Dutch disease, informality, and employment intensity in Colombia

Abstract

From the first half of the 2000s until 2014 the Colombian economy was under the influence of an oil and mining production and export boom that triggered the potential for Dutch Disease effects. As the boom has the potential to induce shifts in the sectorial composition of the economy, it may have significant effects on employment dynamics and on the evolution of employment intensity, especially when the informal sector is sizable. We study the potential effects of this boom, had it extended as forecasted by 2011. For this, we use a recursive dynamic computable general equilibrium model, calibrated to a 2011 Social Accounting Matrix of the Colombian economy, in which activities are differentiated in terms of their formal and informal components, and suitable details are included to account for the stream of income the government receives from the booming activities. We find that the resource shift and spending effects from the boom are sizeable, leading to a relative drop in exports in non-boom sectors and to shrinking output for most sectors of the economy, while employment in the formal sector and for skilled workers is favored. Furthermore, we find that the policy package designed by the Colombian government to face potential Dutch Disease effects on the economy has a limited impact on improving the resource shift and spending effects.

JEL: O19; F17; C68.
Keywords: Exports, Terms of Trade, Dutch Disease, CGE modeling, Colombia

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Acknowledgements

This research work was carried out with financial and scientific support from the Partnership for Economic Policy (PEP) (www.pep-net.org) with funding from the Department for International Development (DFID) of the United Kingdom (or UK Aid), and the Government of Canada through the International Development Research Center (IDRC). The authors are also grateful to Martin Cicowiez for technical support and guidance.

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Executive summary

From the first half of the 2000s and until 2014, the Colombian economy was under the influence of an oil and mining production and export boom that triggered the potential for Dutch Disease effects. This issue was at the center of important policy debates and merits attention due to its potential impacts on several dimensions of the economy. As the boom has the potential to induce shifts in the sectorial composition of the economy, it may have significant effects on employment dynamics and on the evolution of the employment intensity of the economy, especially when the informal sector is sizable.

The sectorial composition of the Colombian economy has shifted in favour of mining and other services to the detriment of agriculture, manufacturing, and public services and construction between 1983 and 2010. The increase in mining production goes back to the mid-eighties with the discovery of ferronickel and was reinforced in the mid-nineties with the discovery of relatively sizeable oil reserves. This increase is largely due to foreign direct investment (FDI). Inbound FDI destined to the oil and mining sector added 24.6 billion dollars to the investment stock between January 2010 and the second quarter of 2013.

Between 1991 and 2011, Colombian exports grew sevenfold (from 7.2 billion dollars to 56.9 billion), which is equivalent to an annual average compound growth rate of 11%. During this timeframe, the export share of mining grew in a remarkable manner. Mining represented 33.6% of total exports in 1991 and reached 71% in 2011. A breakdown of the share of mining exports by subsector shows that oil accounts for the majority throughout the 1991-2011 period. It also shows that coal is the second largest contributor to mining exports and that oil products is the third.

The inflow of foreign currency due to increased mining exports and incoming FDI, jointly with other foreign currency sources such as portfolio investments and remittances, had an impact on the exchange rate. The behaviour of the exchange rate and of sectorial growth in recent years ignited a debate, in policy and political circles, on the possibility that the economy may have shown symptoms of Dutch Disease. In effect, while the simple annual average growth rate for the economy was 4.6% between 2003 and 2013, the corresponding figure in manufacturing was 2.9%. Besides growing more slowly than the whole economy, manufacturing output decreased by 4.1% in 2009, 1.1% in 2012, and 1.2% in 2013. In general terms, the situation for agriculture is similar as it grew at an annual average rate of 2.2%, with moderate decreases in 2008 and 2009 and basically no growth in 2010. In contrast, mining grew at an annual rate of 5.9% and sectors readily identifiable as predominantly non-tradable, such as construction; transport and communications; commerce, hotels, and restaurants; and financial and firm services, grew at rates ranging between 7.7% and 4.9%.

Another issue of contention relates to the behaviour of employment. Until very recently, unemployment stayed at relatively high levels in spite of the economy showing dynamism. During the 2003-2012 period, the unemployment rate was 11.9% on average and it is only as of May 2013 that the unemployment rate has started to recede (probably as a partial consequence of recent fiscal reforms that reduced some surcharges associated with hiring formal labour). In contrast, informal employment has been high and shows no clear sign of declining, accounting for around 50% of total employment, when defined based on occupational position and social security coverage.

In this study we analyze the potential effects of a sustained oil boom (until 2025) on the Colombian economy in terms of changes in the productive structure of the economy, changes in employment, and changes in the behaviour of informal employment. The classic treatment of Dutch Disease distinguishes two effects: a spending effect and a resource shift effect. The first occurs as a result of increased real income accruing from the boom, which translates into greater demand for both tradable and non-tradable goods. The short-run effects from this increase in demand lead to higher prices for non-

tradables (as there are no imports that limit price increases) and larger imports, and a change in the relative price of non-tradables with respect to tradables, implying an appreciation of the real exchange rate, which in turn negatively affects the competitiveness of non-boom export sectors. Higher prices in the non-tradables sector and increased activity in the boom sector induces reallocation of resources from the rest of the economy. This reallocation favours these sectors to the detriment of the rest of the economy and the extent to which it happens mainly depends on consumer behaviour and factor mobility.

The economic mechanics through which these changes take place is very suitable for being analyzed through general equilibrium modeling and this is what we do. We use a recursive dynamic general equilibrium model that allows us to calculate the way larger exports of oil have an impact on the rest of the economy along the lines described above. Our results show that, had international oil prices behaved through 2025 as predicted until 2014 (before the sudden price drop in international markets), the economy would have been 10.4% larger than it would have been if it had remained at the 2011 equilibrium and grown at a rate equal to 4.3% until 2025 (its average growth rate before 2011).

This higher growth would be accompanied by a 13% appreciation of the real exchange rate and an increase in the share of oil exports, going from 39% of total exports (as expected under the baseline scenario) to 56%, yielding a as result that the share in total exports of commodities coming from extractive activities would rise from 53% in 2011 to 66% in 2025. This share increase is not only due to an expected increase in oil exports, but also to a decrease in exports of other commodities as compared to their expected behaviour under the baseline scenario. In fact, quantities exported of agricultural goods grow 0.9 percentage points below the average annual compound rate they have under the baseline scenario, and the same is true for the rest of commodities: coal is 0.4 percentage points under, metals 1.1, non-metals 1.1, industrial goods 1, refinery products 1.3, and services 0.7 percentage points lower. In contrast, quantities exported of oil grow 2.4 percentage points above their average annual compound rate under the baseline.

With higher income, demand increases but the increase is basically met through imports. Imports of all commodities grow faster than under the baseline (from between 1.7 and 1.8 percentage points in the cases of agriculture, coal, metals, non-metals and refinery products, to 2.6 percentage points in the case of services). This is a big difference, yielding an increase in imported volumes with respect to the baseline that amount to 28% in average. As a consequence, import penetration increases in most cases, as demand for domestically produced commodities decreases in relative terms. On the other hand, a shift of resources (labour and capital) between industries takes place in the economy, favouring the oil sector and sectors with the larger direct or indirect connections to it.

Demand for informal workers is 0.7% lower than in the baseline, while demand for formal workers is 6.5% higher. On the other hand, demand for unskilled workers in general is 1.9% higher than in the baseline, but the increase is entirely due to demand for formal workers (as that for informal workers declines). Demand for skilled workers also increases by more than in the baseline, by 4.1%, with the increase, again, entirely due to demand for formal workers. Therefore, the projected prices for oil favour formal over informal employment and within the latter, skilled over unskilled labour. Results for the increase in the capital stock at the sectorial level are analogous to those found in the case of labour. The annual average compound growth rate for capital is higher than in the baseline for formal agriculture, oil, informal non-metals, informal industry, and formal and informal services. Therefore, there is in general a shift of resources from the rest of the economy to this set of sectors and especially to the oil sector. The capital stock of the economy under the boom scenario is 8.4% higher than the baseline level.

Part of the policy response by the Colombian government in facing potential Dutch Disease effects arising from increased oil exports is the establishment of a savings and stabilization fund (FAE for its acronym in Spanish language), targeted to withhold up to 30% of royalties revenue. These resources are meant to be invested abroad by the Central Bank and kept outside of the economy, as a classic

sterilization scheme, unless needed to be used as countercyclical spending, should oil prices or exported volumes decline below an expected threshold.

We also simulated the effects of this measure, assuming that 30% of royalties revenue is saved throughout the entire period. Its expected effect is to decrease to some degree the spending effect arising from the oil boom, in this case particularly by decreasing demand for investment goods. The results from the simulation confirm this expectation. Real GDP at basic prices increases by less than under the boom scenario, while cumulated reserves in the FAE grow to reach around 6% of real GDP in 2025. This lower growth is due to the minor level of capital accumulation achieved by the sterilization scheme. However, there are no substantial differences with respect to the previous simulation.

In sum, a sustained oil price boom would lead to both a resource shift and spending effects in the economy with the consequent relative erosion of its export base and some degree of "deindustrialization". The operation by the government of the FAE tends to lower these effects but it does so to a relatively limited degree. A more successful intervention should probably be comprised of a more aggressive savings strategy and increased spending in the provision of public goods that may impact the productivity of non-boom sectors (like roads, applied research, education, and infrastructure in general).

I. Introduction

1.1. Context of the study

From the first half of the 2000s and until 2014, the Colombian economy was under the influence of an oil and mining production and export boom that triggered the potential for Dutch Disease effects. This issue was at the center of important policy debates and merits attention due to its potential impacts on several dimensions of the economy. These include the likely effects of the export boom on the economy as a whole and on labour market dynamics. As the boom has the potential to induce shifts in the sectorial composition of the economy, it may have significant effects on employment dynamics and on the evolution of the employment intensity of the economy, especially when the informal sector is sizable.

The general context that frames this process may be described as follows. The sectorial composition of the economy, according to national accounts data, has shifted in favour of mining and other services to the detriment of agriculture, manufacturing, and public services and construction between 1983 and 2010. The share of mining in GDP increased from 2% to 8%, while that of other services grew from 56% to 60%. Meanwhile, the shares of agriculture, manufacturing, and public services and construction decreased from 10% to 7%, from 18% to 14%, and from 14% to 11%, respectively.

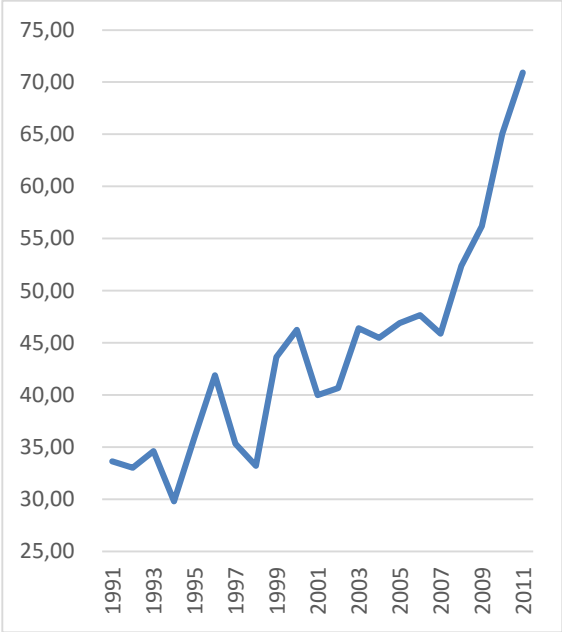
This relatively long-term change goes in hand with the evolution of physical production along this period. As can be seen in Figure 1, the volume index for the mining sector clearly outstrips those of the other sectors of the economy. The increase in mining production goes back to the mid-eighties with the discovery of ferronickel and gets reinforced in the mid-nineties with the discovery of relatively sizeable oil reserves. Starting from a low base and supported by the rise in international prices, the sector increases its share in total value added as mentioned above.

