Fiscal Policy and Inequality in CGE Model for Colombia

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Abstract

In this article we use a Computable General Equilibrium model (CGE) calibrated for the Colombian economy, to analyze the efficiency and the impacts of changes in the tax system on growth, welfare and income distribution. Three scenarios are considered: The first analyzes an increase in VAT rate like the one conducted in Colombia's 2017 tax reform, where the general VAT rate increased from 16% to 19%, leaving the exceptions of the system unchanged. The second scenario evaluates an extension of VAT to all products, including those products of the basic basket. In the third scenario, a decrease on the corporate tax rate of 20% is evaluated, reducing the nominal tax rate from 39% to 31.2%, without altering the other conditions that determine the tax collection and compensating the reduction of the tax collection with a progressive increase of the tax to the people of the decile 5 onwards, whose new rate is between 3% and 14% of their income.

The most important findings are: first, the low cost of compensation that is required to avoid the reduction of welfare of households with lower incomes, so that they do not see their welfare altered (measured through compensated variation) after an increase on indirect taxes. Secondly, it is convenient to move from taxing the production process to taxing the results of the process (through taxes on personal income), decreasing corporate income tax rates and compensating for it, with an increase in personal income tax, even maintaining a zero tax on the lower income population. By mitigating the tax burden of companies, the accumulation of capital can be encouraged, with important positive consequences for medium and long-term growth, without negatively affecting the progressivity of the system.

JEL Classification: C68, D31, H30, I32.

Key words: Computable of General Equilibrium (CGE) Model, Fiscal Policy, Tax Reform, Inequality of Income.

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1 Introduction

Distributive issues occupy more and more the attention of the economists, primarily because of concerns about trends in income concentration and inequality that seem to dominate in recent times, especially in developed economies. [1]. The problems of economic efficiency in state intervetion remain, of course, decisive, but the concern of distribution has gained impotance, because it affects the legitimacy of fiscal policies and their impact on welfare and society.

The state intervetion in the economic activity is generally justified by three reasons: the need to provide public goods, necessary for the proper functioning of society and the economy (protection of property rights, security services and arbitration among agents, elimination or mitigation of asymmetries of information); by the suboptimal accumulation of some productive factors (infrastructure, human capital) that are not efficiently supplied by economic agents due to the existence of incomplete markets or liquidity constraints; and by the need to ensure the inclusion of all social groups in economic progress, ensuring the sustainability of society as a whole, beyond the distributive struggles that characterize any political process [2].

In order to carry out such an intervention, the state relies primarily on tax revenue, which generates, on the one hand, distortions in the efficient allocation of resources of society, and on the other, distributional effects, which can aggravate or attenuate the differences between groups that make up society. Efficiency analyzes were predominant in the economic study until a few years ago, because of the confidence that economic progress guaranteed an adequate diffusion of its benefits among all social groups. But the persistence of inequality and the deepening of gaps between social groups have forced economists to turn their attention to distributive issues.

Thus, it is not only necessary to assess the balance between the positive effects of state intervention and its efficiency costs, but also to evaluate the distributional impacts it generates. This comprehensive approach will allow a more complete discussion of the effects of fiscal policies, their legitimacy and their economic impact.

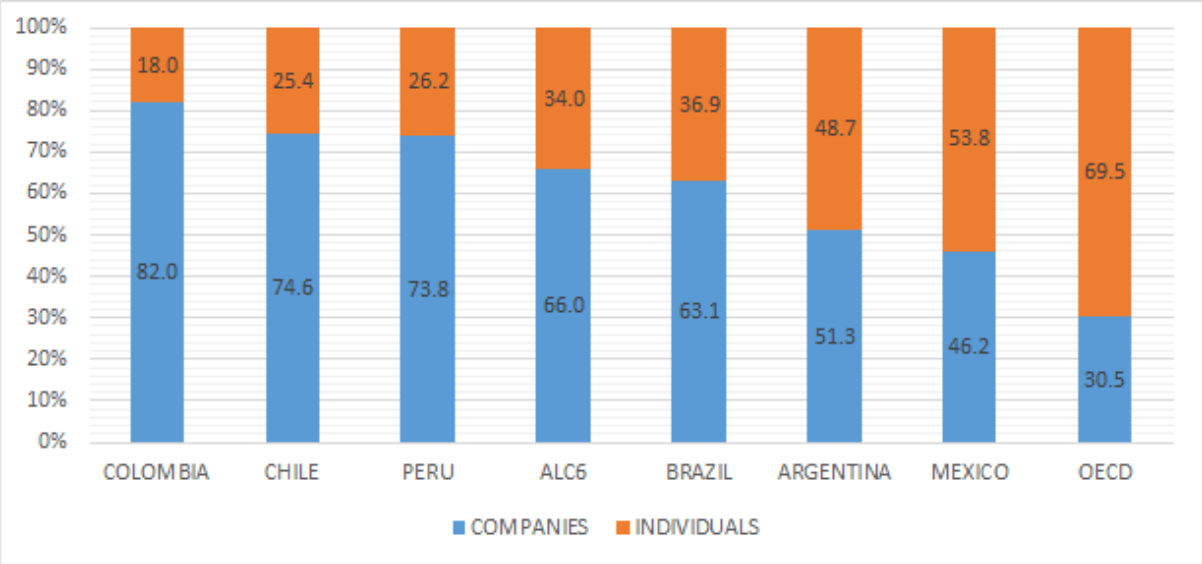
Hence the importance of the tax system being an efficient mechanism that contributes to growth, but at the same time generates more equity. However, Colombia has a complex and inefficient system of tax collection

[1] Especially important in the recent discussion of the work of Atkinson (2015), Piketty et al. (2014) y Saez & Zucman (2014)

[2] Political processes bring into play the interaction between various social groups, who seek to take control of the state, to put it at the service of their interests. But unless a minimum standard of access to the welfare of other groups is guaranteed and the non-violent possibility of access to power of those groups is guaranteed (what Popper wisely summed up in his definition of democracy as the system that allows deposing to the bad rulers without resorting to the violence), the society will not be sustainable.

(affected, in this sense, by lack of regulation and normative imprecisions), with tax exemptions and privileges, in which the multiplicity of regimes and exemptions makes high rates of tax and duty evasion possible. The system also has an "anti-growth" bias, because it concentrates high tax burdens on companies (which produce wealth) and not on people (who receive and enjoy it). In fact, legal persons pay 5 times more than individuals, an excessively high proportion compared to the countries of the region and the OECD, where this ratio is 2.9 times lower than in Colombia (see Figure 1). . On the other hand, the companies face high tax rates that do not benefit investment, but instead, create distortions in the functioning of markets and cause impacts that do not promote economic growth, in addition, these rates are not translated into significant effective collections due to the privileges and tax exemptions that have some taxpayers. [Rojas et al. (2015)].

Figure 1: Total collection of direct taxes of individuals and companies



Source: Ministry of Finance and Public Credit (Colombia)

Although individuals enjoy a lower tax burden compared to companies, the tax structure lacks progressivity, since it does little to reduce the high income inequality, allowing taxpayers with greater relative capacity to not pay more taxes than those who have fewer resources, exerting an inconvenient tax burden on the less privileged social clases. Individuals or companies that have the same level of income make different contributions to the Colombian treasury. Therefore, the system generates vertical and horizontal inequality.

Estimates of Lustig et al. (2014) and OCDE (2015) show that the effect of taxes and transfers on families in OECD countries and Latin American countries like Uruguay, Chile and Brazil reduces income inequality,

measured through of the GINI coefficient [3], while in Colombia this indicator remains unchanged.

It's worth mentioning that the other main source of tax collection, the Value-Added Tax (VAT), has a regressive bias, because it affects citizens in terms of their consumption and not their income, generating a disproportionate burden on the less favored population, which allocate a large part of their income to consumption, therefore, direct taxation should be structured so that the collection is effective and has the necessary progressivity to compensate for this bias. It must incorporate elements that generate greater equity, avoiding both inefficiency and opportunistic behavior of agents. It seeks to generate mechanisms that favor efficiency, and allow fiscal resources for public spending in welfare programs and accumulation of human capital, generating a revolution of social inclusion. [Botero-García & Velez-Álvarez (2016)].

The short-term challenges facing the Colombian economy, plus the presence of ostensible weaknesses in the tax structure, determine the importance of the restructuring of its tax scheme, which will have to maintain macroeconomic stability and strengthen the level of competitiveness benefiting investment, efficiency in the collection, and simultaneously generate greater vertical and horizontal equity.

Efficiency and equity are basic elements in the analysis of reforms in the tax system, and Computable General Equilibrium (CGE) models have proven to be an effective and flexible tool for income distribution analysis and efficiency of the different taxes [4]. The purpose of this paper is to carry out several simulation exercises of the Colombian economy using a CGE model in which the efficiency of the tax and its distributive impact are considered simultaneously. In this way, we are considering both the traditional aspects of tax policy and their role in building a more just and equitable society.

This paper is structured as follows. The next section provides an overview of the latest tax reforms. The Section 3 exhibits a brief analysis of the situation of poverty and income inequality and, finally, a summary of Colombia's macroeconomic environment. In the Section 4 the literature review is presented along with the methodology and the databases used for the calibration of the model in the study. The Section 5 exhibits the theoretical structure of the CGE model. Finally, the results of the simulations and the conclusions are presented in sections 6 and 7, respectively.

