Working paper

Commodity Booms, Human Capital, and Economic Growth. An Application to Colombia

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policy analysis on growth and employment

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Abstract

Empirical research has shown the pro-cyclical behavior in the child labor and income shocks. We want to model the idea that a trade-off exists between the current level of consumption and the future levels of human capital. As shocks in the international prices of commodities affect current income and modify the optimal consumption basket, households adjust their preferences between schooling time and working time for the younger (school-aged) household members. Therefore, the dynamics of human capital accumulation can be affected and, with it, the prospects for economic growth and the sectorial composition of the economy, when commodity production and trade play a significant role in the economy.

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Keywords: Commodity Booms; Human Capital; Labor Child; CGE modeling, Colombia.

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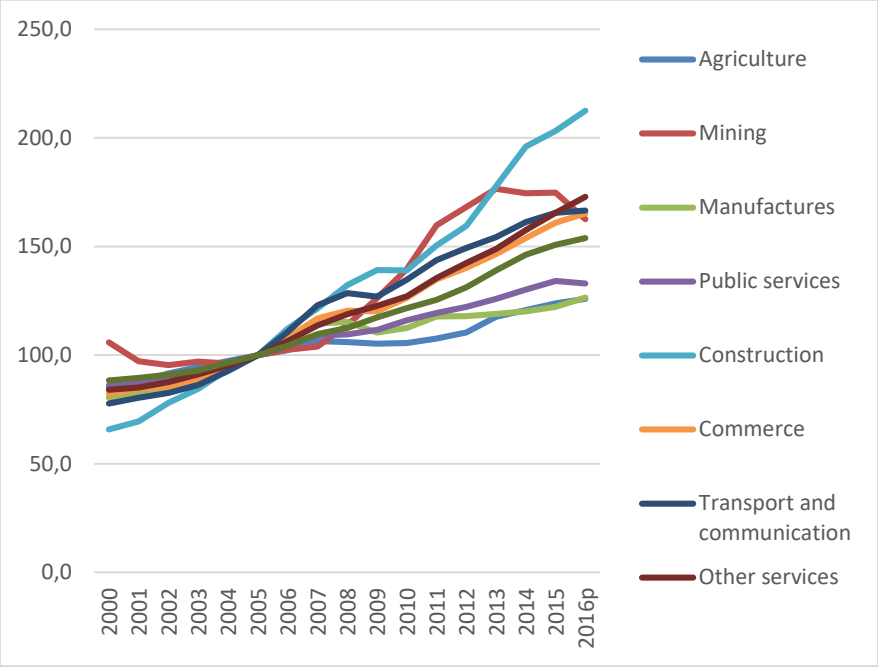
1. Introduction

The motivation for this research is the empirical observation that child labor and income shocks behave in a pro-cyclical manner. That is, in trying to take advantage of expansive periods (with higher general income levels), households withdraw kids from the school system and send them to work at the expense of human capital formation. In this direction, Santos (2014) shows the implications of gold boom on child labor and school attendance in Colombia. According to this paper, the gold boom decreases school attainment in 0.2 standard deviations. The transmission mechanism is clear, the substitution effect dominates income effect, and children leave the school to take advantage from the mining bonanza. The return to school system after prosperity is really scarce. After bonanza children prefer to still working than return to the school because of the starting to earning money.

Beegle, Dehejia and Gatti (2006) examine the relationship between household income shock and child labor. The results show the pro-cyclical relation between income shocks and child labor. Particularly, the authors found that a transitory shock in crop prices in Tanzania increases the child labor in approximately 30%. The same mechanism was presented in Kruger (2007) for coffee production in Brazil. The empirical evidence shows how the education of poor and middle-income children may be adversely affected in the periods of economic growth. Cogneau and Jedwab (2012) explore this mechanism in the context of cocoa prices in Ivory Coast indicating that positive price shocks increased the incidence of child labor.

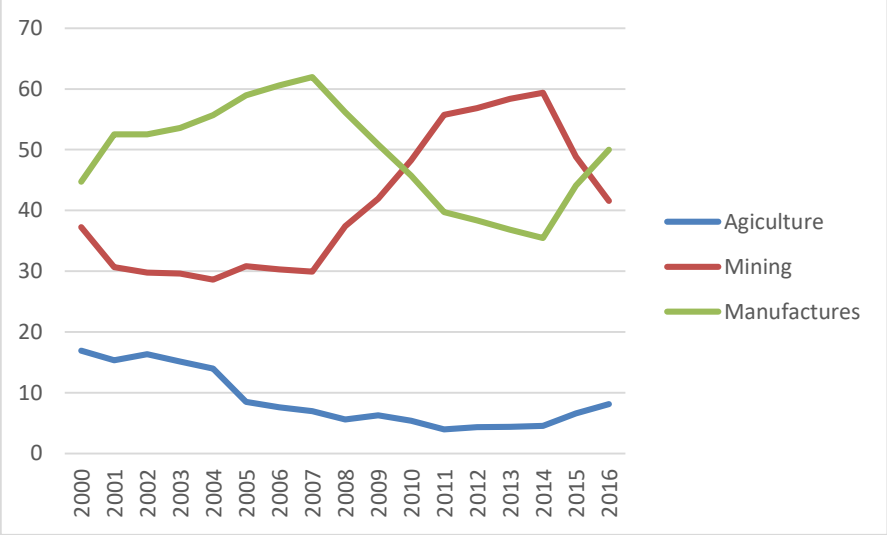
From production side, Colombia has had a boom in the production of commodities since 2009. The high prices on mining-energetic products has promoted the production of this sector, and at the same time, has drove some complementary sectors to this. In particular the services sector has received some stimulus form this bonanza. The figure 1 shows the importance of mining sector in Colombian GDP after international financial crisis. However the figure 2 is more illustrative to show the commodity boom between 2009 and 2015 through the share of sectors in total exports for Colombian economy.