The increase in production is largely due to foreign direct investment (FDI). FDI flows into the Colombian economy have risen from about 1.5 billion dollars in 1994 to about 16.8 billion in 2013, reaching around

7% of GDP. Of these investments, the share of FDI directed to the oil and mining sectors represented 12.6% in 1994, while in 2013 it reached 46.7% (with a peak of 76.4% in 2009). According to data from the Colombian Central Bank, inbound FDI destined to the oil and mining sector has added 24.6 billion dollars to the investment stock between January 2010 and the second quarter of 2013, without counting investment done by Ecopetrol, the national oil company.

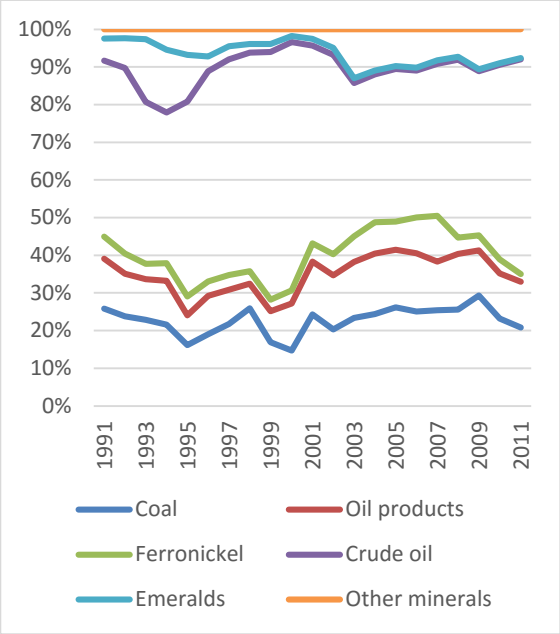
Between 1991 and 2011, Colombian exports grew sevenfold (from 7.2 billion dollars to 56.9 billion), which is equivalent to an annual average compound growth rate of 11%. Over this period, there were just four years in which exports showed negative growth rates, 2009 being the worst (-12.7%). The export share of mining has grown in a remarkable manner during this period. As can be appreciated from the left side panel in Figure 2, mining represented 33.6% of total exports in 1991 and 71% in 2011. A breakdown of the share of mining exports by subsector, shown in the right side panel of Figure 2, shows that oil accounts for the majority of all mining exports during the 1991-2011 period. It also shows that coal is the second largest contributor to mining exports and that oil products is the third (ferronickel, which as mentioned above was the forerunner in the development of the Colombian mining sector, is the fourth largest).

Figure 1. Sectorial Production Volume Index for the Colombian Economy (1975 = 100)



Source: Colombian National Statistical Office (DANE)

Figure 2. Share of mining in Colombian total exports



Source: Colombian National Statistical Office (DANE)

The inflow of foreign currency due to increased mining exports and incoming FDI, along with other foreign currency sources such as portfolio investments and remittances, has had an impact on the exchange rate. Casual observation of the behaviour of the nominal exchange rate (expressed as pesos per US dollar) shows that between 1991 and 2003 it continuously increased at an annual compound rate of 13.4%, while between 2003 and 2012 it has decreased at an annual rate of 5.1%. In a similar fashion, according to the Colombian Central Bank, the real exchange rate index, either calculated based on the producer or the consumer price index, although with fluctuations, has decreased between March 2003 and December 2012 (43.1 percentage points - the decrease until October 2013 is 38.1 percentage points). That is, the most pronounced decline in the real exchange rate is contemporaneous with the acceleration in the rate of increase of the mining export share (as follows from figure 2).

The behaviour of the exchange rate and of sectorial growth in recent years has ignited a debate, in policy and political circles, on the possibility that the economy may be showing symptoms of Dutch Disease. In effect, while the simple annual average growth rate for the economy was 4.6% between 2003 and 2013, the average rate corresponding to manufacturing was 2.9%. Besides growing more slowly than the whole economy, manufacturing decreased by 4.1% in 2009, 1.1% in 2012, and 1.2% in 2013. In general terms, the situation for agriculture is similar as it grew at an annual average rate of 2.2%, with moderate decreases in 2008 and 2009 and basically no growth in 2010. In contrast, mining grew at an annual rate of 5.9% and sectors readily identifiable as predominantly non-tradable, such as construction; transport and communications; commerce, hotels, and restaurants; and financial and firm services, grew at rates ranging between 7.7% and 4.9%.

Another issue of contention, not necessarily related or casted within the Dutch Disease discussion, refers to the behaviour of employment. Until very recently, unemployment stayed at relatively high levels in spite of the economy showing dynamism. During the 2003-2012 period, the unemployment rate was 11.9% on average with moderate variation (the coefficient of variation calculated on monthly data was 0.13). It is only from May 2013 on that the unemployment rate has started to recede, probably as a consequence of recent fiscal reforms that reduced some surcharges associated with formal labour hiring. Between May 2013 and March 2014, the monthly average unemployment rate was 9.3%.

In contrast, informal employment has been high and shows no clear sign of declining, situated at around 50% of total employment, when defined based on occupational position and social security coverage. If defined based on contribution to pensions, informality reached 67.2% of total employment during the 2000s, while representing an average of 82.7% of employment in firms with less than ten workers (which account for 64% of total employment, implying that in firms with more than ten workers informality was around 23% - although with a downward trend). From a sectorial perspective, informality is higher in agriculture, commerce, construction, transport and communications, as well as in certain manufacturing activities (mainly food and beverages, apparel, and textiles).

For steering the economy away from the perils of Dutch Disease, in 2012 the government introduced legislation modifying the royalties system and creating a Savings and Stabilization Fund, administered by the Central Bank and projected to withhold an average of 24% of total royalty revenue flows between 2013 and 2022. This measure followed the implementation in 2011 of a fiscal rule, aimed at achieving fiscal sustainability by putting a ceiling on governmental indebtedness. Due to their recent implementation, the outcomes of these policy instruments are still relatively unknown.

1.2. Research questions and objectives

Given the above context, our aim is to inquire about the impact of the oil and mining production and export boom on: (i) the evolution of the productive structure of the economy, (ii) the evolution of the import intensity in non-boom sectors and its implications for employment dynamics in general, and (iii) the evolution of the informal sector.

As for the first issue, the changes in the sectorial composition of the economy documented above and those that may ensue from further production and exports of oil and mining products will have a potentially important effect on the structure of labour demand. In this respect, estimating the likely path of these changes in the short and medium run is important and instrumental for appraising the evolution of the labour market. With an appreciation of the real exchange rate, non-boom sectors tend to be affected according to their trade position. Non-boom tradable sectors are expected to be negatively affected; in the case of exportables due to erosion of their competitive position as the domestic currency appreciates, and in the case of importables due to increased competition as international prices become lower in terms of domestic currency.

On the contrary, non-boom non-tradable sectors are expected to be positively affected, as higher national income translates into increased demand for them and their prices increase. In the medium run, both the boom sector and the non-tradables sector should increase production at the expense of the rest of the economy as relative prices favour them. This translates into changes in employment levels according, among other factors, to the easiness of factor mobility, relative labour intensiveness across activities, potential adjustments in technology use, and the cross effect between formal and informal activities within each sector.

Therefore, estimation of the impact of Dutch disease economics on employment is not straightforward, especially if taking into account that activities decompose into formal and informal sub-activities. As informality tends to concentrate in the non-tradables sector, we can expect the informal sector to be boosted if the formal part of the non-tradables sector does not absorb (and formalize) informal workers in an accelerated manner, so that it not only hires workers expelled from the non-boom tradable sector but also informal workers from the non-tradables sector. Therefore, the likely effect of Dutch Disease economics on the informal sector is mainly an empirical question. From a policy perspective it is clearly relevant to know whether the informal sector is bound to further increase in size (i.e. number of workers),

what is the likely behaviour of income generation within the sector, and how it translates into households' income.

For these purposes, we use a recursive dynamic computable general equilibrium model to run three types of simulations. In the first, we build the baseline scenario, that is, we trace the expected behaviour of the economy, arising from its 2011 equilibrium and growing at the population growth rate. In the second, we simulate the behaviour of the economy had international oil and coal prices behaved as projected before the price collapse of 2015. In the third, we examine the effects of a set of policy instruments that the government has recently put in place, as briefly described above.

II. Literature review

Dutch Disease economics has received broad attention in the literature. It has been associated with significant medium term income increases arising from an export boom or enhanced foreign capital inflows, including remittances, international aid, and foreign direct investment. The classic treatment of the subject in Corden and Neary (1982) distinguishes two effects: a spending effect and a resource movement effect. The first occurs as a result of the increased real income accruing from the boom, which, provided tradable and non-tradable goods are not inferior, translates in greater demand for both. Short-run effects from this increase in demand lead to higher prices for non-tradables and larger imports, and a change in relative prices of non-tradables with respect to tradables, implying appreciation of the real exchange rate (which in turn negatively affects the competitiveness of non-boom export sectors).

Higher prices in the non-tradables sector and increased activity in the boom sector induces reallocation of resources from the rest of the economy. This reallocation has general equilibrium effects that are not obvious and depend mainly on consumer behaviour and factor mobility.

In its analysis of one of the several coffee booms of the Colombian economy, Edwards (1985) found that higher coffee prices led to an increase in reserves and to a higher rate of money supply. As a consequence, the inflation rate increased and the dynamics of the nominal exchange rate led to real exchange rate appreciation and loss of competitiveness for tradables other than coffee. If, under these circumstances, the government increases its deficit and finances it (even partially) with foreign borrowing, pressure on the real exchange rate increases and a magnification effect ensues. As pointed out by the Colombian Ministry of Finance (2011), the Colombian experience in the management of export booms has not been very fortunate and the economy has experienced growth deceleration in the aftermath of these booms.

There is robust evidence that increases in the terms of trade lead to a real exchange rate appreciation in countries rich in natural resources, as illustrated for example in Spatafora and Warner (1995). In contrast, evidence on a deindustrialization process seems to be less conclusive. For instance, Sala-i-Martin and Subramanian (2003) finds no clear cut effects in this direction, while Ismail (2010) claims that a 10% increase in oil income produces an average 3.4% drop in industrial value added. Also, deindustrialization tends to be higher in economies that are more open to capital flows and have less capital intensive manufacturing sectors.

As happens with deindustrialization, evidence on the long-term consequences of the Dutch Disease is blurred. Sachs and Warner (2001) argue that natural resources abundance has a strong negative effect on economic growth, leading to the infamous "curse of natural resources". Lederman and Maloney (2008) found a positive effect of natural resources abundance on long-term growth. Collier and Goderis (2007), using panel data, try to reconcile these opposite views; they conclude that price booms have a short-term positive impact on growth and that economies with poor governance and natural resource enclaves (like oil and mining) show significantly negative long-term growth effects. Treviño (2011) uses a heuristic

approach for appraising the CEMAC region economies, and finds that in the oil rich ones there is indeed real exchange rate appreciation and factor reallocation but that there is no evidence of a resource curse as oil abundance does not seem correlated with long term performance. Magud and Sosa (2010) argues that there is no mechanism in the literature by which Dutch Disease reduces long-term growth.

Consistent with the above discussion, we take the view (with Magud and Sousa, 2010) that, from a policy making point of view, what is perhaps more relevant is to determine if the appreciation is driven by a permanent (structural) change and then steer the economy away from overshooting, overheating, and the rise of macro imbalances that may prove unsustainable. However, determining whether or not the economy is facing a permanent change is a daunting task and mistakes could be costly. In any case, the short- and medium-run effects of real exchange rate appreciation, where a host of potentially undesirable consequences of Dutch Disease economics are concentrated, should be assessed and hopefully addressed. While our research cannot help in determining the nature of the shock behind the Dutch Disease, it can certainly contribute to the appraisal of its consequences on the three fronts mentioned above and to usefully inform policy making in the corresponding dimensions.