[3] It is a measure of inequality, commonly used to evaluate the distribution of income. It is a number between 0 and 1, where 0 represents perfect equity and 1 corresponds to complete inequality (only one group of people owns all income). For more details see 3

[4] This topic is expanded in Section 4

2 Overview of the latest tax reforms in Colombia

Between 1973 and 2014, 36 modifications have been made to the Colombian taxation law. Out of these, 13 have been made in the last 26 years, which represents 1 reform every 2 years on average. This constant change of the norm can generate an increase of uncertainty and cause distrust in the investors, which in turn can discourage the production and the generation of employment. On the other hand, in the face of this good number of reforms, evaluations of the possible benefits to the economy in terms of effectiveness and progressiveness of each change of law are scarce, because the discussion has focused more on what the next tax reform should have, without taking into account the certainty of the impact on the economy that the previous has generated[5].

Indirect taxes gained more participation since the 1974 reform, which has made the tax system increasingly regressive. However, we will focus briefly on describing the changes that have been made since the last decade of the twentieth century. As for VAT, it went from 10% to 12% in Law 49 of 1990, going from 12% to 14% in Law 6 of 1992 reaching levels of 16% in the Law 233 of 1995, which remains in force. Subsequently, Law 788 of 2002 extended the base and some products that pay a 10% tax increased their rate to 16%, while mobile telephony was taxed at 20%. In 2003, Law 863 created new rates for beer and gambling, 3% and 5%, respectively, in order to increase health resources, and some products excluded from VAT, were taxed at a rate of 5%.

Through an economic emergency, in 1999 the Tax on Financial Movements was created, with a rate of 2 Colombian pesos per 1000 in bank transactions starting at one million pesos. This tax began to be temporary, but then became permanent and increased to 3 per 1000 in Law 633 of 2000, until accentuated in 4 per 1000 by the year 2003, at which level it is currently.[6].

With regard to direct taxation, the number of taxpayers forced to declare income in the 1990 reform was reduced. Two years later, with Law 6 of Tributary law, the tax base was increased and the wealth tax was eliminated. In 1995 the rate went from 30% to 35% for legal entities. For 2002, new exempt incomes and surcharges of 10% were created. In 2003, the investment deduction of 30% was formed, in order to boost productivity and foreign investment. However, the incentive was eliminated in law 1430 of 2010. In law 1111 of 2006 arises once again the wealth tax for capital exceeding 3000 million Colombian pesos. Law 1607 of 2012 establishes Income Tax for Equality (CREE) with the purpose of guaranteeing the resources for the Social

[5]The work of Cárdenas & Perry (1986) between 1974 and 1984, Sánchez & Gutiérrez (1995) between 1980 and 1992, citegonzalez2002reformas for twentieth century reforms and García Molina & Gómez (2005) between 1973 and 1999 are highlighted.

[6]This tax has contributed to the public treasury 0.8 % of GDP on average during the last 4 years (see Table 3)

Security System, the Colombian Institute for Family Welfare (ICBF as per its initials in Spanish) and higher education and in turn alleviate the tax burden for companies, replacing the parafiscal charges for the tax imposed on profits. Lastly, the wealth tax became the tax of wealth through law 1607 of 2014, making changes in the marginal rate of 0.2% for gross assets lower than 2000 million pesos to 1.15% for higher net worth to 5000 million pesos by 2015.

3 Macroeconomic Environment and Income Distribution in Colombia

3.1 Situation of poverty and income inequality in Colombia

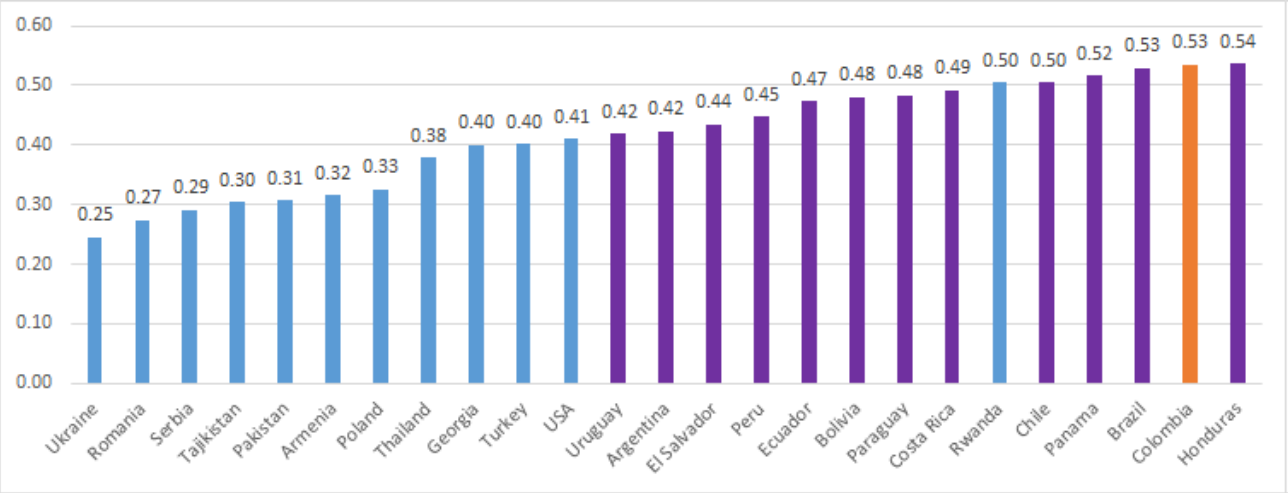
The most common measure to describe the inequality in income or wealth of a country is the GINI index, this index is usually defined mathematically based on the Lorenz curve, which plots the proportion of the total income of the population (y axis) that is cumulatively earned by the bottom x of the population. To calculate this index, we followed Brown (1994), who defined the Gini Index as:

$$G = 1 - \sum_{k=0}^{n-1} (Y_{k+1} + Y_k)(X_{k+1} - X_k) \tag{1}$$

where Y, is the cumulative proportion of income over k households, and X is the cumulative proportion of the population.

Colombia has been characterized by its high levels of poverty and inequality globally. The GINI coefficient for the years 2013, 2014 was 0.540 and 0.539 respectively, with a level of income inequality of 11.8% more in urban than in rural areas for the year 2013 and 8.6% for The year 2014 (see Table 1). Colombia is one of the most inequitable economies in the world, surpassing the inequality indices of most Latin American countries (see Figure 2).

Figure 2: GINI Index of Colombia in relation to other countries



Source: World Bank (2014)

On the other hand, the fifty percent of population with highest income have the 84.5% of total income, where 1% of the population with the highest purchasing power owns 12.4% of total income, and income of the richest 10% is 39 times higher than the income received by the poorest 10%. Even more alarming, the 1% of the population receiving the most income has 619.5 times more than 1% of the population with the lowest purchasing power (See Table 2).

Table 1: GINI coefficient of income and pensions for Colombia in 2013 and 2014

Area	Gini index for pensions		Gini Index for total income	
	2013	2014	2013	2014
Urban	0.992	0.703	0,517	0.514
Rural	0.884	0.866	0.456	0.470
National	0.800	0.749	0.540	0.539

Source: GEIH Survey - DANE (2013 y 2014). Own calculations

Another worrying factor is the high level of inequality in pensions, particularly in rural areas which had GINI of 0.866 in 2014. However, there was a significant reduction in the index between 2013 and 2014 was observed in all areas.

Table 2: Distribution of income in Colombia by percentiles

Percentile	Population	Population (%)	Cumulate population (%)	Total income (%)	Cumulate income (%)
1	495308	1.07	1.07	0.02	0.02
10	683882	1.48	10.45	0.24	1.09
25	461490	1.00	24.92	0.30	4.56
50	463364	1.00	49.85	0.58	15.50
75	463367	1.00	74.81	1.09	35.56
90	464776	1.00	89.84	1.94	57.40
99	476081	1.03	98.95	6.22	87.61
100	487080	1.05	100.00	12.39	100.00

Source: GEIH Survey - DANE (2014). Own calculations

During the last six years, Colombia has presented a reduction in the incidence of poverty, passing from 37.2% of the total national population living in poverty in 2010 to 28% in 2011. In urban areas the reduction was 8.4 percentage points, drop from 33.3% in 2010 to 24.9 % in 2016 and in rural areas, the poverty level changed from 49.7% in 2010 to 38.6 % in 2016, with a decrease of 11.1 percentage points during this period. However, between 2015 and 2016, there was a small increase in poverty, at a national level as well as at an urban area level. (see Figure 3).

In order to get closer to a better understanding the how poor the poor actually are, we consider the poverty gap and the square poverty gap. Mathematically these indices are defined by the following expression:

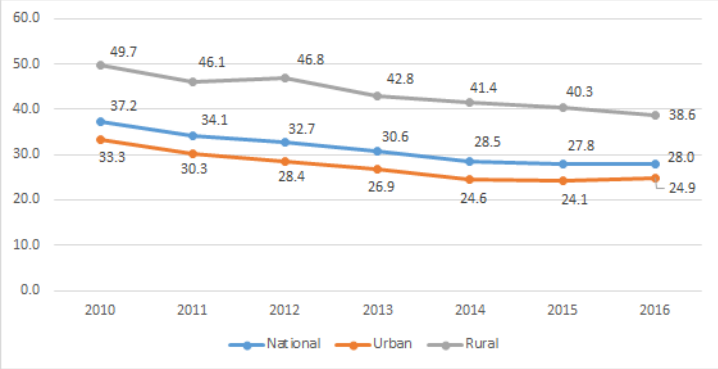
$$P_\alpha = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right)^\alpha$$

where n is the total population, z is the poverty line, q is the number of people below of poverty line, y_i is the income of i-th individual, and α is a parameter that measure of poverty gap. It's important to specify that when $\alpha = 0$, P_0 is the incidence rate of poverty or also called head-count index, which is the proportion of poor people, compared to the total population. If $\alpha = 1$, P_1 is the poverty gap, and P_2 is the square poverty gap, also

known as the poverty severity indicator.