Figure 1: Sectorial production volume index for the Colombian economy (2005=100)



Source: DANE

Figure 2: Share by sectors in total Colombian exports

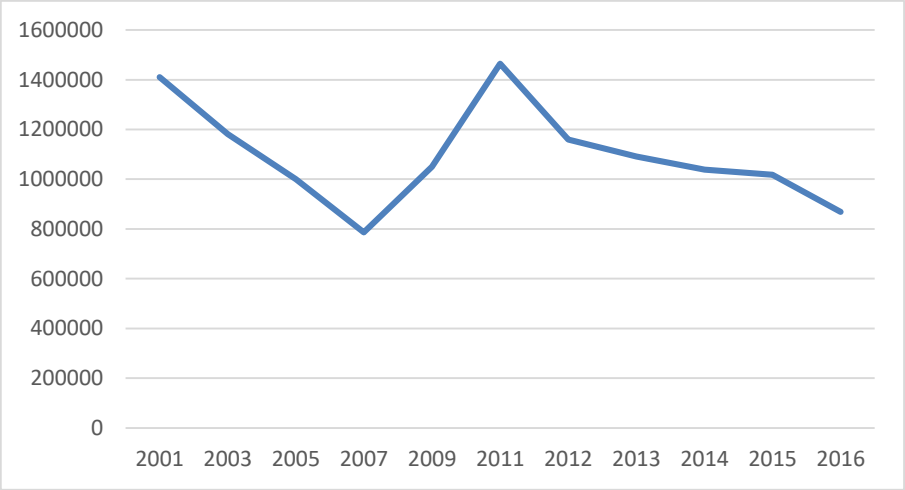


Source: DANE

On the labor market, child labor rate in Colombia was estimated at 9.3% for 2014, which means that about 1.04 million children in the ages between 5 and 17 are working. There is also a wide disparity between child labor rates in Colombia between urban and rural areas, as its incidence in the former was 7.1% in 2014 and 15.1% in the latter. According to figures from the largest Colombian household survey, only 70% of the children that are working attend school. Furthermore, according to the Colombian Ministry of Education, just 60% of the students entering the school system make it through graduation from high school and the within year drop-out rate is 3.6%, so about half the students getting into the school system exit before completion. This high dropout rate is explained the most of times by the insertion of children in labor market.

The impact of this issue extends beyond potential increases in child labor directly linked to the sector affected by the commodity boom (although in sectors such as coffee growing it may be important). The figure 3 shows the estimation of children working around the country for latest years. The recent peak on child labor for Colombia coincide with the boom on commodities. This is not a conclusive demonstration for the relation between commodity booms and child labor but it shows a positive correlation between these two variables.

Figure 3: Number of children working



Source: GEIH-DANE

At the beginning of the millennium, the number of children working in handmade mining in Colombia was estimated between 200000 and 400000, Heck and Ipenza (2014). For instance, there is statistical and anecdotal evidence that child labor may increase in sectors that provide inputs or services to the booming sector, such as hotels, restaurants, commerce, and other personal services, as the experience of the oil boom has shown. Also, even in the case that there are no sizeable economy-wide effects of an increase in child labor due to the activity of a booming sector, regional and local effects may prove significant and only multi-sector modeling could provide clues as to their size.

There is a clear link between human capital and schooling as human capital is "the component of education that contributes to an individual's labor productivity and earnings" (Son, 2010, p. 2). There is a sizeable set of empirical studies documenting a positive relationship between human capital and economic growth. For example, Azariadis and Drazen (1990) show that the literacy rate is significant in determining per capita GDP growth, while Mankiw, Romer, and Weil (1992) find relatively large elasticities of per capita GDP to enrollment rates. Barro and Lee (2010) also find an elastic response of per capita GDP to an additional year of schooling of the labor force.

Nonetheless, there is a body of literature that asserts that the causality runs in the opposite direction as economic growth increases the returns to education and this, in turn, increases people's willingness to study and attain a higher educational level. This is the point in the works of Bils and Klenow (2000), which claim that the effect noted above has been erroneously enhanced due to omitted variable bias, and Krueger and Lindahl (2001), that claim that cross country studies do not control in an appropriate way for policies that are not stationary and lack valid instrumental variables.

From the schooling to growth perspective, increases in child labor rates and, in general, the increase in drop-out rates from the school system, lower the dynamics of human capital accumulation and this hinders economic growth. From the growth to schooling perspective, economic growth that does not increase the return to years of schooling would have a negative effect on human capital accumulation. These relationships lay the ground for an inquiry into the dynamics of human capital accumulation in a context in which returns to schooling are determined by the general equilibrium effects of sectorial growth and its associated demand for different types of labor (different schooling years), while human capital accumulation is affected by household decisions tied to current income and schooling decisions, as in the child labor case depicted above, that feed-back to economic growth.