There is only one piece of work that we are aware of (and which is publicly available) that investigates the potential effects of Dutch Disease in Colombia and which may be useful for appraising its effects on the real economy. The reference is Rojas and Forero (2011) which examines the macroeconomic impact of an oil boom on the Colombian economy and, among other issues, explores alternative scenarios for facing the boom. The paper uses a recursive dynamic CGE model to simulate four scenarios: (i) short-run consumption of income from the boom, (ii) establishment of an external fund, (iii) investment in infrastructure, and (iv) phase off of distorting taxes (the boom's income substituting for lost fiscal revenue). The focus of this work differs markedly from ours in the following ways. While it explores the best courses of action for the government to use the revenue windfall, with growth as the leitmotif of intervention, our work centers around the potential impact of the boom and of policies implemented by the government to manage labour market dynamics in the sense depicted above. Therefore, our work does not explore alternative courses of action for the government to face potential Dutch Disease effects, as Go et al. (2013) does for the case of Niger. Instead, it explores the likely labour market outcomes arising from the price boom and policies implemented, among which the establishment of a stabilization fund is also examined in Go et al. (2013).

III. Data

We built a 2011 SAM for Colombia to run the CGE model and the simulations. Activities are distinguished by their formal or informal character and demand formal and informal labour according to it. Only formal activities pay taxes on production and only commodities produced by formal activities pay indirect taxes. The oil and mining sectors use capital and natural resources as composite capital, while the rest of the economy only uses capital. As Colombia is one of the few countries in the world that still has land available for further expansion (or intensification) of agricultural activities, the issue of competition for land use between extractive activities and agriculture is deemed of low relevance. Hence, we do not consider land as a factor in the production function for agriculture. Rents from natural resources accrue to the government as royalties and the national oil company pays dividends to the government, who also receives dividend payments from other state companies belonging to the rest of the economy. We equate natural resource rents (for extractive activities) to royalty payments that are explicitly accounted for in the National Accounts. On the other hand, dividends accruing from the national oil company come from reports issued by the Ministry of Finance, allowing for splitting the National Accounts item that captures dividend payments to the government.

It is useful to employ the data contained in the SAM to provide a summary of the Colombian economy that allows for a better understanding of its structure and some of the features relevant for our study. In this regard, Table 1 provides a broad picture of the Colombian economy, which is similar in size to that of Denmark but with a population almost nine times larger.

Table 1. Composition of the Colombian economy, 2011

Sector	Type	Sectorial share in:					Capital-labour ratio
		Value added	Total employment	Unskilled labour	Skilled labour	Capital	
Agriculture	Formal	1.6	2.3	4.4	1.4	1.0	0.4
	Informal	5.2	8.2	22.9	2.0	2.0	0.2
Coal	Formal	1.9	0.5	0.4	0.5	3.2	5.5
	Informal	0.0	0.1	0.1	0.0	0.0	0.3
Oil	Formal	9.1	1.1	0.3	1.5	16.7	12.0
Metals	Formal	0.4	0.2	0.3	0.1	0.5	2.5
	Informal	0.3	0.4	1.1	0.1	0.4	0.8
Non-metals	Formal	0.2	0.2	0.3	0.2	0.1	0.4
	Informal	0.2	0.2	0.7	0.0	0.1	0.4
Industry	Formal	8.3	7.4	3.4	9.0	9.4	1.0
	Informal	2.4	3.0	4.7	2.3	1.8	0.5
Refinery	Formal	2.8	0.2	0.1	0.3	6.2	23.3
Services	Formal	37.3	35.8	16.5	43.9	38.8	0.9
	Informal	23.8	30.6	43.8	25.0	17.5	0.5
Pub. Admin.	Formal	6.35	9.87	1.05	13.58	2.26	0.18

Source: SAM 2011

Given the sectorization of the economy we are using, 61% of value added is generated from the services sector, 13.5% comes from industry and refineries, 12.2% from the extractive sector, and 6.8% from agriculture. In total 68.1% of value added arises from formal activities, while the remaining 31.9% is from informal activities. The sectors with the largest informal component are agriculture (76%), metallic minerals (49%), non-metallic minerals (48%), and services (39%), while the least informal are oil, refinery, and public administration, which are completely formal, and coal (98% formal).[1]

The distribution of employment generally follows value added lines: 66.4% of total employment belongs to the services sector, 10.4% to industry, 9.9% to public administration, and 10.5% to agriculture. Unskilled labour is concentrated in the services sector (60.3%), agriculture (27.3%), and industry (8.1%). The figure corresponding to agriculture indicates a high overrepresentation of unskilled labour in this sector with respect to value added. Skilled labour is mostly employed in the services sector (68.9%), the public administration sector (13.6%), and the industrial sector (11.3%).

With respect to capital, its use is conspicuous in the services sector (56.4%), the oil sector (16.7%), the industry sector (11.2%), and the refinery sector (6.2%). The cases of oil and refining show a higher than proportional use of capital with respect to their share in value added suggests a high capital-labour ratio. This feature is confirmed in the last column of Table 1 where we report the sectorial capital-labour ratios. The highest ratios are found in the refinery sector (23.3), the oil sector (12), the coal sector (4.9), and the metallic minerals sector (1.3).

As for international trade, the trade dependency ratio[2] of the Colombian economy was 37% in 2011, a year during which it sustained a negative trade balance equivalent to 1.2% of GDP. As shown in Table 2, the share of products related to the extractive sectors account for 53.2% of total exports, followed by industrial exports (29.3%), and refinery exports (9.3%). On the import side, the majority of trade is in industrial goods (19%), followed by services (9.1%), and refinery products (7.4%). The set of products with the greatest export orientation, as measured by the export coefficient[3] are coal, oil, metals, and refinery products, all in the extractive sectors. Lastly, as shown in the last column of Table 2, the greatest penetration of imports, as measured by the import penetration ratio[4], belong to industrial and refinery products.

Table 2. Main features of Colombian international trade, 2011

Products	Share in total:		Export coefficient	Import penetration
	Exports	Imports		
Agriculture	3.7	4.2	0.07	0.08
Coal	12.2	0.0	0.95	0.01
Oil	39.1	0.0	0.71	0.00
Metals	1.6	0.0	0.30	0.01
Non-metals	0.3	0.2	0.09	0.07
Industry	29.3	79.0	0.11	0.26
Refinery	9.3	7.4	0.26	0.23
Services	4.5	9.1	0.01	0.02

Source: Macro SAM 2011

As follows from the above, the economy shows a relatively important dependence on the extractive sectors, which in spite of having a sizeable but not overwhelmingly high share in value added, have a very high share in exports. This is reflected in the rising importance of governmental income originating from these sectors, reaching almost 11% of total government revenue, of which 63% correspond to royalties and 37% to dividends accruing from the national oil company. In the face of potential Dutch Disease effects, sectors highly dependent on products (different from oil, coal, and minerals) with high export coefficients or high import penetration ratios are likely to be negatively affected to the detriment of the economy in the longer run, provided the extractive products export boom is not of a structural (permanent) nature.

IV. The methodology

As mentioned, we use a dynamic recursive computable general equilibrium model (CGE) for our analysis. CGEs are particularly well suited for the task at hand since they have the capacity to take into account second round effects of the external shocks on the economy and can also provide sectorial and other economic details useful for economic analysis and policy making. In particular, we will use the single country, recursive dynamic version of the Partnership for Economic Policy (PEP) model, fully documented in Decaluwé et al (2012). The model extends to multiple periods the single-period PEP-1-1 model, through

linking successive periods by means of variables that are inherited from the previous one and are transmitted by a set of "dynamic equations". The model belongs to the neoclassical tradition, in a perfect competition setting, and agents' behaviour is drawn from optimization problems. As the model has a thorough documentation, we focus here on the features that distinguish our version of the model from the original one.

As the distinction between formal and informal sectors is central to our objectives, we have both types of activities in the model. While the basic layout of their production function is similar, they differ in two main respects. First, informal activities supply the domestic market; that is, they do not export. Second, informal activities do not pay taxes. The basic structure of both activity types involves a Leontief top nest mixing value added and aggregate intermediate consumption, while in the second nest value added is generated as a constant elasticity of substitution (CES) combination of composite labour and capital. While there is only one type of capital for non-oil and non-mineral extraction activities in the model, oil and mining activities make use of two types of capital: capital and natural resources. On the other hand, composite labour is a CES blend of skilled and unskilled labour, which is of the informal type in the case of an informal activity and of the formal type in the case of a formal activity. Lastly, aggregate intermediate consumption is represented, in the second nest, as a Leontief combination of composite goods.[5]

Given the structure of supply, the implied structure from the demand side assumes imperfect substitution between products produced by formal and informal activities (through a CES aggregator). While informal products come only from domestic (informal) activities, formal products come from domestic formal activities and from the Rest of the World (as imports), once again as imperfect substitutes (CES). Imported products are assumed formal, as are exported products. Therefore, both, formal and informal activities demand composite goods for intermediate consumption and this composition is made up of formal domestic and imported products, on one side, and of informal products, on the other.[6] The same is true for other sources of demand (households, government, and investment). Taxes on products are levied only on products originating from formal activities while those coming from informal activities do not pay taxes.

As follows from the production structures depicted above, we assume the labour market is segmented into a formal and an informal sector. However, the distinction between formality and informality has nothing to do with the intrinsic characteristics of workers, in the sense that there are both skilled and unskilled workers in the two segments and what determines their formal or informal character is simply the type of activity that hires them. While equilibrium in the formal segment is attained through equalization of demand for formal employment and its supply (after deducting labour mobility to the informal sector and unemployment), in the informal segment it is achieved through equalization of demand and total supply (i.e. supply of informal labour plus labour coming from the formal segment). Mobility between the two segments follows a Harris and Todaro (1970) mechanism: mobility stops when the informal wage "equates" the expected wage in the formal sector.[7] Lastly, there is unemployment in the formal segment with real wage downward rigidity, and full employment in the informal segment, under fully adjustable wages. However, there is the possibility that market clearing in the formal segment arises through wages. In this case, the unemployment level in the formal segment hits its (calibrated) minimum, labour supply becomes perfectly inelastic, and wages clear the market (in which case there is

no labour mobility between the formal and informal segments). This is achieved by using a complementary-slackness condition.

Also, a set of features is added to the model for several purposes. First, we isolate rents accruing to the government from natural resources either in the form of royalties or dividends received from the national oil company. The calculation of dividends is endogenous to the model and the rate at which they are generated depends upon the behaviour of international prices.[8] Second, we take into account that investment in oil and mining production is not only dependent on their relative rental rates but also, and mostly, on foreign direct investment (FDI). As a consequence, we single out FDI in the oil and mining sectors and let the market assign new investment only for the remaining part of foreign savings (plus domestic savings), so total investment in these sectors is composed of competitively assigned new capital plus FDI. This feature of the model allows for exogenous shocks to FDI in case it is deemed relevant. Third, we model the administration of oil and mining royalties flowing to the government in a way that allows simulation of the implementation of the Savings and Stabilization Fund (FAE for its Spanish language acronym), a policy measure undertaken by the government to help avoid potential Dutch Disease effects on the economy.[9] In the appendix, we provide a full account of the relevant equations of the model.