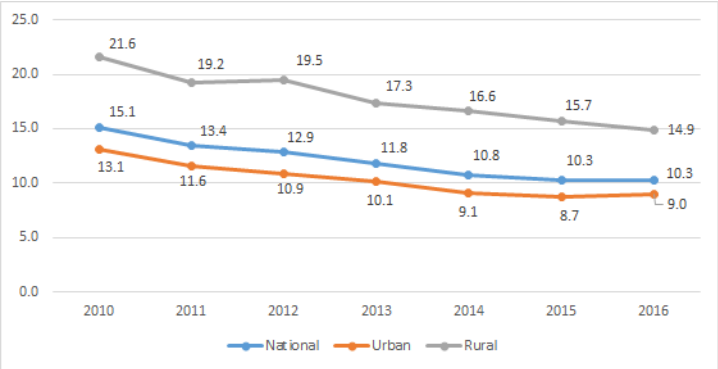
The poverty gap allows us to know the minimum cost of eliminating poverty if the transfers are perfectly directed. The square poverty gap measures the severity of poverty, where a greater weight is assigned to poor people whose per capita incomes are more distant from the poverty line. The results show that these indicators, as well as the incidence of poverty, have presented a significant reduction during the last six years. Although rural area have the highest poverty rates, the decrease has been superior between 2010 and 2016 (see 4 and 5).

Figure 3: Incidence of monetary poverty by area



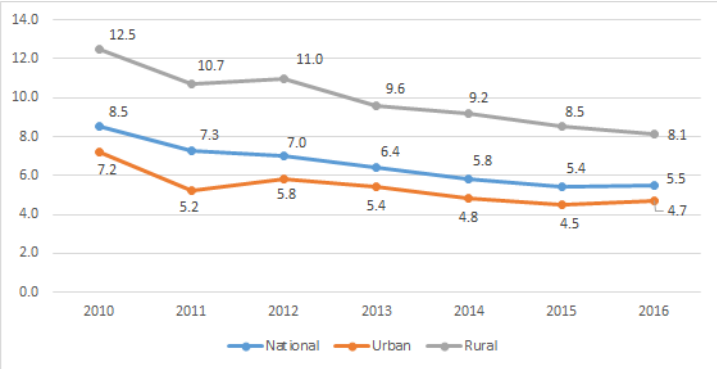
Source: GEIH - DANE (2010-2014)

Figure 4: Poverty gap by area



Source: GEIH - DANE (2010-2014)

Figure 5: Severity of poverty by area



Source: GEIH - DANE (2010-2014)

3.2 Colombia's macroeconomic and fiscal environment

In recent years, the Colombian economy has depended heavily on raw materials, particularly oil and mining. The drop in hydrocarbon prices has led to a significant reduction in central government revenues, from obtaining revenues of 13,196 billion through Ecopetrol, which represented 1.87% of GDP in 2013, to revenues of 4,197 thousand which accounts for only 0.5% of GDP by 2015. This has led to imbalances in fiscal accounts, mainly the increase in the fiscal deficit from 2.3% of GDP in 2012 and 2013 to 3% of GDP by 2015 (see Table 3). This situation could generate difficulties in the generation of new jobs, in addition to a possible reduction in social spending, and affecting the income of populations that receive royalties from oil revenues.

In the case of tax revenues, indirect taxes represent the largest collection. For the case of VAT, over the last four years 5.2% of GDP has been gathered, which accounts for more than 30% of government revenues, however, this collection is considerably low compared to other countries of Latin America and the OECD. For example, Peru collects 17.9% more than Colombia through this tax (see Figure 6), in addition, in the Colombian case, this tax has low productivity and complex administration. The general VAT rate is 16%, however there are products and services with reduced tariffs of 5% and others with exempt with rates of 0%, which generate inequality between economic activities. It is worth emphasizing that, given the regressively of consumption taxes, mechanisms must be sought to unify this tax without generating inequity. In the case of direct taxes, the income tax has shown a significant reduction due mainly to the drop in oil prices.

Table 3: Fiscal Balance of the Central National Goverment (Porcentage of GDP)

Concept	2012	2013	2014**	2015
Total government revenue	16.1	16.9	16.7	16.1
Tax revenue	14.3	14.3	14.3	14.5
Income tax	6.6	6.3	5.0	4.8
VAT of the domestic market	3.6	3.3	3.5	3.5
VAT of the external market	1.8	1.6	1.6	1.7
The customs tariff	0.5	0.6	0.5	0.6
CREE	0.0	0.4	1.6	1.7
Tax on gasoline and diesel	0.3	0.0	0.0	0.0
Tax on financial movements	0.8	0.8	0.9	0.8
Oil revenues (Ecopetrol)	1.1	1.9	1.4	0.5
Total government expenditure	17.9	19.1	19.2	19.1
Interest on government debt	2.4	2.2	2.1	2.2
Total deficit or surplus	-2.3	-2.3	-2.4	-3.0

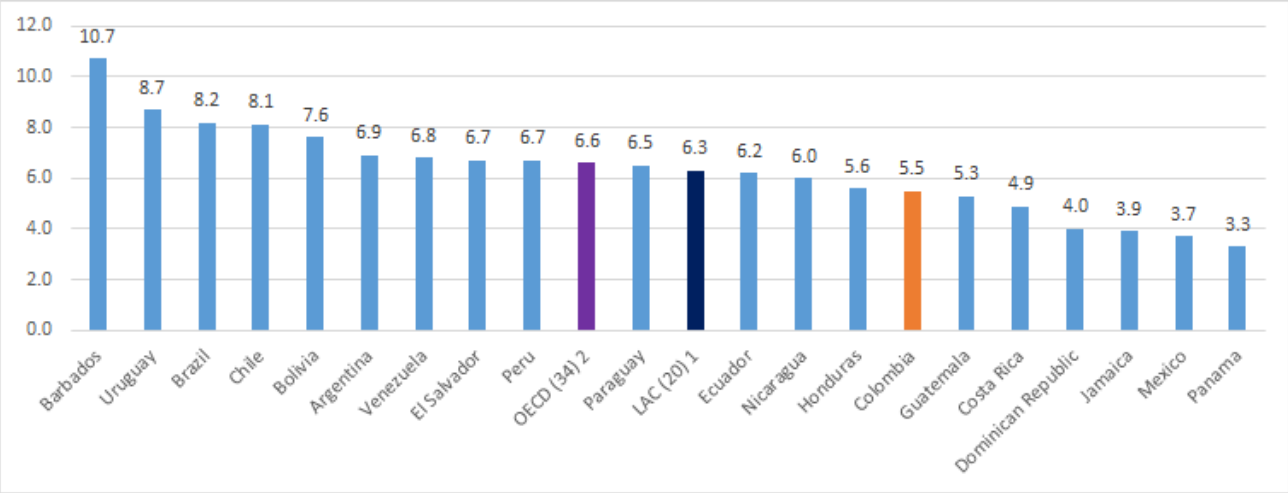
**Preliminary figures

Source: Ministry of Finance and Public Credit (Colombia)

In the labor market, Colombia has high rates of unemployment in the less favored social sectors. In addition, the population has a low participation in the labor market and has the lowest occupancy rates, especially in skilled individuals [7] For the labor market (see Table 11). This reflects the disadvantages faced by the poor against the rich and the enormous costs of education for the lower income population, which is worrying, given that education is a key factor for socioeconomic mobility.

[7] In this study the skilled people are those who have completed one year of studies or more after of culminating secondary education (baccalaureate).

Figure 6: Value Added Tax as a percentage of GDP for Colombia in relation to other countries



Source: Rojas et al. (2015)

Table 4: Basic Macroeconomic Indicators of Colombia 2012-2015

Indicators	2012	2013	2014	2015
Real GDP growth rate	4.0	4.9	4.4	3.1
Per capita real GDP growth rate	3.0	3.8	3.4	2.2
Population growth rate	1.1	1.1	1.1	1.1
Rate of growth of total consumption	4.8	4.6	4.3	3.9
Household consumption	0.0	0.0	0.0	0.0
Final government consumption	0.0	0.0	0.0	0.0
Gross fixed capital formation (GDP - ratio)	4,7	6.1	11.5	2.6
Annual average growth rate of exports	6.0	5.2	-1.3	-0.7
Annual average growth rate of imports	9.1	6.0	7.8	3.9
Inflation rate	2.4	1.9	3.7	6.8
Budget deficit (GDP - ratio)	-2.3	-2.3	-2.4	-3.0

Source: Ministry of Finance and Public Credit (Colombia)

Regarding economic growth, most economic sectors have shown a decline in their contribution to GDP, especially in the industrial sector (see Table 5). In addition, agriculture and fisheries have been in a continuous

stagnation, with little participation in economic development, which represents a challenge for the government in the field of technological investment, to boost the economy of the country. Considering that the agriculture and tourism can play an alternative role and change the strong dependence of oil and mining.