We aim to analyze this issue by means of a recursive dynamic general equilibrium model that encompasses a schooling module that allows for keeping track of human capital formation and accumulation, as will be explained in the methodology section.

In light of the above, our main research questions can be summarized as follows:

- What is the effect of commodity price shocks on human capital accumulation at the economy-wide level?

- How do these effects feed-back into the composition of the labor force in terms of the distribution of their years of schooling?

- How does the (changing) composition of the labor force interact with the demand for labor?

- What does this interaction imply at the sectorial level?

- What is the effect of the dynamics of human capital accumulation on GDP growth in the medium term?

2. Data

We build a 2014 SAM for Colombia to run the CGE model and the simulations. It is useful to employ the macro data 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 sectorial breakdown of the economy, in terms of value added shares, labor demand shares, and capital income shares. For this illustration we split the economy into eleven broad sectors: agriculture; mining; primary sector; other industries; industry; refinery and metals; services; financial services; other services; education services; and public administration). From the data in the table 1 it can be appreciated that services account for the bulk of the economy (59.8% of value added in total), while the mining sector represents around 9% of value added and agriculture 3.8% respectively.

Table 1: Sectorial composition of the Colombian economy, 2014

Sector	Value added share	Labor share	Capital share
Agriculture	3.8	5.8	1.3
Mining	9.3	2.3	18.2
Primary sector	4.3	5.3	3
Other industries	1.2	1.3	1.2
Industry	3.2	4.2	2
Refinery and metals	6.2	2.5	10.8
Services	30.6	32.7	27.9
Financial services	12.3	12.9	11.4
Other services	16.9	13.7	21.1
Education services	5.2	8.3	1.1
Public administration	7.1	11	2

Source: DANE

In relation to the factor shares, services embody 53.3% of labor payments being the most labor intensity sector of these activities. The lowest labor share belongs to the mining sector as could be expected from an activity widely characterized by its capital intensity.[1] On the side of the capital shares, the sector with the highest participations is services and mining and those with the lowest are educational services and agriculture. However, if we compare each sector's value added share with its capital share, it becomes clear that mining, and industry are relatively capital intensive, the first being the most capital intensive.

The figures we have commented about should be taken just as approximations to the "true" factor shares. This is so since mixed income, a mixture of capital and labor, is still in the picture and it distorts the measurement of the factor shares.[2] Mixed income represents 24.4% of value added in the economy, and its distribution among sectors.

On other side, parameters corresponding disaggregation on labor remuneration and home expenditure, are taken from Colombian National Home Survey (Gran Encuesta Integrada de Hogares - GEIH) and Livelihood Survey (Encuesta Nacional de Calidad de Vida- ENCV) for 2014.

GEIH is aimed to produce basic information about size and structure of country's labor force (employment, unemployment and income). It also measures general aspects of people surveyed, such as housing, access to public services, social protection, gender, education, among others. That information is available for country, state, region and municipality levels, and is collected monthly for the whole nation and 13 cities; quarterly for 24 cities or metropolitan areas; biannual for regions; and annual for states (see Table 2).

[1] We do not consider other industries sector for this particular analysis because is part of industry sector

[2] We will distribute the mixed income between factor remuneration through an estimation of Mincer equations.

On the other hand, ENCV is an important referent to collect indicators of social and economic phenomena which support research and policy making. It provides data about home's socioeconomic issues, i.g., shares of home expenditures in different sectors. The survey covers nation and regional levels of the country, including eight regions: Antioquia, Pacífico, Centro, Oriente, Atlántico, Bogotá-Soacha, Orinoquia-Amazonia, y San Andrés y Providencia (see Table 3).

To disaggregate labor remunerations based on GEIH 2014, we used estimations from Mincer equation to correct bias resulting from the tendency of independent workers and employers to report incomes which could be accounted by labor remuneration, mixed income or gross surplus of exploitation. We add labor remunerations according to: kind of job (employees, independents and employers), geographic area (rural, urban, and metropolitan) and individual aspects (qualified: who has achieved post-secondary levels of education, non-qualified: below secondary levels).

We used the next classification of economic activities of productive units where employed surveyed are located: public administration, trade, mining, agriculture, basic education and higher education. We estimated the participation of each of those sectors on remuneration of every kind of labor. These shares where used to disaggregate labor remuneration in the SAM 2014 for Colombia.
Before making simulations of policies considering home location (rural, urban and metropolitan), we disaggregate a representative home expenditure in rural, urban or metropolitan. We used ENCV to disaggregate savings and consumption of SAM's homes.

Next, we calculate representative consumption baskets for each kind of household; we first reclassified survey's expenditure items into the accounting system used by SAM; and then, we added all home expenditures for each SAM's item. Finally, we estimate participation of different homes in total survey's expenditures; those values are used to obtain separately consumption vectors of each type of household.

In addition, we specified income distribution among types of household, considering geographical location (metropolitan area, head and rest). Then, we calculated remunerations for three types of work: qualified, non-qualified and childlike. Direct transfers from other institutional sectors were distributed to households according to the share receive by everyone; those transfers were calculated based on GEIH.