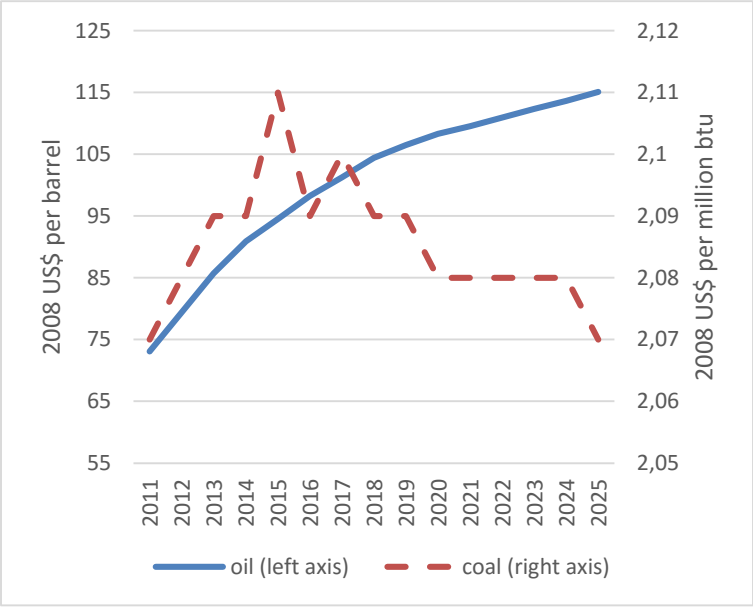
V. Application and results

With the model described above, we run three sets of simulations. One corresponding to the baseline, tracing the behaviour of the economy along a 15-year span, in which the economy is assumed to grow at the steady state rate. A second one, in which international prices of oil and coal grow at the rates forecasted by the World Bank in 2013. In a third simulation, we add the implementation of the FAE by the Colombian government. The steady state rate is assumed to be equal to the average annual growth rate in years close to the baseline (4.3% per year). It is the compound result of population growth (1.3% per year) and a calibrated increase in labour productivity.

In all cases we use the following closure rules. The nominal exchange rate is the numeraire, foreign savings is exogenous, real current government consumption of goods and services is exogenous, foreign direct investment in the oil and coal sectors is exogenous and remains constant, and investment is savings driven. This way, in the face of changes in international prices, the real exchange rate (defined as the nominal exchange rate over the price index for domestically produce goods) varies in order to clear the current account making it possible to capture potential Dutch Disease effects. Lastly, labour is mobile between activities within the limits set by the structure of the labour market as depicted above.

Against the picture depicted in the baseline scenario, in the second one (boom scenario) the international prices of oil and coal vary according to price forecasts issued in 2010, which were the expected prices before the Colombian government projected the behaviour of the economy and designed the policy measures that we simulate in the third scenario. The expected behaviour of prices is depicted in Figure 3, which in the case of oil implies an increase of nearly 60% with respect to the base year (2011) by 2025.

Figure 3. Oil and coal international prices as projected in 2010



Source: US Energy Information Administration

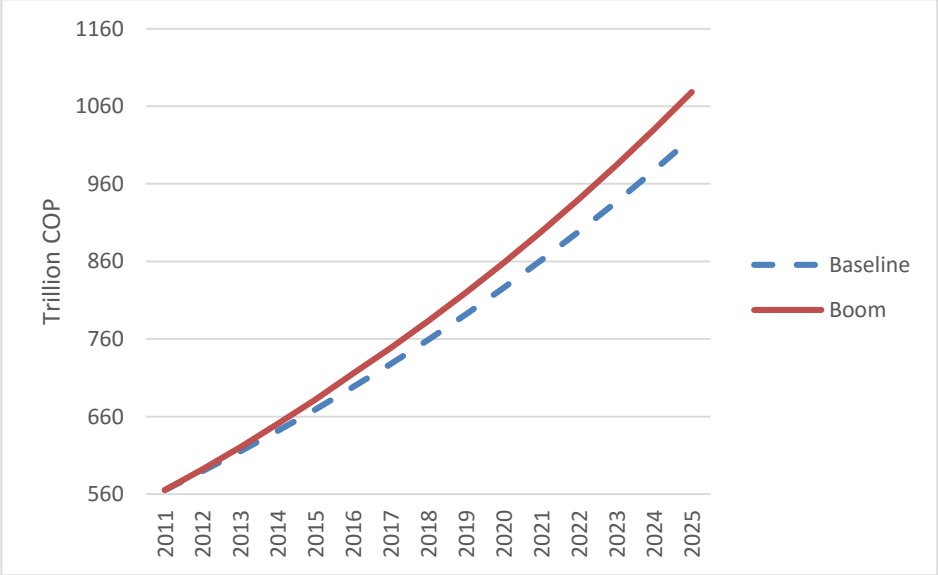
5.1. Boom scenario

Real GDP at basic prices grows under the boom scenario by 0.42 percentage points per year above the implied steady state rate. As follows from Figure 4, this average difference translates into real GDP levels that start at 0.4% above baseline levels in 2012, systematically increasing to reach a 5.8% difference by 2025. Table 3 summarizes the main macroeconomic impacts of the boom scenario. From there, it can be appreciated that real GDP at basic prices increases by 10.4 percentage points more under the boom scenario for the whole period, for total economic growth of 90.7% over the whole period. Consequently, all components of GDP grow more, but investment outperforms both final consumption and government consumption, while the trade balance shrinks as a consequence of exports growing more rapidly than imports (although the trade balance remains negative). Therefore, the new composition of GDP in 2025 shows slight decreases in the share of final consumption (from 61.5% to 60.4%), government consumption (from 15.8% to 14.7%), and the trade balance (from -1.2% to -0.4%), while the share of

investment increases (from 23.9% to 25.3%). Additionally, trade dependence,[10] that stands at 37.3% in the base year increases by 2.3% (to 38.2%), as the real exchange rate depreciates 13%. Lastly, the overall unemployment rate decreases from 10.1% to 7%.

To trace back the forces behind the performance of the economy under the boom scenario, we can look at the sectorial contribution to GDP. Figure 5 shows the sectorial shares in GDP in the base year and in 2025 for the boom scenario. As can be seen, the only two sectors that increase their shares in GDP are oil and formal services, the former by 3.4 percentage points, and the latter by 1.1 percentage points. With no exception, the rest of sectors show decreases in their contributions to GDP, the largest amounting to 1.5 percentage points, in the case of informal services, and the smallest amounting to 0.003 percentage points in the case of informal non-metals. Extractive sectors (oil and mining in general) increase as a share of GDP from 12.3% in 2011 to 15.1% in 2025. Approximately 44% of this increase is due to prices and 56% to quantities produced.

Figure 4. Real GDP at basic prices under the baseline and the boom scenarios



Source: CGE model simulations

Table 3. Main macroeconomic results from the boom scenario (percentage changes)

Scenario	GDP	F. C.	G.C.	I.	T.B.	T.D	RXR	U.R.
Baseline	80.3	80.3	80.3	80.3	80.3	0.0	0.0	10.1
Boom	90.7	119.5	107.4	136.5	-27.8	2.3	-13.0	7.0

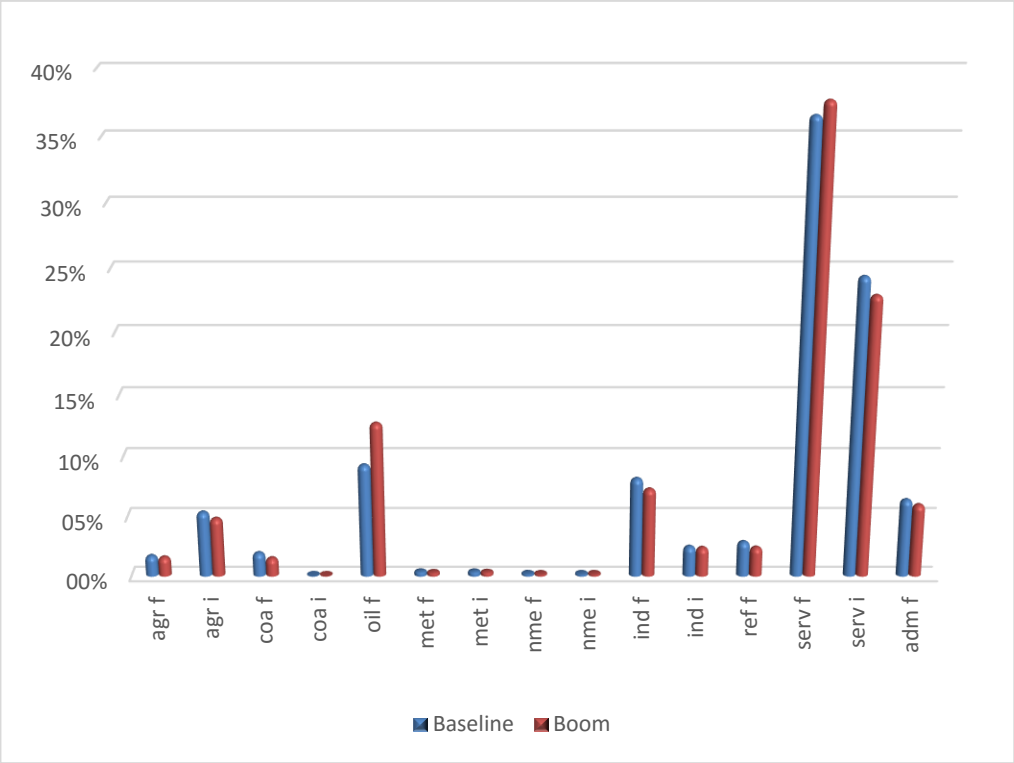
GDP: GDP at basic prices; F.C.: final consumption; G.C.: government's consumption; I.: investment; T.B.: trade balance; T.D.: trade dependence; RXR: real exchange rate; U.R.: unemployment rate.
Figures are percentage changes from the base year to 2025, except for the unemployment rate.
Source: CGE model simulations

Since the force that causes this behaviour is the change in international prices for oil and coal, it is useful to examine the behaviour of international trade. As could be expected, in this case the changes that occur in exported values between the base year and 2025 are much more pronounced that those corresponding to sectorial shares in GDP. As illustrated in figures 6 and 7, there are important changes in the composition of exports, the most relevant being the increase in the share of oil exports, that rises to an expected 39% of total exports by 2025 in the baseline, as compared to rising to 56% of total exports by

2025 in the boom scenario). With these changes, the share in total commodities exports coming from extractive activities rises from 53% in 2011 to 66% in 2025.

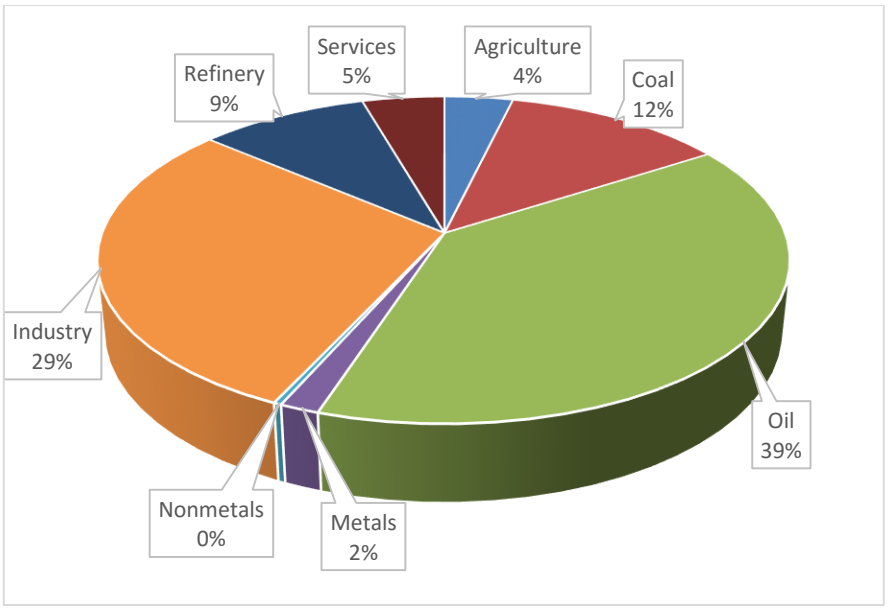
This shift is not only due to the expected increase in oil exports, arising from the increase in prices, but also to a relative decrease in exports of other commodities as compared to their behaviour under the baseline scenario. In fact, export values of agricultural goods grow by 0.4 percentage points less than the average annual compound rate they have under the baseline scenario, and the same is true for the rest of commodities: coal is 0.2 percentage points under, metals 0.6, non-metals 0.6, industrial goods 0.5, refinery products 0.7, and services 0.4. In contrast, the average annual compounded increase in the export value of oil grows by 4.7 percentage points more than in the baseline.