Table 5: Annual gross domestic product by branches of economic activity at constant prices - annual percentage changes

Economic activities (annual percentage change)	2012	2013	2014	2015
Agriculture, livestock, hunting, forestry and fishing	2.5	6.5	3.1	3.3
Mining and quarrying	5.3	5.0	-1.1	0.6
Manufacturing Industries	0.1	0.9	0.7	1.2
Electricity, gas and water supply	2.3	3.0	3.4	2.9
Construction	5.9	11.5	10.5	3.9
Wholesale, hotels and restaurants	3.9	4.5	5.1	4.1
Transport, storage and communications	3.9	3.3	4.7	1.4
Financial intermediation and Real estate, business and renting activities	5.1	4.6	5.7	4.3
Services	4.6	5.9	5.2	2.9

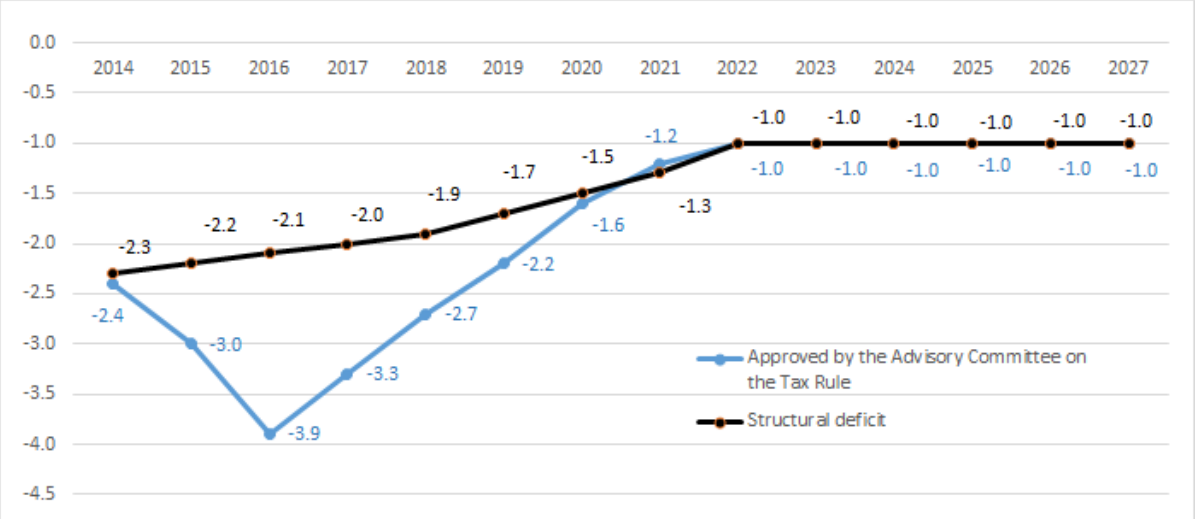
Source: Annual National Accounts (DANE)

The slow recovery of the world economy, particularly of emerging economies, has led Latin America to show moderate growth rates in recent years, from 6.2% in 2010 to 4.7% in 2011, continuing to decline with rates of 2.9% in 2012 and 2013, to reach rates of 0.9% and -0.5% in 2014 and 2015, respectively. Despite this economic outlook for the region, Colombia has sustained growth rates ranging from 4.9 percent to 3 percent, in addition to maintaining a per capita growth rate above the average for Latin American and Caribbean countries (see Table 13). However, as we have already mentioned, Colombia continues to present high levels of income inequality, which reflects that growth and economic policies are only benefiting a small group of the population, giving it greater economic power and, in turn, widening the gaps of inequality.

The international economic situation and the growing budget deficit demand greater leadership of the central government in the optimal management of the fiscal policy that allows the necessary adjustments for the due fulfillment of the Fiscal Rule Law. The country needs a sustainable and responsible administration of public finances to reduce the Central Government's structural deficit from 2.3% of GDP in 2014 to 1.9% in 2018,

to levels of 1.0% in 2022 (see Figure 7), without affecting the State investment, specifically in educational infrastructure, public works, housing of priority and social interest in the rural and urban sector.

Figure 7: Structural and total deficit of the Colombian Central Government



Source: Medium Term Fiscal Framework (2016) - Ministry of Finance and Public Credit (Colombia)

In summary, the current economic situation should be seen as an opportunity for Colombia to seek investment in sectors other than commodities, generating educational policies that are in line with the challenges posed by the new production models in the so-called intelligent industrial system, which would generate not only greater economic returns, but also incentives for long-term investment, leading to greater human capital and formalization of employment, thus increasing productivity, not excluding investment in health and infrastructure quality that includes the underprivileged people and thereby reducing high levels of inequality of income.

4 Literature review and Methodology

The development of new policy instruments aimed at a better understanding of the channels by which adjustment policies affect the poor and the study of possible strategies for poverty reduction through policy reforms has taken hold, forging diverse efforts of some organizations in this direction. One approach is to use Computable General Equilibrium (CGE) [Agénor et al. (2004)]

CGE models have proven to be flexible enough for fiscal policy assessment. They allow the inclusion of sales taxes, value added taxes, import tariffs, export taxes, income taxes, corporation tax, estate taxes and territorial taxes, additionally, admits the treatment of different types of public and capital expenditure in the analysis of the impact of the provision of public infrastructure on private sector productivity. [Feltenstein et al. (2014)]

The use of CGE models for fiscal policy analysis is based on Shoven & Whalley (1972), who extended Arrow-Debreu's general equilibrium model to allow the introduction of taxes and tariffes. The approach, which initially incorporated only simple taxes in the context of static models, it has been expanded to analyze all types of taxes in more complex economic situations.

There are several approaches to poverty analysis and income distribution in the context of CGE models. Savard (2005) indicates that the most outstanding methods are: Modeling with Representative Household Groups (RHG) and the Micro-Simulation (MSM) approach.

The CGE models with RHG have become a standard tool to study the impact of distorting taxes in specific economies and to make efficiency analyzes in the restructuring of the tax system taking into account that efficiency and equity are the most relevant issues in the evaluation of tax policy reforms [Ahmed & O'Donoghue (2007)]. In addition, in the context of indirect taxes, these models provide a link with the utility functions of households and thus indicate the loss of welfare due, for example, to an increase in the VAT rate. In the case of personal income taxes, the CGE models allow a detailed treatment of the labor-leisure relationship, which is relevant in the analysis of labor participation issues. Agénor et al. (2004) state that RHG models seek to capture a variety of channels by which stabilization policies and structural reforms affect growth, income inequality and poverty.

Although the CGE methodology with RHG has been able to address a variety of economic policy issues, it has also been criticized because it does not allow modeling of microeconomic behavior within groups with only one representative household. Households have to be aggregated into representative urban and rural agents according to the information provided by household survey data. The aggregation suppresses a significant amount of useful information and, consequently, many researchers[8] prefer micro-simulation models, which do allow the incorporation of a high degree of detail of the household, although they do not have many of the character-

[8]The pioneers of this discussion were Adelman & Robinson (1978) with the microsimulation approach by conducting a study for Korea, followed by Dervis et al. (1984) with another study also directed towards Korea.

istics of the endogenous modeling of the CGE models with RHG.

While the micro-simulation approach has been widely used for distributive analyzes of fiscal reforms[9], Davies (2004) suggests that the MSM approach is limited to the distributional effects of a reform, given the Individual behavior is largely invariant, as well as its inability to model prices, wages and macro variables. Åvitsland & Aasness (2004) adds that these assumptions an cause the loss of valuable information due to their partial equilibrium nature.

In this paper, a CGE model will be constructed with different groups of heterogeneous representative households. Income and labor market information for each group of households were calculated from Great Integrated Household Survey (GEIH, as per its initials in Spanish). The expenditure information was deduced from the Quality of Life National Survey (ENCV, as per its initials in Spanish). The results were adjusted to the Annual National Accounts. These database are administered by the National Administrative Department of Statistics (DANE, as per its initials in Spanish) for Colombia. All data were calculated for 2014. On the other hand, for the fiscal accounts, the Fiscal Balance of the National Government, administered by the Ministry of Finance and Public Credit, was considered.

5 Theoretical Structure of the CGE Model

In the CGE model developed in this study for Colombia there are 25 types of agents: 20 groups of representative households, companies, central government, local governments, social security administered by the government and the rest of the world. The 20 groups of households were constructed by deciles according to the per capita income of the expenditure unit in rural and urban áreas[10]. The behavior of each private agent is governed by conventional neoclassical microeconomics, and the supply and demand equations of the agents are derived from the solutions of the optimization problems. The basic theoretical assumptions of the model are as follows[11]:

[9] Some papers are Decaluwé et al. (1999a), and Decaluwé et al. (1999b). Savard (2005) compares both methodologies for the Philippines. Another more recent is Nahar & Siriwardana (2013) to Bangladesh

[10] The tables 11 and 13 describe the participation in the labor market, the income and expenses of each of the 20 households used in the model

[11] Due to the length of the model, we do not add the total of equations, however we describe the structure of the model in the appendix

5.1 Supply

The model consists of 20 productive sectors and 20 types of products. It also considers three types of productive factors: skilled labor, unskilled labor and capital. On the other hand, an informal branch, which employs unskilled labor, is discriminated against; this makes it possible to disaggregate formal and informal unskilled labour.