Table 2: Colombian National Home Survey - GEIH

Information	**Source:** Gran Encuesta Integrada de Hogares (GEIH)
General description of the source	The Gran Encuesta integrada de Hogares (GEIH), is a survey that solicits information about the employment conditions of people (do they work, what do they work for, how much do they earn, if they have social security in health or if they are looking for work), in addition to the general characteristics of the population such as gender, age,

	marital status and educational level, it is asked about their sources of income. It is a probabilistic, multistage, stratified sampling survey of unequal and self-weighted conglomerates (for the twenty-four capital cities with their Metropolitan areas)
What is the level of coverage of the data provided there? (National, Regional, city)	The GEIH provides the country with information at the national level, head-rest, regional, departmental, and for each of the capitals of the departments. The disaggregation of the results of the GEIH in turn are: **Monthly:** Total National and, total 13 cities **Quarterly:** National Total by head, rest and cities or metropolitan areas. **Semestral:** Regions **Anual:** Departments.
What is the sample size / records available?	Approximately 62,000 households are visited annually (30,000 households in 13 areas, 14,400 in the Rural Zone and 17,500 in 11 cities).
What internal indicators are used for quality control?	Indicators of Reliability (Coverage of Homes and Households) and Quality (Response Rate) that ensure the quality of the collection and the precision estimators of the results (sampling error less than or equal to 5% with a reliability level of 95%).
What is the level of statistical significance?	With the current sample for the current GEIH it is possible to estimate, on average, statistically significant variations of 1.5 percentage points of the monthly unemployment rate, with 95% confidence.
Methodology used.	For people 10 years and older, a direct informant is accepted. For people 10-17 years old who are not working or are not looking for a job, a suitable informant is accepted as well as for people who have disabilities and cannot answer the survey themselves. No information should be accepted from employees of domestic service, retired, neighbors or minors, except when the minor is the head of the household or spouse.

What reports / studies are derived from the information?	Press release, monthly statistics bulletin and website: www.dane.gov.co
How often are reports generated? (Both from the source itself, as of the reports / studies)	Monthly since August 2006. The information collection period is weekly for the 32 cities with their metropolitan area and monthly for head and rest.
Who are the users of the information?	Research centers
Where is the information available to be consulted?	www.dane.gov.co
Who is responsible for processing the data?	Dirección de Metodología y Producción Estadística DIMPE- DANE
What are the requirements that must be done to access?	An account must be created on the DANE website (without cost) and specify the purposes of the investigation. The anonymity of the respondents must be guaranteed.

Source: Own elaboration

Table 3: Livelihood Survey - ENCV

Information	**Source:** Encuesta Nacional de Calidad de Vida
General description of the source	This research quantifies and characterizes the living conditions of Colombians including variables related to **housing** (material of walls, floors and public services), **people** for which variables of: education, health, childcare, strength of work, expenses and income, etc. are included, and **households** that involve variables such as: possession of assets and perception of the boss or spouse on living conditions in the home.
What law or regulations apply for the construction of the survey?	Confidentiality policy: Law 79 of 1993. Copyright Law (1032 of 2006)
How is the information recorded?	The information is recorded by the pollster on mobile storage devices with the supervision of an official. Subsequently, it is consolidated and sent to the DANE headquarters in Bogotá where it is validated according to quality criteria.
What internal indicators are used for quality control?	Coverage indicators. Response rate. Quality of the collection.

	Indicators of errors and inconsistencies. Alarms: High number of vacant homes, high number of rejections, low average of people, among others.
What is the level of coverage of the data provided there? (National, Regional, city)	The survey is significant at the national level, head-rest. 9 regions Antioquia, Pacífico, Centro, Oriente, Atlántico, Bogotá-Soacha, Orinoquía-Amazonía, and San Andrés y Providencia.
What is the size of the sample / records with which it is counted?	21.383 homes nationwide.
What is the level of statistical significance that it used?	For the rural area, error occurred in 7% of the estimates. In urban area it is 5%. The level of significance is 95%.
Methodology used.	Multipurpose interview with an average duration of 1.5 hours per interview. Collection of information on mobile devices. The information is collected between September and October with prior sensitization to households and training to the interviewers. The average performance of the pollster is 7 daily surveys in urban areas.
What reports / studies are derived from the information?	Press releases, press bulletins containing the general results at the national and regional levels. Annexes with more specific information on the website
How often are reports generated? (Both from the source itself, as of the reports / studies)	1993, 1997, 2003, 2008 y yearly since 2010.
Who are the users of the information?	Research centers
Where is the information available to be consulted?	The information with the metadata and the questionnaires for the different modules are available on the website of the institution.
Who is responsible for processing the data?	Dirección de Metodología y Producción Estadística DIMPE-DANE.
What are the requirements that must be met to access?	An account must be created on the DANE website (without cost) and specify the purposes of the investigation. The anonymity of the respondents must be guaranteed.

Source: Own elaboration.