Figure 5. Sectorial shares in GDP in 2011 and 2025



Source: CGE model simulations

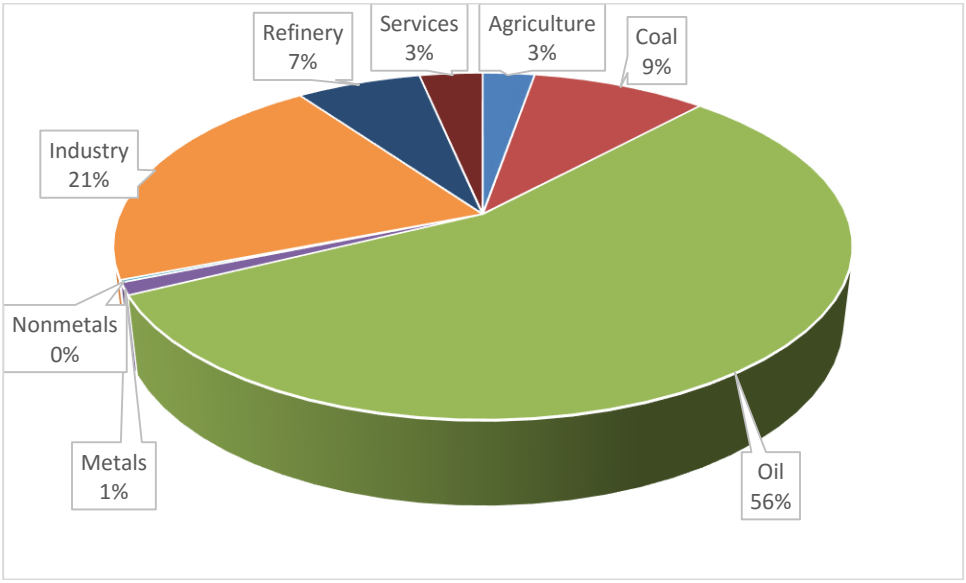
Figure 6. Commodities' shares in exports in 2025 (baseline scenario)



Source: CGE model simulations

This behaviour conforms to what could be expected from Dutch Disease effects. The real exchange rate depreciates by 13% over the 15-year span of the simulations in order for the external balance to hold, as the prices of exportables are linked to international prices and cannot adjust in the face of decreased international competitiveness and stronger domestic demand.[11] As the Dutch Disease rationale goes, prices in non-tradable sectors are not tied to international prices and therefore can adjust, and with the higher demand that increased income in the economy generates, their prices rise, thereby pushing the real exchange rate to appreciate.

Figure 7. Commodities' shares in exports in 2025 (boom scenario)



Source: CGE model simulations

In our case, there is a feature of the modeling that may introduce differences with respect to the standard Dutch Disease rationale: non-tradeable commodities are produced by the informal sectors but, from the demand side, they always are imperfect substitutes with commodities produced by the formal sectors, which are always tradeable. However, before considering this topic, it is convenient to examine the behaviour of imports and its relationship with demand for domestic products.

As a summary measure of the evolution of quantities imported of goods we can examine the differences between the annual average compound growth rate of imports under the boom and baseline scenarios. The relevant figures are presented in the first column of Table 4. From there, it can be seen that imports of all commodities grow faster under the boom scenario than under the baseline.[12] The difference is noticeable, yielding an increase in imported volumes between the boom scenario and the baseline that amount almost 26% on average, as reported in column three of the table.[13]

Import penetration increases in most cases, as demand for domestically produced commodities decreases in relative terms. As shown in the second column of Table 4, their annual average compound growth rate decreases with respect to the baseline by 0.2% on average, with the exception of oil, services, and non-metals whose rates increase by 0.4%, 0.5%, and 0.2%. In terms of quantities, imports increase more under the boom scenario, leading to an average difference with respect to the baseline, not counting services, in the order of 26% (third column of Table 4), with the lowest figure in industry (21.8%) and the highest in services (41.3%). The opposite is true in most cases for demand for domestically produced goods (fourth column) for which there are lower increases under the boom scenario in most cases (averaging -2.1%). The exceptions to this are demand for oil (increases by 5.3%), non-metals (2.2%), and services (6.6%). Lastly, total domestic absorption[14] increases more in the boom scenario than in the baseline in most cases (fifth column in Table 4), implying a stronger effect on the imports side. The exceptions to this are absorption of coal, non-metals and pubic administration. As there are no imports of oil, demand for domestically produced goods completely determines absorption, which increases more in the boom scenario.

Table 4. Differences between the boom and baseline scenarios in annual average growth rates for imports and demand for domestic production and percentage changes in quantity levels of imported and demanded domestic production and absorption for 2025

	Growth rates		Levels		
	Imports	**Domestic**	**Imports**	**Domestic**	**Absorption**
Agriculture	1.7%	-0.1%	24.7%	-0.9%	1.5%
Coal	1.8%	-0.2%	26.4%	-2.5%	-2.4%
Oil		0.4%		5.3%	5.1%
Metals	1.8%	-0.2%	27.0%	-2.6%	-2.4%
Non-metals	1.7%	0.2%	26.0%	2.2%	4.5%
Industry	1.5%	-0.1%	21.8%	-0.7%	7.0%
Refinery	1.8%	-0.3%	27.6%	-3.9%	5.9%
Services	2.6%	0.5%	41.3%	6.6%	7.2%
Pub. Adm.		0.0%	0.0%	-0.5%	-0.5%

Source: CGE model simulations

The effects of these changes as they are passed on to the activity level depends upon the commodity composition by production in a sector and the way that commodities end up distributed between the international and domestic markets, in the case of the formal sectors, while for the informal sectors there is a one to one relationship between activity levels and domestic demand. Table 5 shows the behaviour of total production by sector (in quantity), in terms of the annual average compound growth rates under the boom scenario, as well as their difference with the baseline. As shown above, demand for domestic commodities increases by less in the boom scenario for all commodities except for oil, non-metals, and services and this should lead to lower increases in total production in informal sectors whose production is concentrated in the other commodities. The figures in Table 5 confirm this, with the exception of informal industry whose output increases by slightly more than in the baseline. On the other hand, the informal non-metals and informal services sectors show increases which are higher than those in the baseline (consistent with the larger increase in demand for non-metals and services).

Table 5. Average annual compound growth rates for total quantity produced at the sectorial level and difference with the baseline

Sector	Boom	Difference
Agriculture formal	4.4%	0.06%
Agriculture informal	4.1%	-0.22%
Coal formal	4.0%	-0.32%
Coal informal	4.1%	-0.19%
Oil formal	6.2%	1.90%
Metals formal	3.7%	-0.61%
Metals informal	4.1%	-0.21%
Non-metals formal	4.0%	-0.31%
Non-metals informal	4.7%	0.39%
Industry formal	4.1%	-0.24%
Industry informal	4.5%	0.17%
Refinery formal	3.7%	-0.64%
Services formal	5.0%	0.68%
Services informal	4.3%	0.05%
Public administration formal	4.3%	-0.04%

Source: CGE model simulations

With respect to formal sectors, the behaviour of total production is nuanced by the interaction between the possibility of diverting production from exports to the domestic market (and vice versa) and production of the same commodities by other formal sectors which is only targeted to the domestic market. With the exception of the oil sector, all formal sectors increase the share of each commodity that they deliver to the domestic market, to the detriment of the export market (since exports of all commodities but oil relatively decrease). As informal sectors and formal sectors delivering a particular product only to the domestic market have no possibility of reducing production by lowering exports, they must accommodate by reducing deliveries to the domestic market. This opens up a space for formal sectors that export and sell to the domestic market to have a smaller reduction in the amount of the commodities that they deliver to the domestic market (this is, for instance, the case in formal agriculture).

In other cases, the scarcity of other sectors delivering the same good to the domestic market leads to a relative decline in deliveries to this market across the board (an example of this is the formal and informal metals sectors). In the cases where demand for the commodity rises relative to the baseline (non-metals and services) the size of the increase determines whether all sectors delivering the good to the domestic

market can grow above their baseline levels. While for non-metals the increase is relatively smaller than for services, the formal non-metals sector relatively decreases both exports and trades to the domestic market, while the informal non-metals sector relatively increases. In the case of services, the increase in demand for the commodity suffices for generating relative increases for the formal and informal services sectors. For the services sector, the only one besides oil that increases total production much above the baseline level, the driver for its growth stems from the input-output relationships, especially for self-intermediate consumption that tends to amplify the feedback effects.

A point is that is important to make here is that in this dynamic there is no role for potential substitution between commodities commonly produced by the formal and informal sectors, as there is nothing in the shock to international prices that affects relative prices between these sectors. Price differences between them (say agricultural products originating from the formal sector and originating from the informal sector) arise only from indirect taxes applied to the product generated by the formal sector. Therefore, from the standpoint of the composite good that is demanded in the economy, the shares corresponding to formal and informal supply remain constant.[15]

Having discussed changes in the sectorial composition of the economy and changes in import penetration as they are transmitted to the sectorial level, we can now turn to examine the ensuing changes in labour demand. Table 6 shows the annual average compound growth rates for informal employment at the sector level for the boom scenario and their differences with respect to the baseline. It can be seen that employment of unskilled workers grows less in the boom scenario for agriculture, coal, and metals, and does it more for non-metals, industry, and services, inducing a slight change in the sectorial composition of this type of employment. As for skilled workers, employment increases faster under the boom scenario only for the non-metals sector[16] and in informal industry.

Table 6. Annual average compound growth rates for informal employment at the sectorial level (boom scenario) and difference with the baseline

Sector	Unskilled informal		Skilled informal	
	Boom	Difference	Boom	Difference
Agriculture informal	1.07%	-0.23%	0.96%	-0.34%
Coal informal	1.09%	-0.21%	0.98%	-0.32%
Metals informal	1.03%	-0.27%	0.92%	-0.38%
Non-metals informal	1.73%	0.43%	1.62%	0.32%
Industry informal	1.52%	0.22%	1.41%	0.11%
Services informal	1.34%	0.04%	1.23%	-0.07%

Source: CGE model simulations

Table 7 shows the average growth rates at the sector level for formal employment in the boom scenario, as well as their differences relative to the baseline. In the case of unskilled workers, growth rates are higher in the boom scenario for agriculture, oil, services and public administration. In spite of the high growth rate in the oil sector, its share in this type of employment only increases from 1.2% under the baseline to 1.8% in the boom scenario. Even though this type of employment in agriculture and public administration grows by more in the boom scenario, these sectors lose share compared to the baseline. With respect to skilled workers, growth rates are higher under the boom scenario for oil and services, increasing their share in this type of employment (in the case of oil it increases from 2.1% in the baseline to 3%).

Labour demand changes arising from the sectorial level generate the following picture in terms of labour market dynamics. Informal demand for workers, both unskilled and skilled, grows slightly less under the boom scenario, showing annual average compound rates of 0.03% and 0.07% below the baseline rate. In contrast, formal demand for workers, unskilled and skilled, grows more rapidly than in the baseline, with differences in the order of 0.6% and 0.4%, respectively. Considered together, that is irrespective of the skill level, informal demand for workers grows less in the boom scenario, while formal demand for workers grows more, with differences in annual growth rates of -0.05% and 0.46%, correspondingly. On the other hand, demand for unskilled workers, either in the formal or informal sectors, and for skilled workers, grow more in the boom scenario. That of unskilled workers grows by 0.14 percentage points more, which means that the positive dynamics of unskilled workers employed in the formal sector more than compensates the negative dynamics corresponding to demand in the informal sectors. Lastly, a similar behaviour is observed in the case of demand for skilled workers, for which the positive dynamics of formal demand for skilled workers outstrips the negative dynamics coming from informal activities, leading to an overall difference in growth rates between the boom scenario and the baseline of 0.3%.