The 20 productive sectors were grouped according to the National Accounts information as follows: Agricultural sector (Agriculture and Coffee), Mining sector (Mining and Oil), Industrial sector (Food, Light Industry, Intermediate Goods Industry, Heavy Goods Industry), Services sector (Home public services, Construction of buildings, Civil works, Commerce, Hotel industry, bars and restaurants, Transportation, Communications, Financial Services, Real Estate Activities, Government Services, Other Services).

There are 5 productive sectors modeled with endogenous imports (Agriculture, Food, Light Industry, Intermediate Goods Industry, Heavy Goods Industry). Two sectors are modeled in perfect competition (informal sector and agriculture), the other 18 sectors were modeled on monopolistic competition). The 19 formal sectors hire skilled (tc) and unskilled labor (tnc) added through a CES function to obtain formal total labor. For the j-th sector, with $j = 1,\ldots,19$ as follows:

$$tt_j = bc_j \left(\delta c_j tc_j^{-\rho c_j} + (1-\delta c_j)\, tnc_j^{-\rho c_j} \right)^{1/\rho c_j} \tag{2}$$

where tt denotes the total employment, bc, δc and $\sigma_c = 1/(1-\rho c)$ denote the scale parameter, the participation parameter and the elasticity of substitution of the aggregation of the skilled and unskilled labor, respectively. The first-order conditions determine the skilled and unskilled labor ratio in terms of wages (w, wc y wnc denote the total, the skilled and the unskilled wage, in this order) and the participation parameter of the job aggregation function.

$$\frac{tc_j}{tn_j} = \left(\frac{wnc_j}{wc_j} \frac{\delta c_j}{(1-\delta c_j)} \right)^{\sigma c_j} \tag{3}$$

The aggregation is given by:

$$w_j tt_j = wc_j tc_j + wnc_j tnc_j$$

The value added (va) of each productive sector is described through a CES function that adds labor and

capital (k):

$$va_j = bk_j \left(\delta k_j k_j^{-\rho k_j} + (1 - \delta k_j) tt_j^{-\rho k_j} \right)^{1/\rho k_j} \tag{4}$$

where bk, δk and σk are the parameter of scale, participation and elasticity of substitution of the capital aggregation function, respectively. The first-order conditions describe the capital-labor ratio that minimizes costs, in terms of total wage, capital income and the participation parameter of the capital aggregation function (r):

$$\frac{k_j}{tt_j} = \left(\frac{w_j}{r_j} \frac{\delta k_j}{(1 - \delta k_j)} \right)^{\sigma k_j} \tag{5}$$

And the price of value added (pva) is determined from:

$$pva_j va_j = r_j k_j + w_j tt_j$$

Third, the product of each economic sector (y) is obtained from the incorporation of the value added with taxes (vaa) and intermediate purchases (v) in a function of fixed coefficients. On the other hand, the informal sector only uses unskilled labor, and the technology of this sector is described by fixed coefficients:

$$vaa_j = cvaa_j y_j \tag{6}$$

$$v_j = \sum_j io_j y_j \tag{7}$$

where io is the coefficient of the production matrix. Let py be the price of the product of each sector. In addition, let $pvaa$ and $pximp$ be the prices of the value added and the taxed goods, both with taxes, respectively. The accounting equation is:

$$py_j y_j = pvaa_j vaa_j + \sum_k pximp_k io_{k,j} y_k$$

Considering the value added tax for each sector ($ivap$), the accounting equation is

$$pvaa_j vaa_j = pva_j va_j (1 + ivap_j)$$

The informal sector uses only unskilled labor, and its technology is a fixed coefficient technology.

The production of the sectors are distributed according to the production matrix *yimp*, including taxes and prices of each sector (*py*) are established from the prices of each product (*p*) in a linear function as follows:

$$yimp = \sum_k y_k pcc_{k,j} py_j = \sum_k p_k pcc_{k,j} \tag{8}$$

The entrepreneurs decide whether to export (*e*) or sell their products in the domestic market (*d*). To model this decision a CET is used (a production possibilities frontier, constant elasticity), which is applied to the formed subset by all tradable sectors, excluding mining and oil. For the latter two sectors it is assumed that total production is the aggregation of domestic sales and exports in a linear function[12]. For *je*-th exporting sector:

$$yimp_{je}iu = be_{je}\left(\delta e_{je} e_{je}^{-\rho e_{je}} + (1-\delta e_{je})\, d_{je}^{-\rho e_{je}}\right)^{1/\rho e_{je}} \tag{9}$$

subject to:

$$yimp_{je} = e_{ie} + d_{je}$$

The expansion path, for the prices *pd* and *pe* of domestic sales and exports, respectively, is:

$$\frac{e_j}{d_j} = \left(\frac{pd_j}{pe_j}\frac{\delta e_j}{(1-\delta e_j)}\right)^{\sigma e_j} \tag{10}$$

And total sales are:

$$p_j yimp_j = pe_j e_j + pd_j d_j$$

The price of exports is defined from the price (*pwe*) and the exchange rate (*er*) as:

$$pe_j = pwe_j er$$

The demand for exports comes from the well composed function of the rest of the world, or Armington function[13], which adds domestic sales to sales from other sources (*ee*):

[12] This is to assume that there is no possible substitution between domestic sales and exports in these sectors

[13] See Armington (1969)

$$ex_j = bx_j \left(\delta x_j e_j^{-\rho x_j} + (1-\delta x_j) ee_j^{-\rho x_j} \right)^{1/\rho x_j} \tag{11}$$

$$\frac{e_j}{ee_j} = \left(\frac{pww_j}{pwe_j} \frac{\delta x_j}{(1-\delta x_j)} \right)^{\sigma x_j} \tag{12}$$

Similarly, domestic sales, in aggregation with imports (m), determine the function of well-composed, or Armington function of domestic purchases:

$$x_j = bm_j \left(\delta m_j m_j^{-\rho m_j} + (1-\delta m_j) d_j^{-\rho m_j} \right)^{1/\rho m_j} \tag{13}$$

$$\frac{m_i}{d_i} = \left(\frac{pd_i}{pm_i} \frac{\delta m_i}{(1-\delta m_i)} \right)^{\sigma m_i} \tag{14}$$

$$px_j = x_j pm_j m_j + pd_j d_j$$

The price of imports is defined by:

$$pm_j = pw_j (1 + aran_j) \tag{15}$$

The well-composed (x) and well compounded tax ($ximp$) relationship is defined:

$$x_j = cx_j ximp_j \tag{16}$$

The accounting equation is

$$pximp_j ximp_j = px_j x_j (1 + iva_j)$$

5.2 Demand of goods and job offer

The utility function of households is determined by a utility function (U) Stone - Geary [14] or Extend Linear Expenditure System (ELES) that incliudes save. In our case we also add leisure through the job offer. In summary, the utility function depends on consumption (C) and minimum subsistence consumption ($\bar{C}$), saving (S) in proportion to the consumer price index (ipc) and leisure, represented by people of working age who do not participate in the skilled labor market ($PETC - PEAC$) or the unskilled labor market ($PETN - PEAN$).

[14] This function was first obtained by Geary (1950) and Stone (1954) was the first to estimate linear expenditure system

Households maximize utility, subject to the restriction of aggregate expenditure, saving and non labor income of the households (*OING*), plus incomes of skilled and unskilled economically active persons. Therefore, households make their decisions that allow them to maximize their consumption, savings and their participation in the labor market in terms of disposable income and wages. For the good i and the household k we have:

$$U_k = \sum_{i=1}^{20}(m_{i,k}\log(C_{i,k}-\bar{C}_{i,k}))+m_0\log\left(\frac{S_k}{ipc}\right)+\gamma_1\log(PETC_k-PEAC_k)+\gamma_2\log(PETN_k-PEAN_k) \quad (17)$$

where:

$$\sum_{i=1}^{n} m_{i,k}+m_0=1$$

subject to:

$$E(wc_k)PEAC_k+E(wnc_k)PEAN_k+OING_k=\sum_{i=1}^{n} pxc_{i,k}C_{i,k}+s_k \quad (18)$$

where $E(wc_k)$ and $E(wnc_k)$ are the expected income for skilled and unskilled work units. On the other hand, the available income and subsistence income are defined as:

$$Y_{disp_k}=\sum_{i=1}^{n} C_{i,k}pxc_i+s_k \quad (19)$$

$$Y_{subs_k}=\sum_{i=1}^{n} \bar{C}_{i,k}pxc_i \quad (20)$$

from the first order equations we obtain:

$$C_{i,k}=\bar{C}_{i,k}+\frac{m_i\left(Y_{disp_k}-Y_{subs_k}\right)}{pxc_i} \quad (21)$$

$$S_k=m_0\left(Y_{disp_k}-Y_{subs_k}\right) \quad (22)$$

$$PEAC_k=PETC_k-\frac{\gamma_1\left(Y_{disp_k}-Y_{subs_k}\right)}{wc_k} \quad (23)$$

$$PEAN_k=PETN_k-\frac{\gamma_2\left(Y_{disp_k}-Y_{subs_k}\right)}{wnc_k} \quad (24)$$

