiveness can be captured by two of the most well-known indices: the Global Competitiveness Index prepared by the World Economic Forum and the World Competitiveness Ranking prepared by the World Competitiveness Center of the International Institute for Management Development (IMD), a business school in Lausanne. It includes several items and cost is one of the most important considered in the elaboration of these indexes.

tages for a given industrial product, we should worry if our country is likely to lose that competitive advantage because of the new energy prices.

Second, if energy is the most important input for industries today, we should try to rely on cheap sources of energy. For this, the least we can do is to consider removing all taxes on energy inputs, that is, fuels and electricity. This means that all indirect taxes on fuels must be removed, including general sales taxes and excise taxes.

This set of countries did not find alternatives to gas because their lack of high technology in their firms (Wijetilleke, Lakdasa and Suhashini K., 1995). Consequently, rising oil prices hit harder in emerging economies. These countries are also dependent on oil imports for fuels and also for electricity generation and they do not have nuclear power facilities, wind/solar power infrastructure, as developed countries do. In sum, they will be more affected, in relative terms, in their competitiveness.

Our result goes along the line of Jimenez-Rodriguez and Sanchez (2005) and Jones, Leiby and Paik (2004) because the impact of oil prices affects our set of countries asymmetrically to different sectors. This result is very significant in oil importing countries.

Bacon (1992), concludes that fuel taxes can reduce air pollution cheaply through fuel substitution, depending on how flexible activities are with regard to the fuel used. However, in developing countries there is not much flexibility because of the low technology.

Table 9 shows how the price of gas in other countries can be so low. In the USA, the gas price is US$3.45. In addition, as of July 1, 2008, the average amount of tax imposed on a gallon of gas sold in the United States was 49.4 cents per gallon (API, 2008). We have estimated the distortion of prices for Peru, Chile and Colombia. The distortion of prices, expressed in percentage, measures the difference of consumer price with respect to the same price without taxes. This distortion is 29%, 69% and 7% in Peru, Chile and Colombia respectively. This means that the tax system within this sample of countries is very significant.

If all taxes on fuels are removed, we are not against the pro-environment groups because we try to promote a fair and competitive system for this set of countries without increasing the social cost of pollution[16]. There are developed countries that emit more gases, and they do not have heavy taxes on oil.

Also, many economists (Porter and Claas van der Linde, 1999) argue that if we look for oil substitutes such as ethanol and biodiesel, this will increase competitiveness. Additionally, worries about the environment make biofuels an acceptable alternative of renewable energy. Ethanol is a biofuel that can compete with oil because of accessible technology and low costs (Porter and Claas van der Linde, 1999).

Biodiesel and natural gas are another alternative to fossil oil. Natural gas is very cheap and is used by Europeans (Clementi, 2005). Natural gas does not contain carbon or any other similar particle; it is renewable[17], and therefore, it is not as harmful to the environment as gas[18].

In South America, Venezuela has the largest source of natural gas. Peru has 13 trillion cubic feet–enough to provide the domestic market and exports for decades (Vargas-Llosa, 2008). The same author says that because the government and much of the opposition demonized foreign investment, the exploitation of those reserves began only a few years ago. Therefore, Peru was importing an expensive resource and making its industry less competitive.

[16] Table 10 shows how the per-capita gas emission is high in industrialized countries. Unfortunately, we do not have data for the sample of countries in our study. However, we can infer that their emission of gases would not be comparable to the USA or Western European countries. The 1994 statistics for China are very interesting, and it would be interesting to have up-to-date figures.

[17] When it has this characteristic, it is called natural gas which is a biogas obtained from biomass. By upgrading the quality to that of natural gas, it becomes possible to distribute the gas to customers via the existing gas grid and to burn it in existing appliances.

[18] According to Clementi (2005), Italy has 500,000 vehicles that use natural gas.

The Colombian case is very interesting because there is an impediment to explode exploiting natural gas. According to Caballero and Reinstein (2004), policymakers are responsible for the delay in starting the exploitation of natural gas.

We believe that our study sheds light on the search for alternatives to reduce the size of companies carbon footprints without losing competitiveness among the industries in this particular sample of countries.

Table 9: Ranking of cheapest gas in the world[19]. *Source: Associates for International Research (AIRINC).*

Rank	**Country**	**Price (US$)/gal**
1.	Venezuela	0.12
2.	Iran	0.40
3.	Saudi Arabia	0.45
4.	Libya	0.50
5.	Swaziland	0.54
6.	Qatar	0.73
7.	Bahrain	0.81
8.	Egypt	0.89
9.	Kuwait	0.90
10.	Seychelles	0.98
44.	United States	3.45

4. Conclusions and Recommendations

The effects of the oil price crisis on emerging economies are multiple. The probable effects of an oil price of over $100 per barrel include the following: (a) increase

[19] Prices in US dollars; 155 countries were surveyed between March 17 and April 1, 2008. Prices are not adjusted for cost of living.

[20] The countries in this study do not have data available, but they are not as industrialized as the USA or Western Europe.

Table 10: Gas emission by country[20]. *Source: Carbon Planet.*

Country	**Year**	**CO_2e Mt/person**
Australia	2000	27.54
USA	2002	24.09
Canada	2003	23.45
Russian Federation	1999	12.91
Netherlands	1999	11.02
United Kingdom	2003	11.01
European Union	1999	10.74
Japan	2002	9.65
Mexico	2000	7.04
Hong Kong	2003	6.39
China	1994	3.05
India	2001	1.34

of oil import value and balance-of-payment deficit, (b) cost pressures over all economic sectors, (c) recession, and, most importantly, (d) a negative impact on competitiveness.

We have seen that the impact of the present level of oil prices has been to increase energy costs to 12%, 13%, and 10% for Peru, Chile and Colombia respectively. This summarizes the relevance of the energy cost for these countries today.

Our study goes along the line of Alaimo and Lopez (2008) who find that OECD countries tend to reduce oil intensity which contrast Latin America countries (and more generally for middle-income countries like our sample) where oil intensities appear to be unaffected by oil prices.

Then, competitiveness is affected negatively within this set of countries when there is an increase in the price of energy. We recommend restructuring the existing high oil taxes in these countries in order to make them competitive without leaving aside regulations dealing with the emission of gases.

Alternative policies should promote the establishment of new power sources such as solar, eolic, or tidal energy[21]. These new investments should not alienate us from our goal of better environmental management and will, at the same time, allow the countries in the study to be more competitive.

This paper also seeks to make a contribution to green management in emerging economies by focusing on the need for energy efficiency in the coming years. There are many methodologies that can measure the impact of an oil price increase on the economy: Panel Regressions, General Equilibrium Models or Input Output Matrix. The latter methodologies have some advantages and disadvantages in getting the real impact without ignoring channel transmission, consumer preferences and producer abilities to change their source of energy.

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[21] Along this line Porter, M. and Claas van der Linde (1995) illustrates some energy-saving investment in the US. The use of alternative use of energy has been restricted in Chile and Colombia (see De Miguel, O'Ryan, Pereira and Carriquiri (2006) and Caballero and Reinstein (2004).

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