Table 7. Annual average compound growth rates for formal employment at the sectorial level (boom scenario)

Sector	Unskilled formal		Skilled formal	
	Boom	Difference	Boom	Difference
Agriculture formal	1.43%	0.13%	1.22%	-0.08%
Coal formal	-0.46%	-1.76%	-0.67%	-1.97%
Oil formal	4.76%	3.46%	4.53%	3.23%
Metals formal	0.41%	-0.89%	0.20%	-1.10%
Non-metals formal	1.03%	-0.27%	0.82%	-0.48%
Industry formal	1.09%	-0.21%	0.88%	-0.42%
Refinery formal	0.57%	-0.73%	0.35%	-0.95%
Services formal	2.20%	0.90%	1.99%	0.69%
Public administration	1.46%	0.16%	1.25%	-0.05%

Source: CGE model simulations

The above changes in average growth rates lead in the following way into quantities of worker types demanded. Informal demand for unskilled workers in 2025 is 0.47% lower than in the baseline and for skilled workers is 1% lower. On the contrary, formal demand for workers is significantly higher. In the case of unskilled workers demand is 8.4% higher and in the case of skilled workers demand is 6.2% higher. From the standpoint of formality-informality, informal demand shrinks by 0.7% relative to the baseline, while formal demand is 6.5% higher. In terms of skill level, demand for unskilled workers is 1.9% higher in the boom scenario and demand for skilled workers is 4.1% higher.

All labour types grow at the same rate,[17] but labour demand grows at different rates.[18] While informal demand for workers grows at a slower rate than supply, formal demand grows faster than supply.[19] This means that in the boom scenario there is less space in the informal labour market to accommodate formal workers who prefer informal employment to unemployment and, at the same time, there is a net increase in demand for formal workers. As a consequence, there is less "migration" of workers from the

formal to the informal labour market segment[20] and unemployment rates in the formal segment are lower.[21] In relative terms, the unemployment rate decreases the most for skilled formal workers.

Results for the increase in the capital stock at the sectorial level are analogous to those found in the case of labour. The annual average compound growth rate for capital is higher in the boom scenario for formal agriculture, informal coal, oil, informal non-metals, informal industry, and formal and informal services. Therefore, there is in general a shift of resources from the rest of the economy to this set of sectors, especially to the oil sector.[22] The capital stock of the economy in the boom scenario is 8.4% higher than in the baseline level.

In a "standard" Dutch Disease setting, commodities produced by the informal sector would be treated as purely non-tradable and therefore the spending effect would increase their prices, further pushing the real exchange rate up. In our modeling, this type of commodities do not directly compete with imports, but their prices are "disciplined" by international prices as they are imperfect substitutes in consumption with the composite imports - "formal" commodities. As a consequence, even though there is nothing in the shock we model that changes relative prices between commodities produced by formal and informal activities (as mentioned above), their shares in total absorption change due to foreign competition.

In the boom scenario, the ratio between international prices and the prices of commodities produced by formal activities decreases with respect to the baseline, so imports increase their share in domestic absorption. On the other hand, the ratio between the price of the composite imports - "formal" commodities - and the price of commodities produced by informal activities also declines in the boom scenario, but it does so to a lesser extent. Therefore, the composite commodity increases its share in domestic absorption at the expense of "informal" commodities to a lesser degree than that experienced by "formal" commodities. As a result, we have a tendency for production of "formal" commodities to shrink by more than that of "informal" commodities.

In general, demand for domestically produced commodities decreases as a whole in the boom scenario for all commodities except for oil, non-metals, and services (the first due to international prices and the others due to input-output linkages). Within the composite imports - "formal" commodity - the share of "formal" commodities decreases in all cases with respect to the baseline and within the composite imports - "formal" commodity - the share of "informal" commodities also decreases, but it does so to a lesser extent. Although these variations are quite heterogeneous in levels across commodities, just to give an idea of the difference in shares within the two nests, it can be said that in average the decrease in shares for "formal" commodities is around 2.2%, while among "informal" commodities it is around 0.3%. Therefore, the standard spending effect is ameliorated in this case, as the prices of "informal" commodities indirectly depend upon international prices.[23]

5.2. FAE Scenario

As mentioned, part of the policy response by the Colombian government in facing potential Dutch Disease effects arising from increased oil exports is the establishment of a saving and stabilization fund (FAE for its acronym in Spanish language), targeted to withhold up to 30% of royalty revenues. These resources are meant to be invested abroad by the Central Bank and kept outside of the economy, as a classic sterilization scheme, unless needed to be used as countercyclical spending should oil prices or exported volumes decline below an expected threshold.

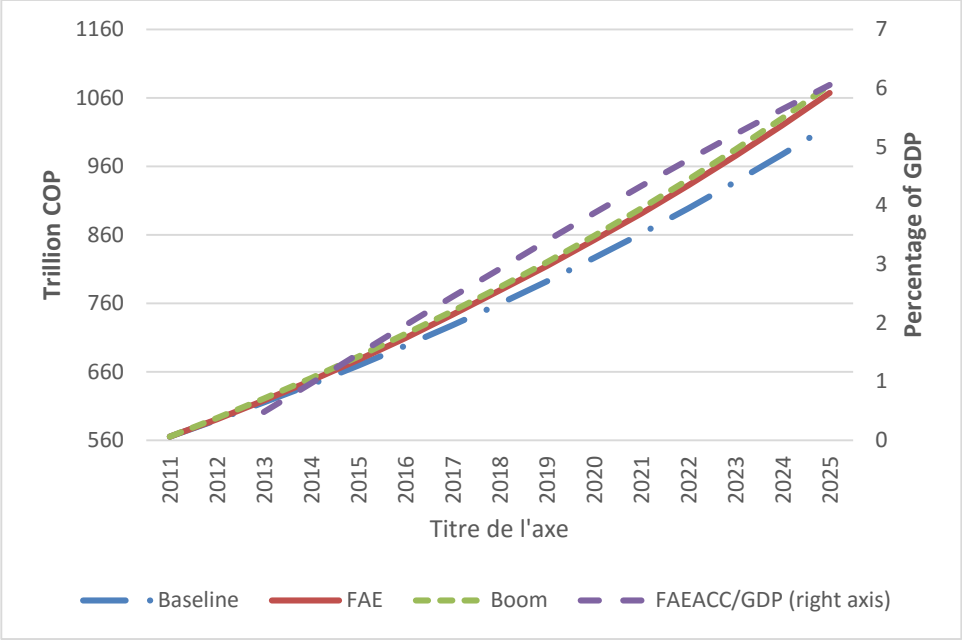
Our third scenario, identified as FAE, simulates the effects of this measure, assuming that 30% of royalty revenues are saved throughout the entire period. The expected effect of this measure is to reduce to some degree the spending effect arising from the oil boom, in this case particularly by decreasing demand for investment goods. The results from the simulation confirm this expectation. Real GDP at basic prices increases by less than in the boom scenario, as illustrated in Figure 8, while accumulated reserves in the FAE grow to reach around 6% of real GDP in 2025. This lower growth is due to the minor level of capital accumulation achieved by the sterilization scheme.

While all changes registered in the economy under this scenario essentially mimic those discussed previously in their direction but differ in level, we concentrate the discussion on the changes in variables related to the spending and the resource shift effects. The central tenet of the sterilization scheme is to curb spending to some degree. This is reflected in the behaviour of total domestic demand, demand for imports and demand for investment. We first discuss the behaviour of total domestic demand and demand for imports and leave investment demand for later.

Demand for domestically produced goods falls for all commodities except oil, non-metals, and services and it does so to a greater extent than under the boom scenario, with differences ranging between 0.7 and 1.2 percentage points. On the other hand, for the commodities whose demand increases, the increase is lower under the FAE scenario than under the boom scenario, with differences ranging between 1 and 1.6 percentage points.

On the side of demand for imports we have a similar situation. While imports partly substitute for domestically produced commodities, the degree to which they succeed is lower in the FAE scenario in the face of lower disposable income in the economy. Demand for imports decreases in all cases with respect to the boom scenario, by 2.8 percentage points in the cases of agriculture and coal, by 2.3 percentage points for metals, 3.1 percentage points for non-metals, 2.6 for industry, 1.6 for refinery, and 4.1 for services.

Figure 8. Real GDP at basic prices under the baseline, boom, and FAE scenarios



Source: CGE model simulations

Table 8. Annual average compound growth rates for informal employment at the sectorial level (FAE scenario)

Sector	Unskilled informal		Skilled informal	
	Boom	Difference	Boom	Difference
Agriculture informal	1.08%	-0.22%	0.98%	-0.32%
Coal informal	1.07%	-0.23%	0.97%	-0.33%
Metals informal	1.08%	-0.22%	0.98%	-0.32%
Non-metals informal	1.63%	0.33%	1.52%	0.22%
Industry informal	1.45%	0.15%	1.35%	0.05%
Services informal	1.35%	0.05%	1.25%	-0.05%

Source: CGE model simulations

With respect to resource shift effects, tables 8 and 9 show labour demand changes at the activity level induced under the FAE scenario. In Table 8 we can see that all changes in labour demand for informal workers follow the same trend as in the boom scenario but their sizes differ. That is, in the cases in which labour demand decreases in the boom scenario with respect to the baseline it also decreases in the FAE scenario but to a lesser extent, leading to smaller differences with respect to the baseline. In the cases in which labour demand increases in the boom scenario with respect to the baseline, in the FAE scenario the increase is somewhat dampened, so the results are closer to the baseline. The exceptions to the two observations are demand by informal coal and informal services for both unskilled and skilled workers. As could be expected, the results follow a similar pattern in the case of labour demand from formal activities. Interestingly, in the case of oil, increases in labour demand are higher for both types of workers.

At a more structural level, informal demand for unskilled and skilled workers decreases by roughly the same proportion in the FAE and in the boom scenario, yielding basically no effect from the policy intervention, while formal demand for unskilled workers increases by less and for skilled formal workers increases in the same proportion.[24] As a consequence, in the FAE scenario, informal demand for workers

decreases by the same amount as than in the boom scenario and formal demand for workers increases by slightly less. From the viewpoint of qualification, demand for unskilled workers increases by slightly less in the FAE scenario and the increase is entirely due to demand for formal workers, while demand for skilled workers increases in the same proportion as in the boom scenario. Lastly, there is a negligible negative effect of the FAE on the unemployment rate, which is 0.1 percentage points higher than in the boom scenario.

Table 9. Annual average compound growth rates for formal employment at the sectorial level (FAE scenario)

Sector	Unskilled formal		Skilled formal	
	Boom	Difference	Boom	Difference
Agriculture formal	1.31%	0.01%	1.16%	-0.14%
Coal formal	-0.33%	-1.63%	-0.47%	-1.77%
Oil formal	4.87%	3.57%	4.72%	3.42%
Metals formal	0.45%	-0.85%	0.30%	-1.00%
Non-metals formal	1.03%	-0.27%	0.89%	-0.41%
Industry formal	1.09%	-0.21%	0.94%	-0.36%
Refinery formal	0.64%	-0.66%	0.50%	-0.80%
Services formal	2.10%	0.80%	1.95%	0.65%
Public administration	1.43%	0.13%	1.28%	-0.02%

Source: CGE model simulations

In terms of capital, demand increases with respect to the baseline for oil, informal non-metals, and formal and informal services, while it decreases for the other activities. These increases are of a lower magnitude than the ones corresponding to the boom scenario in all cases except for informal non-metals. Formal agriculture, informal coal, and informal industry show relative decreases in demand for capital (i.e. their demand grows less than in the baseline), while they registered relative increases in the boom scenario. Therefore, the size of capital reallocation comes as a result of two forces: less pull from some sectors and higher push from others. The net result is that the share of the oil sector in the capital stock is larger with the FAE than in the boom scenario, so the policy intervention worsens the extent of the resource shift as far as capital is concerned.

In a more general setting, the capital stock of the economy is 6.1% higher in the FAE scenario than in the baseline, but is 2.3 percentage points below the one attained under the boom scenario. The difference is due to lower investment due to the operation of the sterilization scheme, which leads to lower demand for investment purposes for agriculture, industry, and services. These lower demand levels feed back through input-output linkages and show up in changes in factor demand, as discussed previously.