It is assumed that there is frictional unemployment in the skilled labor market, so:

$$E(wc_k)=wc_k(1-tdc_k)$$

where tdc is the skilled unemployment rate. On the other hand, when an ELES demand system is adopted to represent the consumption behavior of households in a CGE model, the income elasticity of each of the parameters of each product and the Frisch parameter for each group of households are decisive in the calibration process. For this it is defined:

$$\begin{aligned} I_k &= E(wc_k)PEAC_k + E(wnc_k)PEAN_k + OING_k - s_k \\ &= \sum_{i=1}^{n} pxc_{i,k}C_{i,k} \end{aligned} \tag{25}$$

The parameter of Frisch is the substitution parameter that measures the sensitivity of the marginal utility of income to the relation between income and expenses. This parameter establishes the relationship between price and income elasticity. The Frisch parameter is determined on the basis of the quotient of a household's total expenditures and the temporary income (ie the difference between family income and total expenditure on subsistence needs):

$$Frisch_k = \frac{I_k}{I_k - \sum_{i=1}^{n} pxc_i\bar{C}_i} \tag{26}$$

Marshallian price elasticities and income - expenditure elasticities are:

$$\varepsilon_{i,k} = \frac{\bar{C}_{i,k}\left(1 - m_{i,k}\right)}{C_{i,k}} - 1 \tag{27}$$

$$\eta_{i,k} = \frac{m_{i,k}I_k}{pxc_i\bar{C}_{i,k}} \tag{28}$$

respectively. From the equation 21, as follows:

$$m_{i,k} = \frac{pxc_i\left(C_{i,k} - \bar{C}_{i,k}\right)}{I_k - \sum_{i=1}^{n} pxc_i\bar{C}_{i,k}} \tag{29}$$

replacing $m_{i,k}$ in equation 28, we obtain the income-expenditure elasticities in terms of the parameter of Frisch and the consumption additional to that of subsistence:

$$\eta_{i,k} = \frac{I_k}{I_k - \sum_{i=1}^{n} pxc_i \bar{C}_{i,k}} \frac{\left(C_{i,k} - \bar{C}_{i,k}\right)}{\bar{C}_{i,k}}$$
$$= Frisch_k \frac{\left(C_{i,k} - \bar{C}_{i,k}\right)}{\bar{C}_{i,k}} \tag{30}$$

Thus, the subsistence consumption is determined by calibrating the Frisch parameter and the income-expenditure elasticity.

In the unskilled labor market, the *PEAN* can target the formal or informal sector. The decision is modeled using a CET function. The expansion path (which can be considered a more general form of the Harris-Todaro equation [15]) is:

$$\frac{PEANI_k}{PEANF_k} = \left(\frac{1-\delta_s}{\delta_s} \frac{wtnc(1-desemfn_k)}{wti_k} \right)^{\sigma_s} \tag{31}$$

where *PEANI* and *PEANF* are informal and formal unskilled labor, *wtnc* is unskilled wage and *wti* is informal unskilled wage. It's worth mentioning that *wtnc* is exogenous (set by the minimum wage regulation) and the formal unskilled unemployment rate ($desemfn$) is endogenous.

The model balances the internal demands (consumption, intermediate demand, gross formation of fixed capital, inventories, civil works and public expenditure) with the production destined for the national market, making the prices endogenous.

5.3 Closure of markets

The formal unskilled labor market is adjusted for unemployment: the wage is exogenously determined. The markets for skilled labor and informal unskilled labor are adjusted by prices. The foreign exchange market can be adjusted by price (exchange rate) or by quantity (capital flows).

5.4 Macroeconomic closure

The model supports several macroeconomic closures, for this work we consider savings-driven closure, allowing the exchange rate to set the investment exogenously, and to adjust to external saving, to produce equilibrium.

[15] For details see Harris & Todaro (1970)

6 Simulations and results

As we have already mentioned, the public finances of Colombia have relied heavily on indirect taxes, particularly on VAT. This section shows the results of an increase in VAT by 3 percentage points for those products that have a VAT rate of 16% like the one conducted in Colombia's 2017 tax reform, doing an analysis on welfare and the trade-offs needed to avoid regressive effects on the poorest population. On the other hand, an additional simulation will be exposed where the VAT increase at a standard rate for all products, including the products of the basic basket, without altering the collection. Finally, we carry out a simulation where taxes are reduced to companies (replaced by a rising income tax for households that have the higher incomes) and their implications are analyzed on some macroeconomic variables.

Welfare is measured in terms of the compensating variation, which makes it possible to calculate, against an increase in prices, what additional income each household needs to reach its initial utility level. In addition, we will study the variations of disposable income, consumption and saving, which result from the different proposed scenarios:

- *Simulation 1*: It consists of increasing the tax on all goods and services that has a VAT rate from 16% to 19%.
- *Simulation 2*: Evaluates an extension of VAT to all products, including those products of the basic basket, but accompanied by a reduction of the applied rate, in such a way that tax collection is maintained, control of evasion is facilitated, and compensations to low-income groups, affected by the generalized application of the tax.
- *Simulation 3*: The decrease in corporate taxes is estimated at 20% (which is equivalent to moving from a nominal tax rate of 39% to 31.2%, without altering the other conditions that determine the tax collection). Taxes are replaced by a progressive income tax, which is charged to households from the decile 5, and gradually increases with income, from 3% of the total income of the decile 5 to 14% for the decile 10 using a polynomial function.

6.1 Changes in income and expenditure of households

The effects on purchasing power and consumption in the 20 groups of households in the three simulations are presented in Table 8. First, the increase in VAT by three percentage points for products with a general rate of 16% and the scenario of applying a standard VAT rate to all products, including basic basket products, reduce

disposable income, expenditure and savings for all groups, and given that the variations are proportional the Gini index remains unchanged in both scenarios. Notwithstanding, the impacts on welfare are much greater in the scenario in which the VAT rate is standardized.

The level of welfare achieved according to the utility function also decreases in these scenarios and consequently all households would require compensation in their income to reach the original level of utility, but although it would be expected that the compensation increases with the income, the households of the decile 10 do not suffer as strong an impact as the rest of the population.

For simulation 3, the mechanism of income taxes has been designed in a progressive way avoiding the direct impact of the most vulnerable population. However, due to the decline in unskilled employment and the possible reduction in transfers from other households, income and savings of households in the first 4 deciles are also reduced.

6.2 Effects on some macroeconomic and fiscal variables.

The tables 6 , 7 and 9 show the results of the effects of the three simulations on the basic macroeconomic variables and government collection. In the first two simulations, the expected short-term effect would be the reduction of consumption, that can affect the growth of the economy. But, in both cases, there are an increase of the balance of trade, and specifically in the case where VAT is fixed as ana standard rate for all products, this effect produces an increase in GDP, even though consumption drops by just over 4%.

The increase in direct taxes on households, to the extent that it is compensated by the decrease in taxes on businesses, has a positive effect on GDP: consumption certainly decreases, but this is compensated by an increase in investment, which should allow (through accumulation of capital) a future increase in production. In fact, the reduction of corporate tax generates an increase in gross fixed capital formation in more than 4 points as a percentage of GDP, which represents in the medium term additional growth of the economy, without generating a negative impact on the income of the poorest population, because the tax rate for this population is zero. In general, in all cases, unskilled employment is affected, as are inventories and average wage of skilled employees, with a much stronger effect in the second simulation.

Table 6: Selected Macro Variables (nominal and percentage changes) for the three simulations

Macro and fiscal variables	Base	Simulation 1		Simulation 2		Simulation 3	
	value	value	variation (%)	value	variation (%)	value	variation (%)
GDP	757.506	756.338	-0,15	760.857	0,44	759.865	0,31
Aggregate skilled employment	5.703.522	5.703.930	0,01	5.705.870	0,04	5.743.763	0,71
Aggregate unskilled employment	15.799.836	15.682.956	-0,74	15.489.056	-1,97	15.440.739	-2,27
Aggregate real household consumption	463.603	455.288	-1,79	444.611	-4,10	444.756	-4,07
Aggregate real private investment	195.176	195.176	0,00	195.176	0,00	203.895	4,47
Inventories	3.720	3.681	-1,04	3.655	-1,76	3.711	-0,24
Average skilled real wage	36,7	35,8	-2,30	34,7	-5,21	35,9	-2,03
Average unskilled real wage	15,5	15,5	0,00	15,5	0,00	15,5	0,00
Total exports	120.923	121.960	0,86	125.173	3,52	123.619	2,23
Total imports	161.748	155.599	-3,80	143.590	-11,23	151.947	-6,06
Tax collection	108.342	114.528	5,71	114.334	5,53	109.240	0,83
VAT renueves	40.017	47.056	17,59	47.056	17,59	40.604	1,47

Table 7: Other Macro Variables for the three simulations

Macro variables	Base value	Simulation 1	Simulation 2	Simulation 3
Central government deficit (GDP-ratio)	-2,42	-1,81	-1,58	-2,38
Tax collection (GDP-ratio)	14,30	15,14	15,03	14,38
Investment coefficient	25,77	25,81	25,65	26,83
Unemployment rate	9,09	9,64	10,29	10,02
Informality Rate	42,62	42,79	42,66	41,45
Gross fixed capital formation (percentage change)				4,47

Table 8: Percentage changes in disposable income, expenses ,save and compensation as a percentage of disposable income of Households for the three simulations