3. The methodology

For attaining the objectives listed above, we will use a recursive dynamic applied general equilibrium model. In particular, we will start with the single country, recursive dynamic version of the Partnership for Economic Policy (PEP) model, fully documented in Decaluwé et al (2012). This model extends to multiple periods the single-period PEP-1-1 model, by linking successive periods through a set of variables that are inherited from the previous one and transmitted to the following one by a set of "dynamic equations". The model belongs to the neoclassical tradition, in a perfect competition setting, and agents' behavior is drawn from optimization problems. Since, as mentioned, the model has a thorough documentation, we do not expand here in describing it. Instead, we focus on the changes we plan to introduce in order to achieve our objectives.

The main change we introduce to the model has to do with household's behavior. While in the standard setting households' endowments of production factors are exogenous to the household, and (aside from transfers) their income is given once salaries and capital rents are determined in equilibrium, we follow Cloutier, Cockburn and Decalawé (2008) in making human capital endogenous to the household decision making process. In this context, households decide every period how much they demand for education services and, consequentially, how much they increase human capital in the form of their stock of skilled workers.

Hence, we posit that there is a trade-off between schooling decisions and current household income. In the face of potentially higher relative wages for unskilled workers, households may decide to stop the school cycle of some of their members in return for higher current income to the detriment of future human capital (skilled labor). We aggregate the sectorial composition of the economy to eleven production sectors (AGR: agriculture; MIN: mining; PRI: primary sector; OIN: other industries; IND: industry; RME: refinery and metals; SER: services; FIN: financial services; OSE: other services; EDU: education services; ADM: public administration), and consider two labor categories (unskilled and skilled),[3] while including three household types depending on their geographical location (head, rest and cities or metropolitan areas).

On the production side, we will assume that production depends on the composition of labor force between skilled and unskilled labor. At the same time, the child labor is assumed as a portion of unskilled labor. The quality and extent of human capital formation will be computed as the product of the interaction of educational outcomes, as affected by schooling decisions made by the households as follows from their income maximization problem.

In this framework, as the household can endogenously modify the composition of its labor force (between the unskilled and the skilled components) it at the same time decides on its current income level given the different wages for each category of labor and the costs associated to the education. Therefore, assuming, as in Coutier et al (2008), that the households' maximization problem is separable, it first decides its maximum income level and then maximizes utility. As shocks in the international prices of commodities can affect

[3] We define skilled workers as they who have studied at least the basic primary cycle (5 years of scholarly).

current income by changing relative wages, households adjust their optimal choosing of schooling time for their younger (school-aged) household members. As follows, this decision-making at the household level can affect the dynamics of human capital accumulation for the economy at large and, potentially with it, the prospects for economic growth (especially when commodity production and trade plays a significant role in the economy).

The household optimization problem can be described as follows. In the first stage, households maximize their income (YH) choosing the amount of children that study (γ) and the amount of children that work (1-γ). In this sense, the children that work provide a new short run income source for the household. For the household this is a one and for all decision, as the children that are sent to work will not return to the school,[4] undermining the future levels of human capital (and the incomes it generates) for the household. The second stage is the standard household utility maximization problem with the particularity that education demands were decided in the income maximization problem and they are given for this stage. Households do not derive utility from education consumption.

At the aggregate level, the total labor force (L_t), which we suppose equal to the population, is the sum of the children ($L_{ch,t}$) and adult populations ($L_{a,t}$).

$$L_t = L_{ch,t} + L_{a,t}$$
$$with\ L_{ch,t} = \varphi L_t\ and\ L_{a,t} = (1-\varphi)L_t$$

At the same time, the adult labor force is composed by skilled ($L_{s,t}$) and unskilled labor ($L_{u,t}$), so the composition of labor is the result of households decisions on the schooling time of children.

$$L_{a,t} = L_{s,t} + L_{u,t}$$
$$where\ L_{s,t} = \delta L_{a,t}\ and\ L_{u,t} = (1-\delta)L_{a,t}$$

The decision variable in the household's income maximization problem is the proportion of children that is sent to school ($L^s_{ch,t} = \gamma_h L_{ch,t}$) which at the same time defines the proportion of children that work($L^w_{ch,t} = (1-\gamma_h)L_{ch,t}$):

$$\underset{\gamma_h}{Max}\ YH_{ht} = W_{ut}L_{u,h,t} + W_{st}L_{s,h,t} + W_{ut}L^w_{ch,t} + W_{st}(1-e)L^s_{ch,t} - P_{ed,h,t}qedu_{ht}edut_h L^s_{ch,t} + NLI_{ht} - CBE_{ht}$$

$$s.t.\ \ L_h = b^l\left[\beta^l\left((1-\gamma h)L_h\right)^{\varepsilon} + \left(1-\beta^l\right)(\gamma L_h)^{\varepsilon}\right]^{\frac{1}{\varepsilon}}$$

where $edut$ is the share of the period that has to be dedicated for studying by future skilled workers, and the constraint is a CET aggregator of the stock of unskilled and skilled workers in the household ($b^l, \beta^l, and\ \varepsilon$ are CET parameters specific to the household type).