5.3. Sensitivity of results

As discussed, the sensitivity of the model's results to the elasticity of substitution in consumption between goods produced by formal activities and goods produced by informal activities is important for understanding their behaviour. In our setting, the relevant elasticity is that for substitution between the composite imports-goods produced by formal activities ("formal" goods) and goods produced by informal activities ("informal" goods). In the simulations we use an elasticity value of two, which has no empirical basis but seems a convenient value given the fact that we have only one representative household and it could be expected that, as the economy's income rises, consumers will be willing to substitute to "formal" goods consumption from "informal" goods consumption, given the presumed

higher quality of the former. In what follows, we report the most relevant results from a limited sensitivity analysis in which different values of this elasticity are used (0.5, 1, and 3) for the FAE scenario.

The first thing to notice is that real GDP shows negligible changes from one elasticity value to another (for 2025, they range from a -0.023 to a 0.035 percentage points difference with respect to the result attained for the value used as a base). Therefore, the overall performance of the economy is not the cause of changes in the behaviour of other variables of interest and vice versa, and these changes arise solely as a consequence of the use of different elasticity values.

Table 10 reports the annual average growth rates of demand for domestically produced goods by formal and informal activities under the different elasticity values. From there it follows that the growth rate of demand for goods produced by formal activities increases with the elasticity value, while that of the demand for goods produced by informal activities decreases (the only exception to this is demand for oil whose growth rate always increases, as there are no imports of this good). For the particular case of the elasticity value used as a base for reporting results, it can be seen that growth rates are the same for goods produced by both types of activities. This peculiarity does not affect the general sense of the results as should be clear in what follows.

A higher substitution elasticity favours demand for goods produced by formal activities as the appreciation of the local currency makes imports cheaper and they directly compete with them, lowering their prices relative to the price of goods produced by informal activities. From the standpoint of activities' total aggregate output, the outcome can be described as follows. As the elasticity value increases, the average annual growth rate increases for informal agriculture, formal coal, oil, formal metals, informal industry, refining, formal services, and public administration, while it decreases for formal agriculture, informal coal, informal metals, formal and informal non-metals, formal industry, and informal services. The difference between the two perspectives arises from two sources: exports by formal activities and the composition of the set of goods that activities produce. In the case of the latter, for instance, while both formal and informal agriculture produce agricultural goods, industrial goods and services, the ratio of industrial goods and services to agricultural goods produced by informal agriculture is significantly lower than that of formal agriculture.

Table 10. Average annual growth rates for domestically produced goods (FAE scenario)

Products	Formal activities				Informal activities			
	Elasticity values				Elasticity values			
	0.5	1	2	3	0.5	1	2	3
Agriculture	3.93%	3.98%	4.18%	4.45%	4.34%	4.31%	4.18%	3.89%
Coal	2.88%	3.14%	4.05%	5.30%	4.10%	4.09%	4.05%	4.00%
Oil	4.60%	4.60%	4.61%	4.63%	4.60%	4.60%	4.61%	4.63%
Metals	4.11%	4.09%	4.04%	3.98%	4.14%	4.12%	4.04%	3.91%
Non-metals	4.27%	4.29%	4.37%	4.50%	4.51%	4.48%	4.37%	4.20%
Industry	4.09%	4.11%	4.17%	4.28%	4.62%	4.53%	4.17%	3.60%
Refinery	3.90%	3.90%	3.91%	3.91%	4.50%	4.39%	3.91%	2.84%
Services	4.66%	4.66%	4.67%	4.70%	4.71%	4.70%	4.67%	4.59%
Pub. adm.	4.28%	4.28%	4.29%	4.30%				

Source: CGE model simulations

Labour demand trails changes in activities' total aggregate output and activities' labour demand shares by labour type. The resulting annual average growth rates for labour demand are shown in Table 11. As can be seen, the growth rate of labour demand by informal activities remains below the baseline figure for all elasticity values and labour types. However, as the elasticity value rises, the growth rate increases for both labour types (although it remains lower for skilled workers). The situation for labour demand

growth rates from formal activities is the opposite. First, growth rates are always above the baseline figure, and second, they decline with the elasticity value for unskilled workers while they remain at the same value for skilled workers.

Table 11. Average annual growth rates by labour type (FAE scenario)

Activity	Labour type	Baseline	Elasticity value			
			0.5	1	2	3
Informal	Unskilled	1.30%	1.26%	1.26%	1.27%	1.29%
	Skilled	1.30%	1.23%	1.23%	1.24%	1.25%
Formal	Unskilled	1.30%	1.89%	1.87%	1.80%	1.69%
	Skilled	1.30%	1.73%	1.73%	1.73%	1.73%
Informal	All	1.30%	1.24%	1.24%	1.25%	1.27%
Formal	All	1.30%	1.76%	1.75%	1.74%	1.72%
All	Unskilled	1.30%	1.43%	1.43%	1.41%	1.40%
All	Skilled	1.30%	1.59%	1.59%	1.59%	1.59%

Source: CGE model simulations

At a more aggregated level, growth rates for labour demand by informal activities increase with the elasticity while those related to formal activities decrease. Nonetheless, it should be noted that the former stays below the baseline figures while the latter remains above. That is, the international oil price boom favours labour demand by formal activities, but it does so relatively less as the elasticity of substitution between goods produced by formal and informal activities grows larger. On the other hand, growth rates for both unskilled and skilled labour demand are larger in the FAE scenario than in the baseline, but those for unskilled workers decrease when the elasticity value increases, but stay at the same level in the case of skilled workers.

From all of the above, it can be said that changes in the elasticity value examined in this section do affect the levels of the results obtained, but they do not alter their direction, conferring validity to the general sense of the analysis presented in the previous sections.

VI. Conclusions and policy implications

We have examined the likely effects of an oil price boom, sustained until 2025 and behaving according to price projections made in 2011, before the 2015 price plunge in international markets. According to our estimations, the annual average growth rate of the Colombian economy would have been 0.42 percentage points higher than projected in the baseline, leading to an economic production being 10.4 percentage points larger in 2025.

This stronger growth would have been led by oil exports, which in 2025 would reach 56% of the total export value as compared to 39% in the baseline. The higher inflow of foreign exchange, almost 30% above that in the baseline, would generate a 13% depreciation of the real exchange rate, with the concomitant disincentive for exports other than oil.

The higher income accruing to the economy pushes domestic absorption up which is basically met by increased imports since domestic production shifting from exports to the domestic market is incapable of keeping pace with increased demand. Import penetration at the product level increases in all cases, varying from 0.2 to 6.6 percentage points depending on the specific product.

The mix of lower exports and lower demand for domestically produced goods leads to lower production levels for the majority of products. The exceptions to this are oil, non-metallic minerals, and services,

which in spite of facing higher imports show increased domestic production. The transmission of these changes to the sector level is mediated by the fact that activities may produce more than one commodity and, furthermore, may be formal or informal.

As a result, at the sectorial level, while in terms of gross product at current prices all activities but formal coal (which suffers a negative international price shock) grow faster than in the baseline, most sectors grow less in total quantity produced. While formal agriculture, oil, informal non-metals, informal industry, and formal and informal services grow more than under the baseline, the remaining nine sectors shrink.

These changes determine the extent to which factor demand behaves. As could be expected, labour demand in the cases of activities that expand total production faster under the oil price boom tends to grow more while for the rest of sectors it does the opposite. However, with the exception of the oil sector, demand for skilled workers for these sectors increases at a slighter slower pace than in the baseline. A similar behaviour is observed with respect to capital use. The sectors whose total physical production increases more rapidly under the oil boom scenario show higher relative increases in capital use.

Notwithstanding this resource shift effect, it is possible to further qualify the effects of the oil boom in terms of demand for labour. In the aggregate, in the oil boom scenario demand for skilled workers increases by more than demand for unskilled workers (even though both increase more than in the baseline), while demand for formal workers increases by more and demand for informal workers increases by less. Therefore, the oil boom shifts incentives in the labour market in favour of skilled formal workers.

The sectorial composition of the economy, in terms of its gross value, shifts in favour of the oil and services sectors as compared to the baseline and oil and mining-related governmental income as a share of total governmental income increases from 10.8% in the baseline to 14.7% in the oil boom scenario.

It is important to notice that, although the informal activities do not export nor do they directly compete with imports, there is nothing in the shock that affects relative prices for the like products produced in the formal and informal sectors. Therefore, the proportion in which the economy produces goods in the formal and informal sectors remains unaltered (although this result is also dependent upon the elasticity of substitution in consumption between goods originating from the formal and informal sectors). As agents in the economy demand a composite good that mixes imports with goods generated in the formal sectors in the first place, and then with goods produced in the informal sectors, prices for the latter are indirectly disciplined by international prices, ameliorating the usual Dutch Disease effect that leads to an increase in the prices of non-tradables (or a decrease, depending on their degree of substitutability with formal products).

In sum, a sustained oil price boom would lead to both resource shift and spending effects in the economy with the consequent relative erosion of its export base and some degree of "deindustrialization". The operation by the government of the FAE tends to lower these effects, with some caveats, but it does so to a relatively limited degree. A more successful intervention should probably be comprised of a more aggressive savings strategy and increased spending in the provision of public goods that may affect the productivity of non-boom sectors (like roads, applied research, education, and infrastructure in general). On the other hand, the lower dynamics of demand for unskilled labour, especially from informal activities, calls for increased governmental action in the provision and quality enhancement of educational services, in line with the expected behaviour of the labour market.

Along with the FAE, the government created two other funds, a regional compensation fund and a regional development fund (FCR and FDR, respectively, for their acronyms in Spanish). The first is aimed at channelling social spending into local projects, basically as a way to redistribute non directly productive spending across regions, and the second is targeted to develop regional productive projects. The latter was designed to start operations in 2014, a moment at which the set of projects it could carry out would

begin to be defined. As further work, we will extend the model to appraise the likely impact that the implementation of the FDR may have for improving governmental intervention for facing Dutch Disease.

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Annex

Implementation of the composite commodity

$$QF_{i,t} = B\_M_i * \left[\beta\_M_i * IM_{i,t}^{-\rho\_M_i} + (1 - \beta\_M_i) * DDF_{i,t}^{-\rho\_M_i} \right]^{\left(-1/\rho\_M_i\right)}$$

$$IM_{i,t} = \left[\frac{\beta\_M_i}{(1 - \beta\_M_i)} * \frac{PDF_{i,t}}{PM_{i,t}} \right]^{\sigma\_M_i} * DDF_{i,t}$$

$$Q_{i,t} = B\_Q_i * \left[\beta\_Q_i * QF_{i,t}^{-\rho\_Q_i} + (1 - \beta\_Q_i) * DDI_{i,t}^{-\rho\_Q_i} \right]^{\left(-1/\rho\_Q_i\right)}$$

$$QF_{i,t} = \left[\frac{\beta\_Q_i}{(1 - \beta\_Q_i)} * \frac{PDI_{i,t}}{PQF_{i,t}} \right]^{\sigma\_M_i} * DDI_{i,t}$$

$$DD_{i,t} = B\_DD_i * \left[\beta\_DD_i * DDF_{i,t}^{-\rho\_DD_i} + (1 - \beta\_DD_i) * DDI_{i,t}^{-\rho\_DD_i} \right]^{\left(-1/\rho\_DD_i\right)}$$

$$DDF_{i,t} = \left[\frac{\beta\_DD_i}{(1 - \beta\_DD_i)} * \frac{PDI_{i,t}}{PDF_{i,t}} \right]^{\sigma\_DD_i} * DDI_{i,t}$$

$$PDF_{i,t} = (1 + ttic_{i,t}) * \left[PL_{i,t} + \sum_i PC_{i,t} * tmrg_{ij,i} \right]$$

$$PDI_{i,t} = \left[PL_{i,t} + \sum_i PC_{i,t} * tmrg_{ij,i} \right]$$

$$PC_{i,t} * Q_{i,t} = (PQF_{i,t} * QF_{i,t}) + (PDI_{i,t} * DDI_{i,t})$$

$$PQF_{i,t} * QF_{i,t} = (PDF_{i,t} * DDF_{i,t}) + (PM_{i,t} * IM_{i,t})$$

Where:

$QF_{i,t}$: $Quantity\ demanded\ of\ "formal"\ composite\ commodity\ i$
$IM_{i,t}$: $Quantity\ of\ product\ i\ imported$
$DDF_{i,t}$: $Demand\ for\ domestic\ formally\ produced\ commodity\ i$
$Q_{i,t}$: $Quantity\ demanded\ of\ composite\ commodity\ i$
$DD_{i,t}$: $Domestic\ demand\ for\ commodity\ i\ produced\ domestically$
$PDF_{i,t}$: $Price\ of\ "formal"\ composite\ commodity\ i$
$PM_{i,t}$: $Price\ of\ imported\ product\ i\ (including\ all\ taxes\ and\ tariffs)$
$PDI_{i,t}$: $Price\ of\ "informal"\ domestic\ product\ i\ sold\ in\ the\ domestic\ market$
$PQF_{i,t}$: $Price\ of\ "formal"\ composite\ commodity\ i$
$PL_{i,t}$: $Price\ of\ local\ product\ i\ (excluding\ all\ taxes\ on\ products)$
$PC_{i,t}$: $Purchaser\ price\ of\ composite\ comodity\ i\ (including\ all\ taxes\ and\ margins)$
B_M_i: $Scale\ parameter\ (CES\ -\ composite\ "formal"\ commodity)$
β_M_i: $Share\ parameter\ (CES\ -\ composite\ "total"\ commodity)$
ρ_M_i: $Elasticity\ parameter\ (CES\ -\ "formal"\ composite\ commodity)$
σ_M_i: $Elasticity\ (CES\ -\ composite\ "formal"\ commodity)$
B_Q_i: $Scale\ parameter\ CES\ (composite\ "total"\ commodity)$

β_Q_i: $Share\ parameter\ (CES\ -\ composite\ "total"\ commodity)$
ρ_Q_i: $Elasticity\ parameter\ (CES\ -\ "total"\ composite\ commodity)$
σ_Q_i: $Elasticity\ (CES\ -\ composite\ "total"\ commodity)$
B_DD_i: $Scale\ parameter\ (CET\ -\ "composite\ domestic\ formal-informal"\ commodity$
β_DD_i: $Share\ parameter\ (CET\ -\ "composite\ domestic\ formal-informal"\ commodity)$
ρ_DD_i: $Elasticity\ parameter\ (CET\ -\ "composite\ domestic\ formal-informal"\ commodity)$
σ_DD_i: $Elasticity\ (CET\ -\ "composite\ domestic\ formal-informal"\ commodity)$
$ttic_{i,t}$: $Tax\ rate\ on\ commodity\ i$
$tmrg_{ij,i}$: $Rate\ of\ margin\ i\ applied\ to\ exported\ commodity\ i$

Implementation of the labour market

$$\left(LS_{lf,t} - MIGR_{lf,t}\right) * \left(1 - UERAT_{lf,t}\right) = \sum_j LD_{lf,j,t}$$

$$\left(LS_{li,t} + \sum_{lf} MIGR_{lf,t}\right) = \sum_j LD_{li,j,t}$$

$$MIGR_{lf,t} = \zeta_{lf} * \left\{\frac{\sum_{li} W_{li,t}}{\left(1 - UERAT_{lf,t}\right) * W_{lf,t}}\right\}^{\psi_l}$$

$$WREAL_{l,t} = \frac{W_{l,t}}{PIXCON_t}$$

$$WREALMIN_{lf,t} = \frac{WO_{lf,t}}{PIXCONO}$$

$$WREAL_{lf,t} \geq WREALMIN_{lf,t}$$

$$min\left(UERAT_{lf,t}\right) = ueratmin_{lf}$$

Where:

$LS_{l,t}$ $Supply\ of\ type\ l\ labour$
$MIGR_{lf,t}$: $Formal - informal\ "migration"$
$UERAT_{l,t}$: $Unemployment\ rate\ factor\ l$
$LD_{l,j,t}$: $Demand\ for\ type\ l\ labour\ by\ industry\ j$
$W_{l,t}$: $Nominal\ wage\ for\ type\ l\ labour$
$WREAL_{l,t}$: $Real\ wage\ rate\ factor\ l$
$PIXCON_t$: $Consumer\ price\ index$
$WREALMIN_{lf,t}$: $Minimum\ real\ wage\ rate\ factor\ l$
$WO_{lf,t}$: $Wage\ rate\ of\ type\ l\ labour\ (base\ year)$
$PIXCONO$: $Consumer\ price\ index\ (base\ year)$
$ueratmin_{lf}$: $Minimum\ unemployment\ rate\ factor\ l$
ζ_{lf}: $scale\ parameter\ for\ the$ migration $of\ labour\ type\ l$
ψ_l: $Elasticity\ of\ "migration"\ for\ labor\ type\ l\ with\ respect\ to\ relative\ wages$

Implementation of royalties and oil dividends payments

$$YGREG_t = \sum_{nr}\left[\lambda\_RK_{gvt,nr} * \sum_{j}\left(R_{nr,j,t} * KD_{nr,j,t}\right)\right]$$

$$YGDIP_t = \sum_{f} FDIP_{f,t}$$

$$YGDIO_t = \omega\_DV_{gvt,dio} * \sum_{f} FDIO_{f,t}$$

$$YROWDIV_t = \omega\_DV_{row,div} * \sum_{f} FDIV_{f,t}$$

$$YHDIV_t = \omega\_DV_{h,div} * \sum_{f} FDIV_{f,t}$$

$$FDIV_{f,t} = \omega\_FD_{div,f} * YFK_{f,t}$$

$$FDIO_{f,t} = \omega\_FD_{dio,f} * YFK_{f,t}$$

$$FDIP_{f,t} = \omega\_FDIP_f * \sum_{ka,joil} TDIP_{ka,joil,t} * KD_{ka,joil,t} * R_{ka,joil,t}$$

$$TDIP_{ka,joil,t} = tdipO_{ka,joil}\left[\frac{e_t * PWX_{coil,t}}{PE\_FOB_{coil,t}}\right]^{\sigma\_REG_{joil}}$$

Where:

$YGREG_t$: $Government's\ income\ form\ royalties$
$R_{nr,j,t}$: $Rental\ rate\ of\ type\ k\ capital\ in\ industry\ j$
$KD_{nr,j,t}$: $Demand\ for\ type\ k\ capital\ by\ industry\ j$
$YGDIP_t$: $Government's\ income\ form\ oil\ dividends$
$FDIP_{f,t}$: $Firms´payments\ of\ oil\ dividends$
$YGDIO_t$: $Government's\ income\ form\ non-oil\ dividends$
$FDIO_{f,t}$: $Non-oil\ governmental\ firms\ dividends$
$YROWDIV_t$: $ROW's\ income\ from\ dividends$
$FDIV_{f,t}$: $Firms'\ payments\ for\ dividends$
$YHDIV_t$: $Households'\ income\ from\ dividends$
$YFK_{f,t}$: $Capital\ income\ of\ type\ f\ businesses$
$TDIP_{ka,joil,t}$: $Tax\ rate\ on\ oil\ (endogenous)$
e_t: $Exchange\ rate\ (price\ of\ foreign\ currency\ in\ local\ currency)$
$PWX_{coil,t}$: $World\ price\ of\ exported\ product\ i\ (expressed\ in\ foreign\ currency)$
$PE\_FOB_{coil,t}$: $FOB\ price\ of\ exported\ commodity\ i\ (in\ local\ currency)$
$\lambda\_RK_{gvt,nr}$: $Share\ of\ type\ k\ capital\ income\ received\ by\ agent\ ag$
$\omega\_DV_{gvt,dio}$: $Agents\ share\ in\ income\ from\ dividends$

$\omega\_FD_{div,f}$: $Dividends\ share\ in\ firms\ capital\ income$
ω_FDIP_f: $Firm's\ type\ share\ in\ oil\ dividends$
$tdipO_{ka,joil}$: $Tax\ rate\ on\ oil\ (gov't\ dividends)$
σ_REG_{joil}: $Elasticity\ of\ oil\ dividends\ to\ international\ prices$

Implementation of FDI for oil and mining

$$CAPFLOW_t = SROW_t - FDIMIN_t$$

$$GFCF_t = IT_t - \left(\sum_i PC_{i,t} * VSTK_{i,t}\right) + FDIMIN_t$$

$$IT_t = \sum_h SH_{h,t} + \sum_f SF_{f,t} + SG_t + CAPFLOW_t$$

$$IT\_PRI_t = IT_t - IT\_PUB_t - \left(\sum_i PC_{i,t} * VSTK_{i,t}\right) + FDIMIN_t$$

$$IT\_PRI_t = PK\_PRI_t * \left(\sum_{k,bus} IND_{k,bus,t}\right) + FDIMIN_t$$

$$KD_{k,j,t} = KD_{k,j,t-1} * \left(1 - \delta_{k,j}\right) + IND_{k,j,t-1} + fdishr_{k,j} * FDIMIN_t$$

Where:

$CAPFLOW_t$: $Capital\ flow\ from\ ROW\ net\ of\ Foreign\ Direct\ Investment\ in\ mining$
$SROW_t$: $Rest - of - the - world\ savings$
$FDIMIN_t$: $FDI\ in\ the\ oil\ and\ mining\ sectors\ (in\ local\ currency)$
$GFCF_t$: $Gross\ fixed\ capital\ formation$
IT_t: $Total\ investment\ expenditures$
$PC_{i,t}$: $Purchaser\ price\ of\ composite\ comodity\ i\ (including\ all\ taxes\ and\ margins)$
$VSTK_{i,t}$: $Inventory\ change\ of\ commodity\ i$
$SH_{h,t}$: $Savings\ of\ type\ h\ households$
$SF_{f,t}$: $Savings\ of\ type\ f\ businesses$
SG_t: $Government\ savings$
IT_PRI_t: $Total\ private\ investment\ expenditures$
IT_PUB_t: $Total\ public\ investment\ expenditures$
PK_PRI_t: $Price\ of\ new\ private\ capital$
$IND_{k,bus,t}$: $Volume\ of\ new\ type\ k\ capital\ investment\ to\ industry\ j$
$\delta_{k,j}$: $Depreciation\ rate\ of\ capital\ k\ in\ industry\ j$
$fdishr_{k,j}$: $Share\ of\ sector\ j\ in\ capital\ type\ k\ accruing\ as\ FDI$

Implementation of the FAE

$$YGFAE_t = faeintrat * FAEACC_t$$

$$FAE_t = faerat_t * YGREG_t$$

$$SROW_t = YROW_t - \left(\sum_i PE_{FOB_{i,t}} * EXD_{i,t}\right) - \left(\sum_{agd} TR_{agd,t}\right) + FAE_t - YGFAE_t$$

$$FAEACC_{t1} = FAEACCO$$

$$FAEACC_t = FAE_{t-1} + FAEACC_{t-1}$$

Where:

$YGFAE_t$: $Government\ interest\ income\ from\ the\ FAE$
$FAEACC_t$: $Funds\ cumulated\ in\ the\ FAE$
FAE_t: $Fondo\ de\ Ahorro\ y\ Estabilizacion$
$YROW_t$: $Rest - of - the - world\ income$
$EXD_{i,t}$: $World\ demand\ for\ exports\ of\ product\ i$
$TR_{agd,t}$: $Transfers\ to\ domestic\ agents$
$FAEACCO$: $Initial\ funds\ accumulated\ in\ the\ FAE$
$faeintrat$: $Interest\ rate\ for\ the\ FAE$
$faerat_t$: $share\ of\ royalties\ income\ destined\ to\ the\ FAE$