Area	Household groups	Simulation 1				Simulation 2				Simulation 3			
		Disposable income	Expenses	Save	Compensation (% of income)	Available income	Expenses	Save	Compensation (% of income)	Available income	Expenses	Save	Compensation (% of income)
Urban	U1	-1,86	-1,86	-2,32	1,91	-4,34	-4,34	-5,31	4,26	-2,73	-2,73	-3,38	2,50
	U2	-1,77	-1,77	-2,25	1,93	-4,28	-4,28	-5,32	4,52	-4,26	-4,25	-5,24	4,27
	U3	-1,82	-1,82	-2,30	1,94	-4,42	-4,42	-5,48	4,66	-3,87	-3,86	-4,78	3,84
	U4	-1,90	-1,89	-2,38	2,06	-4,62	-4,61	-5,68	4,92	-3,57	-3,56	-4,38	3,65
	U5	-1,90	-1,90	-2,36	1,95	-4,60	-4,60	-5,62	4,72	-5,28	-5,27	-6,41	5,38
	U6	-1,94	-1,93	-2,40	1,96	-4,66	-4,65	-5,69	4,86	-4,82	-4,81	-5,87	4,96
	U7	-1,96	-1,94	-2,41	1,95	-4,66	-4,64	-5,67	4,81	-4,40	-4,38	-5,36	4,46
	U8	-1,99	-1,97	-2,45	2,07	-4,72	-4,67	-5,76	5,10	-4,24	-4,18	-5,19	4,49
	U9	-2,02	-1,95	-2,41	1,95	-4,71	-4,54	-5,60	4,68	-4,64	-4,46	-5,58	4,68
	U10	-1,80	-1,70	-2,18	1,71	-3,96	-3,73	-4,82	3,86	-4,21	-3,95	-5,17	4,39
Rural	R1	-1,47	-1,47	-2,14	1,95	-3,35	-3,34	-4,78	4,17	-3,93	-3,92	-5,36	4,27
	R2	-1,39	-1,38	-2,23	1,89	-3,24	-3,22	-5,10	4,12	-4,17	-4,15	-6,20	4,63
	R3	-1,49	-1,48	-2,35	1,96	-3,47	-3,45	-5,42	4,45	-3,55	-3,54	-5,27	3,97
	R4	-1,67	-1,62	-2,14	2,05	-3,93	-3,80	-5,02	4,73	-3,16	-3,07	-3,99	3,46
	R5	-1,71	-1,65	-2,18	2,08	-4,01	-3,86	-5,09	4,81	-3,03	-2,92	-3,84	3,40
	R6	-1,81	-1,70	-2,26	2,08	-4,28	-4,01	-5,35	4,88	-5,00	-4,71	-6,17	5,41
	R7	-1,85	-1,75	-2,30	1,99	-4,38	-4,13	-5,43	4,68	-5,29	-5,01	-6,50	5,55
	R8	-1,86	-1,74	-2,31	2,02	-4,34	-4,06	-5,37	4,63	-4,47	-4,19	-5,50	4,61
	R9	-1,96	-1,82	-2,46	2,28	-4,61	-4,32	-5,68	4,96	-4,18	-3,89	-5,24	4,71
	R10	-1,90	-1,82	-2,22	1,62	-4,22	-4,02	-4,96	3,69	-4,31	-4,06	-5,24	4,36

As for the compensated variation, if it were desired to remedy the full impact of the VAT increase on the whole population, it would require less than 20% of the new tax collection. However, that would be nonsense. Compensation should be given to the underprivileged population so as not to widen inequality gaps. In our case, we consider the first four deciles of the population, and we note that only 1.66 % of the additional collection is necessary in the case of simulation 1, and 3.76 % in the case of simulation 2 (the scenarios where increases VAT). The other surprise result is that the GINI index remains unchanged with the increase in VAT, even if it taxes the basic basket, making this tax a good collection tool, given its efficiency, simplicity and its collection power, and the low compensatory cost in terms of welfare. Even generating a regressive measure of increasing direct taxes to the richest population and leaving the tax rate at zero, the GINI index remains unchanged, reflecting the persistence of the poor distribution of income.

Table 9: Cost of fiscal changes in welfare

	Simulation 1	Simulation 2	Simulation 3
Measure in money			
Total compensating variation**	9.632	22.133	22.006
Compensated variation for the first 4 deciles**	1.904	4.302	3.565
Per capita compensating variation*	208.056	478.070	475.342
Per capita compensating variation for the first 4 deciles*	86.762	196.010	162.402
Measure in percentage			
Total compensating variation (% of collection)	8,41	19,36	20,14
Compensated variation for the first 4 deciles (% of collection)	1,66	3,76	3,26

** This data is in Colombian peso billions

* This data is in Colombian pesos

Table 10: GINI index for each of the simulations

Inequality measure	Base value	Simulation 1	Simulation 2	Simulation 3
GINI index	54,73	54,68	54,66	54,73

7 Conclusions

The economic contexts of Colombia, and the high levels of income inequality in the country, make it essential to analyze the fiscal and tax situation that allows the sustainability of public finances, while at the same time providing elements that reduce the marked differences between the social groups.

Indirect taxes have been a very important tool for public finances in Colombia, given their efficiency in collection and their reduced levels of evasion. However, the impact it generates on the consumption of households, particularly the poorest, makes it very difficult to implement tax changes if these imply an increase in the tax burden on households.

However, the CGE model presented in this paper, simulating the Colombian economy, allows us to conclude that it is possible to reconcile progressivity and efficiency in a tax system. Although indirect taxes, such as VAT, would be expected to generate regression, in our case, we show that the VAT increase keeps the GINI index unaltered, and taking into account that the cost of compensation is low, its simplicity and the low rate of evasion that could be achieved in a simple and uniform system, and the effectiveness of collection (around four percentage points of collection for the forty percent of the population with less income in the case of Colombia), VAT constitutes a privileged tool of the tax system.

In the case of income tax, imposing a zero tax on the lower income population, and mitigating the tax burden of companies, capital accumulation can be encouraged, with important positive consequences on growth in the medium and long term. The tax is, in this sense, economically efficient, without sacrificing meritorious social objectives. Additionally, the persistence of the poor distribution of income in the different scenarios raised in this work, both in direct and indirect taxes, is highlighted.

The VAT increase with adequate compensation for the most vulnerable social groups, and the reduction of taxes on companies, in exchange for higher taxes on households, are two clear examples of the type of policies that can be implemented, when objectives are tax efficiency, economic efficiency and equity, which are necessary in today's world. The challenge facing economic policy in general, is to design the mechanisms by which these objectives can be reconciled. It depends on societies to be prosperous, equitable and sustainable.
Of course, mechanism design that makes it possible to compensate income to lower income households efficiently are the foundation of future research tasks.

References

Adelman, I. & Robinson, S. (1978). *Income distribution policy in developing countries: A case study of Korea*. Stanford University Press.

Agénor, P.-R., Chen, D. H., & Grimm, M. (2004). Linking representative household models with household surveys for poverty analysis: A comparison of alternative methodologies. *World Bank Policy Research Working Paper*, (3343).

Ahmed, V. & O'Donoghue, C. (2007). Using cge and microsimulation models for income distribution analysis. *Department of Economics, National University of Ireland Galway, working paper*, 89.

Armington, P. S. (1969). A theory of demand for products distinguished by place of production. *Staff Papers*, 16(1), 159–178.

Atkinson, A. B. (2015). *Inequality, What Can Be Done?* Harvard University Press.

Åvitsland, T. & Aasness, J. (2004). Combining cge and microsimulation models: Effects on equality of vat reforms.

Botero-García, J. & Velez-Álvarez, L. G. (2016). Dos visiones sobre la reforma tributaria. *Centro de Pensamiento Estratégico*.

Brown, M. C. (1994). Using gini-style indices to evaluate the spatial patterns of health practitioners: theoretical considerations and an application based on alberta data. *Social science & medicine*, 38(9), 1243–1256.

Cárdenas, M. & Perry, G. (1986). Diez años de reformas tributarias en colombia. *Editorial Universidad Nacional, Bogotá*.

Davies, J. B. (2004). Microsimulation, cge and macro modelling for transition and developing economies. united nations university. *World Institute for Development Economics Research*.

Decaluwé, B., Dumont, J.-C., Savard, L., et al. (1999a). Measuring poverty and inequality in a computable general equilibrium model. *Cahier de recherche du CRÉFA n*, 99, 20.

Decaluwé, B., Patry, A., Savard, L., Thorbecke, E., et al. (1999b). Poverty analysis within a general equilibrium framework. *African Economic Research Consortium*.

Dervis, K., Melo, J. d., & Robinson, S. (1984). *General equilibrium models for development policy.* Number A World Bank Research Publications. Cambridge university press.

Feltenstein, A., Lopes, L., Porras-Mendoza, J., Wallace, S., et al. (2014). Modeling tax reform in developing countries. *Taxation and Development: The Weakest Link?: Essays in Honor of Roy Bahl*, (pp.6̃9).

García Molina, M. & Gómez, A. P. (2005). ¿ han aumentado el recaudo las reformas tributarias en colombia? *Revista de economía institucional*, 7(12), 43–61.

Geary, R. C. (1950). A note on "a constant-utility index of the cost of living". *The Review of Economic Studies*, 18(1), 65–66.