In the maximization problem of each kind of household, $W_{ut}L_{u,h,t}$ is the income from the unskilled adult labor force, where W_{ut} is the corresponding wage. In a similar fashion, $W_{st}L_{s,h,t}$

[4] This is an assumption based on the student's desertion rate.

is the income accruing from the skilled adult labor force, W_{ut} being its respective wage. $W_{ut}L^{w}_{ch,t}$ is the income generated from child labor. $W_{st}(1-edut)L^{s}_{ch,t}$ is the income generated by new skilled workers (i.e. by children that have finished the school cycle and have become adult skilled workers). $P_{ed,h,t}qedu_{ht}edut_{h}L^{s}_{ch,t}$ is the cost of education for the children that study to become skilled workers, net of governmental transfers. $P_{ed,h,t}$ is an index price for the higher education services. NLI and CBE are non-labor incomes and the cost of basic education, respectively. We assume that primary education is universal, so the only schooling decision that is taken by the household refers to higher education.

The cost of education (CE_{ht}) refers to the net cost of the higher education cycle.[5] It means that it takes into account the direct cost of education (CED_{ht}) for each kind of household and the public subsidy for education that the government provides to each household type (TED_{ht}). The form in which the education cost is determined let us model different educational policies from the government, in order to simulate their specific implications on the different sectors of the economy in the long run.

$$CE_{ht} = CED_{ht} - TED_{ht}$$

The result from the income maximization problem of the household is:

$$\frac{\gamma_h}{1-\gamma_h} = \left[\frac{W_s}{W_u} - \frac{edutW_s}{W_u} - \frac{P_{ed}qedu_h edut}{W_u}\right]^{\omega}\left(\frac{\beta_h}{1-\beta_h}\right)^{\omega}$$

where $\omega = \frac{1}{\varepsilon-1}$ is the elasticity of transformation between skilled and unskilled labor. The schooling decision of the household depends on the difference between relative skilled and unskilled wages, the opportunity cost of schooling, and the direct cost of education.

Income maximization determines the household's budget constraint, and once determined, the household optimally chooses its consumption levels of all goods (except education) through the utility maximization problem.

The dynamics of the labor endowment in the model is governed by population growth. New children are born at rate n, which we assume constant, so $L_{ch,t+1} = L_{ch,t}(1+n)$. The children from the previous period become either skilled or unskilled laborers depending on the income maximization problem of each household and add to their corresponding labor stocks. Therefore, the dynamics of population growth and the composition of labor is determined in the following way:

$$L_{t+1} = L_{ch,t+1} + L_{a,t+1}$$

$$L_{t+1} = L_{ch,t}(1+n) + (L_{s,t} + L^{s}_{ch,t}) + (L_{u,t} + L^{w}_{ch,t})$$

$$L_{t+1} = new\ children + stock\ of\ skilled\ work + stock\ of\ unskilled\ work$$

Thus, the new children are born at an exogenous constant growth rate, the new skilled work is the previous amount of skilled work plus the children that studied in the preceding period,

[5] We assume everybody studies at least the basic education cycle.

and the new unskilled work is the previous amount of unskilled work plus the children that worked in the prior period.

4. Application and results[6]

Based on the model presented above we simulate the impacts on households' labor composition and education demand of a 20% increase in international export price of mining sector. This shock would affect the relative wages between skilled and unskilled labor and consequently the household decision on education share of their children. The final effect will depend on the government decision in terms of transfers to households for children education.

We use the following closures in the simulation. The consumer index price is fixed which allows for exchange rate adjustment. Current account balances is exogenous and fixed. Finally, current government expenditures on goods and services and government expenditure on education are fixed and exogenous to determine household behavior after shock. [7]

4.1 Main macroeconomic results

In this section we will present the results on the main macroeconomic variables after shock of 20% on international prices on mining commodities. The table 4 summarizes the results as percentage of change respect to the base scenario.

Table 4: Main macroeconomic results

	GDP	Consumption	Investment	Exchange rate
% of change	2.28	2.063	2.99	-8.54

GDP at basic prices, Consumption: final consumption
Source: CGE model simulation

The shock on international prices on mining commodities affects directly the added production in the country. This good new on the mining prices increases the GDP for Colombia in 2.28% given the importance of the sector in the national production. In the same direction, the greater the domestic production the greater the demand for production factors. From one side the greater demand for capital increases the total investment in the economy in 2.99%. On the other side, the greater demand for labor grows households' incomes and at the same time their final consumption for a 2.06%.

[6] These results are based on simulations with our first approach to complete model. There are some remaining changes to do on the model to achieve the complete model presented in the methodology, particularly: Households and education division and long run dynamic. We attached the Program and data for this model.

[7] In other scenario is possible to change this closure to understand the impact of government policy on education. For these cases the government expenditure on education might be endogenous to household decision or we can shock the transfers to households for education and identify the effects on households' decision on education children

As is frequently in economies with large commodities sector, a shock on international prices in this kind of products has a direct effect in the exchange rate. In this particular case the appreciation of nominal exchange rate is 8.54%. This is an important level of appreciation which has direct implication on sectorial composition and trade balance of the economy.

The table 5 presents the sectorial composition after shock for both the total aggregate output and external sector. The results show an evident new composition of production after the raise in international prices of mining commodities. The mining sector increases 9.33% its production because of the better international conditions for selling its products. At the same time this greater production in mining sector drives other sectors, particularly the services sector which growth 1.48%. The rest of sectors reduce their production as a result of the new assignation of resources inside of the economy and the impact of the appreciation of exchange rate on external sector.

Is important to underline from this point that education services reduces its production as a consequence of the shock in 0.63%. This is a central result for the next section in which we will analyze the shock's impact on households' decision for children education.

Table 5: Sectorial composition after shock (% of change)

Sector	Total output	Exports	Imports
AGR	-4,34	-11,72	14,44
MIN	9,33	12,62	10,25
PRI	-0,10	-9,22	17,17
OIN	-4,11	-10,83	16,10
IND	-4,42	-9,87	9,40
RME	-7,95	-12,35	9,83
SER	1,48	-8,57	23,20
FIN	-2,81	-11,33	20,89
OSE	-0,01	-10,09	23,91
EDU	-0,63	0	0
ADM	-1,13	0	0

Sectors: AGR: agriculture; MIN: mining; PRI: primary sector; OIN: other industries; IND: industry; RME: refinery and metals; SER: services; FIN: financial services; OSE: other services; EDU: education services; ADM: public administration.
Source: CGE model simulation

The effects of exchange rate appreciation are presented in the table 5. The mining sector is the only one sector that expands its exports thanks to the better international prices in this kind of commodities. The imports are greater in all sectors. The lower exchange rate lets to import cheaper and it is reflected in a more imports for each of the sectors. The most growing sectors in their imports are services sectors with around 22% more than in base scenario, followed by the primary sector with 17% and other industries with 16%.

4.2 Results on education and labor composition

We present in this section the results on education and labor variables after shock. First, we show the results separately, and later we discuss how these are defined simultaneously. The table 6 displays the main results on education variables after shock on international prices of mining commodities. The share of children attending school falls in 0.63% which at the same time reduce the demand for education in households in the same rate. The education subsidy rate drops in 0.87% which mean that households should assume more proportion of education cost. In particular, households pay 1.93% more for education services. The last effects are caused in reason of the constant public expenses in education.

Table 6: Main results on education variables

Variable	% of change
Share of children attending school in households	-0,63
Education subsidy rate	-0,87
Educational expenses by household	1,93
Public expenses in education (Transfers to households)	0
Total education demand by households	-0,63

Source: CGE model simulation

On the labor variables side, the effects from the shock increase both the skilled and unskilled labor wage rate. However, the relative wage between skilled and unskilled labor fall in 0.304%. The earlier result is related with the share of each kind of labor supplied by the households. The share of skilled labor supplied drops in 0.09% while the share of unskilled labor supplied raises in 0.012. The labor income for households raises 1.87% given the new outlook on relative wages and labor supply.

Table 7: Main results on labor variables

Variables	% of change
Wage rate of skilled	1,71
Wage rate of unskilled	2,02
Share of skilled labor supply within household	-0,09
Share of unskilled labor supply within household	0,12
Supply of skilled labor	-0,09
Supply of unskilled labor	0,12
Labor income of type h households	1,87

Source: CGE model simulation

As we said before, both the education and labor decision are simultaneously determined. The shock on international prices on mining commodities produces a new composition of the added production which at the same time modifies the demand for factor of production. The result is a greater demand for both types of labor and capital. However the demand for unskilled labor grows more that the demand for skilled labor modifying the relative wages in favor of unskilled labor.

On the education decision of children takes part different determinants. From one side the population growth, given the constant expenditure of government in education, reduces the education subsidy rate. This effect raises the cost of education for the households. On the other side, the lower wage premium for skilled labor reduce the incentives for households for send the children to school to become skilled labor.

The final decision of households on the children education depends on an income maximization problem. From the income side, the change on the relative wages generates an incentive for the children to become unskilled labor. On the cost side, the greater cost of education and the greater opportunity cost increase the cost for households to send each child to the school. The added effect results in a drop in the share of children attending school.

The result show how shocks in the international prices of commodities affect current income and modify the optimal consumption basket. Households adjust their preferences between schooling time and working time for the younger (school-aged) household members. Therefore, the dynamics of human capital accumulation can be affected.

Although the shock on international prices of commodities might reduce the schooling time for the children in benefit of work time, the simulation shows that public expenditure on education can counteract this effect. The greater the education subsidy rate the lower the education cost assumed by households and the lower the schooling drop out.

5. Conclusions and policy implications

The Colombian economy has been characterized by the great importance of commodities production. Some decades ago the coffee production was the main economic activity, and more recently, the oil and mining production has become in the main sector of production for the country. The boom in these markets after international shocks on prices has direct consequences on productive structure on the country. Particularly, the booms on these sectors modify the demand for labor, and at the same time, affect the demand in other sectors related to these activities, particularly the services sector. This earlier effect determines the child labor in different zones of the country and at once has implication on the labor qualification, the human capital accumulation, and at the end, on economic growth.

The present research studies the relationship between shocks on international prices of commodities and the labor child through a computable general equilibrium approach. Simultaneously, the study lets to understand the role of government in this relationship to avoid the raise in child labor through policy actions aimed to reduce schooling drop out.

The results show the direct relation between the boom on commodities sector and the schooling dropout. The shock on international prices of commodities increases the relative wages between unskilled and skilled labor which become in an incentive for school-aged children to drop out the school and take part of labor force as unskilled workers. Concurrently, the shock increase both the direct and opportunity cost for households send the children to study if the government does not adjust their transfer to households for education.

As a result from the shock, the education demand from households is lower and the unskilled labor increases its participation in the total labor composition (*ceteris paribus*). This effect has direct repercussions on the long run human capital formation and economic growth of the economy. The children that stop the study cycle to start working do not return to school which will go against the skilled labor formation in the country. The greater the schooling drop out the lower the human capital formation and the lower the long run economic growth.

The other direction in which the results from the model could be interpreted is related with government policy actions. The greater the transfers from government to households for children education, the lower the cost assuming by households and the lower the schooling drop out (*ceteris paribus*). It means that government has instruments to promote the education and capacitation for children and younger people to seek to ensure greater levels of skilled labor that contribute to the economic growth in the long run.

Despite the fact that results from the model are in terms of added economy the policy recommendations could go to focus in particular regions and sectors. The shock on international prices on commodities has significant implications on added economy but its effects can perceived in greater dimension on the production regions of this kind of goods. Given the last, the government might center its actions on particular zones in which shock effects are greater. In this sense, instruments as conditional transfers for education can counteract the shock effect on schooling drop out, and simultaneously, on human capital formation.

As final comments, we conclude that shocks on international prices of commodities affect the child labor in Colombia because of income incentives and greater cost of education. However, policy actions from government, specifically greater transfers for education, can neutralize this effect and avoid its implications on human capital formation.

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Annex

In this annex we show the modifications on PEP 1.1 to obtain the model presented in this paper.

Endogenous labor supply:

$$LS_{un} = \sum_{h} LS_{h,un}$$

Where:

$LS_{un} = Total\ unskilled\ labor\ supply$
$LS_{h,un} = Total\ unskilled\ labor\ supply\ by\ household$

$$LS_{sk} = \left(\sum_{h} LS_{h,sk}\right)(1 - edut)$$

Where:

$LS_{sk} = Total\ skilled\ labor\ supply$
$LS_{h,sk} = Total\ skilled\ labor\ supply\ by\ household$
$edut$: $Share\ of\ active\ life\ spent\ in\ education\ by\ skilled\ labor$

$$\gamma_{h,sk} = 1 - \gamma_{h,un}$$

Where:

$\gamma_{h,sk} = Share\ of\ skilled\ labor\ supply\ by\ household$
$\gamma_{h,un} = Share\ of\ unskilled\ labor\ supply\ by\ household$

$$LS_{h,sk} = \gamma_{h,l} L_h$$

Where:

$LS_{h,sk} = Total\ skilled\ labor\ supply\ by\ household$
$\gamma_{h,sk} = Share\ of\ skilled\ labor\ supply\ by\ household$
$L_h = Total\ labor\ supply\ by\ household$

$$\frac{\gamma_{h,sk}}{\gamma_{h,un}} = \left[\frac{W_s}{W_u} - \frac{edutW_s}{W_u} - \frac{P_{ed}edut_h qedu_h(1-edusubrate)}{W_u}\right]^{\omega} \left(\frac{\beta_{h,un}}{\beta_{h,sk}}\right)^{\omega}$$

Where:

$\gamma_{h,sk} = Share\ of\ skilled\ labor\ supply\ by\ household$
$\gamma_{h,un} = Share\ of\ unskilled\ labor\ supply\ by\ household$
$W_s = Wage\ rate\ for\ skilled\ labor$
$W_u = Wage\ rate\ for\ unskilled\ labor$
$edut$: $Share\ of\ active\ life\ spent\ in\ education\ by\ skilled\ labor$
$P_{ed} = Index\ price\ education$
$qedu_h = Quantity\ of\ education\ services\ per\ student\ for\ household\ h$
$edusubrate = Rate\ of\ educational\ subsidy\ by\ the\ government$
$\omega = Elasticity\ of\ transformation\ labor\ CET$
$\beta_{h,un} = Share\ paremeter\ unskilled\ labor\ CET$
$\beta_{h,sk} = Share\ paremeter\ skilled\ labor\ CET$

$$\gamma_{h,un} = \left\{\left[LS_{h,un} + (L_h(1+poprate) - L_h)(1-schoolshare)\right]/L_h(1+poprate)\right\}$$

Where:

$\gamma_{h,un} = Share\ of\ unskilled\ labor\ supply\ by\ household$
$LS_{h,sk} = Total\ skilled\ labor\ supply\ by\ household$
$poprate = population\ growth\ rate$
$schoolshare = Share\ of\ children\ attending\ school\ in\ household$

Education demand

$$ED_h = qedu_h L_h poprateSchoolshare_h$$

Where:

$ED_h = Total\ education\ deman\ by\ household$
$qedu_h = Quantity\ of\ education\ services\ per\ student\ for\ household\ h$
$L_h = Total\ labor\ supply\ by\ household$
$poprate = population\ growth\ rate$
$schoolshare = Share\ of\ children\ attending\ school\ in\ household$

$$C_{edu,h} = ED_h(1-edusubrate)$$

Where:

$C_{edu,h} = Private\ demand\ for\ education\ by\ household\ (no\ subsidized)$
$ED_h = Total\ education\ deman\ by\ household$
$edusubrate = Rate\ of\ educational\ subsidy\ by\ the\ government$

$$CG_{edu} = \left(\sum_h ED_h\right) edusubrate$$

Where:

$CG_{edu} = Public\ demand\ education$

$ED_h = Total\ education\ deman\ by\ household$
$edusubrate = Rate\ of\ educational\ subsidy\ by\ the\ government$