Harris, J. R. & Todaro, M. P. (1970). Migration, unemployment and development: a two-sector analysis. *The American economic review*, (pp. 126–142).

Lustig, N., Pessino, C., & Scott, J. (2014). The impact of taxes and social spending on inequality and poverty in argentina, bolivia, brazil, mexico, peru, and uruguay introduction to the special issue. *Public Finance Review*, 42(3), 287–303.

Nahar, B. & Siriwardana, M. (2013). Trade opening, fiscal reforms, poverty, and inequality: A cge analysis for bangladesh. *The Developing Economies*, 51(2), 145–185.

OCDE (2015). Colombia economic survey. *Publicaciones OCDE*.

Piketty, T., Goldhammer, A., & Ganser, L. (2014). Capital in the twenty-first century.

Rojas, S., Bonilla, R., Córdoba, R., Lewin, A., Morales, O. D., Montoya, S., Perry, G., Piza, J. R., et al. (2015). *Comisión de Expertos para la Equidad y la Competitividad Tributaria. Informe Final presentado al Ministro de Hacienda y Crédito Público. Diciembre de 2015*. Technical report, FEDESARROLLO.

Saez, E. & Zucman, G. (2014). *Wealth inequality in the United States since 1913: Evidence from capitalized income tax data*. Technical report, National bureau of economic research.

Sánchez, F. & Gutiérrez, C. (1995). *Casos de éxito de reformas fiscales en Colombia: 1980-1992*, volume 71. Naciones Unidas, Comisión Económica para América Latina y el Caribe.

Savard, L. (2005). Poverty and inequality analysis within a cge framework: A comparative analysis of the representative agent and microsimulation approaches. *Development Policy Review*, 23(3), 313–331.

Shoven, J. B. & Whalley, J. (1972). A general equilibrium calculation of the effects of differential taxation of income from capital in the us. *Journal of public economics*, 1(3), 281–321.

Stone, R. (1954). Linear expenditure systems and demand analysis: an application to the pattern of british demand. *The Economic Journal*, 64(255), 511–527.

8 Appendix

Figure 8: Theoretical structure of the model

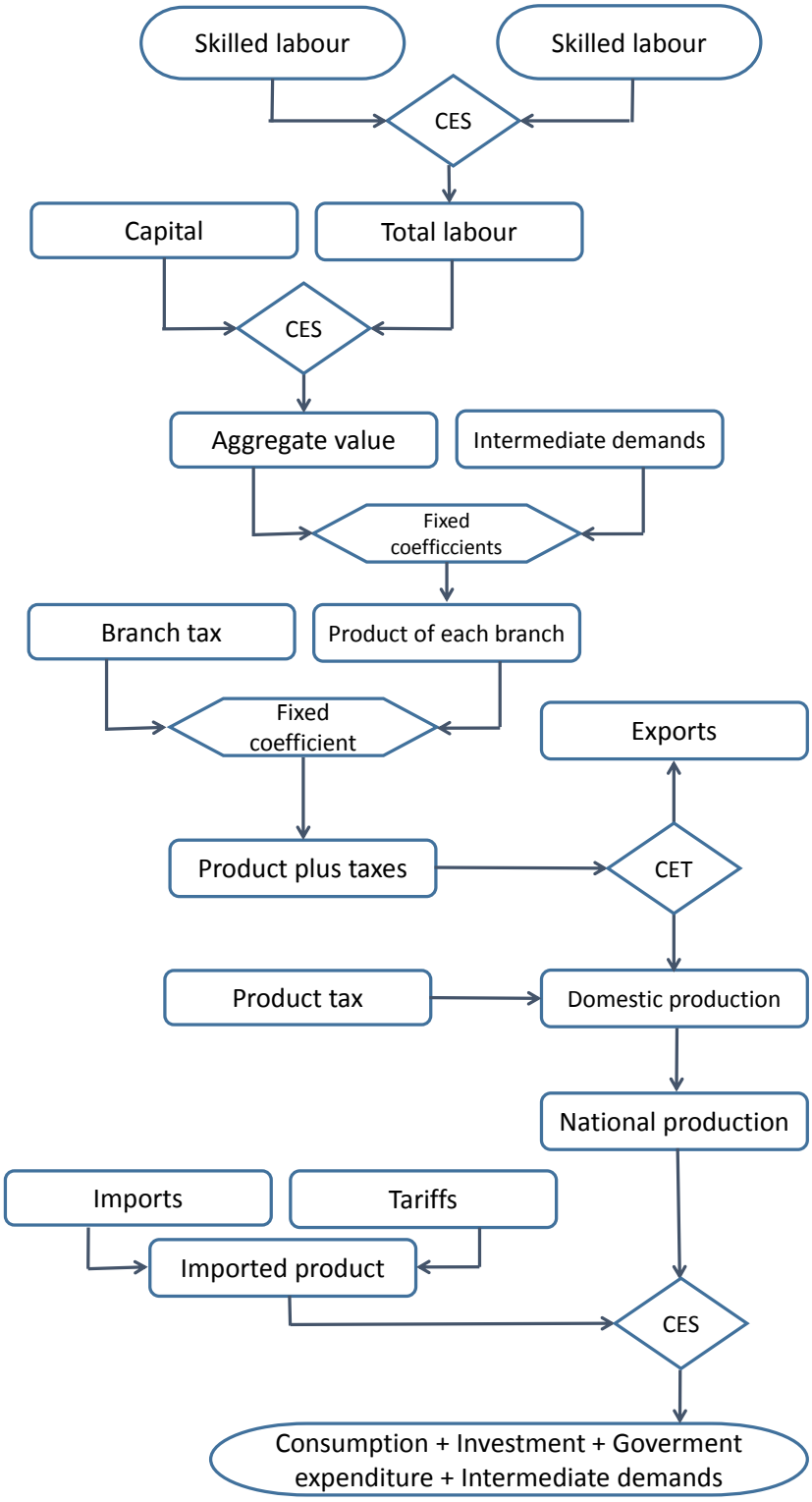


Table 11: Number of households, population, and labor market for the 20 groups of households of the model

Area	Decile	Number of households	Population	People per household	Labor force articipation rate (%)			Unemployment rate (%)			Occupancy rate (%)		
					Unskilled	Skilled	Total	Unskilled	Skilled	Total	Unskilled	Skilled	Total
Urban	U1	597,447	2,399,774	4.0	47.92	62.95	48.74	25.94	54.73	27.96	35.51	28.50	35.12
	U2	764,805	3,281,031	4.3	53.86	71.32	54.99	15.24	32.50	16.68	45.66	48.14	45.82
	U3	923,088	3,764,241	4.1	58.03	73.13	59.37	12.96	25.57	14.32	50.52	54.43	50.87
	U4	1,023,499	3,933,577	3.8	61.21	75.43	62.94	11.38	23.53	13.13	54.27	57.68	54.67
	U5	1,105,712	4,073,960	3.7	63.64	78.69	66.03	9.58	16.68	10.89	57.58	65.57	58.84
	U6	1,169,217	4,098,952	3.5	65.10	81.39	68.49	7.80	13.49	9.17	60.06	70.41	62.21
	U7	1,211,984	3,966,268	3.3	65.36	85.29	70.67	6.66	10.94	8.02	61.03	75.96	65.01
	U8	1,244,346	3,559,935	2.9	65.86	85.63	72.59	5.31	8.08	6.40	62.39	78.71	67.95
	U9	1,278,271	3,430,347	2.7	60.05	85.07	71.91	4.17	6.46	5.41	57.60	79.57	68.02
	U10	1,312,797	3,058,665	2.3	49.04	83.28	72.56	3.70	3.93	3.87	47.26	80.01	69.75
Rural	R1	763,380	3,391,404	4.4	46.66	60.23	46.80	8.08	36.00	8.38	42.92	38.55	42.88
	R2	594,198	2,428,721	4.1	54.06	68.51	54.31	5.81	23.17	6.16	50.93	52.63	50.97
	R3	441,843	1,641,001	3.7	59.19	74.98	59.60	5.04	24.69	5.62	56.24	56.46	56.25
	R4	331,834	1,109,870	3.3	63.76	80.97	64.45	3.48	18.50	4.23	61.54	65.99	61.72
	R5	253,785	759,660	3.0	66.39	80.11	67.21	4.06	14.44	4.77	63.74	68.54	64.01
	R6	196,174	544,965	2.8	70.56	86.89	71.96	2.27	8.46	2.89	69.04	79.54	69.88
	R7	142,503	349,817	2.5	76.99	81.78	77.57	2.61	7.48	3.13	75.05	75.66	75.14
	R8	115,406	246,904	2.1	77.50	83.84	78.45	3.51	8.91	4.28	74.84	76.37	75.09
	R9	81,594	172,776	2.1	70.27	84.51	73.72	2.44	2.35	2.41	68.56	82.53	71.94
	R10	47,096	83,881	1.8	64.70	84.27	75.05	4.22	5.20	4.80	61.96	79.89	71.45
National total		13,598,979	46,295,749	3.4	59.42	82.38	64.23	8.70	10.26	9.09	54.28	73.93	58.39

Source: GEIH and ENCV - DANE (2014). Own calculations

Table 12: Share of income and expenditure over the total for each group of households of the model

Area	Decile	Labor income				Non labor income	Expenses		
		Formal		Informal			Household consumption	Social secury contributions	Taxes
		Unskilled	Skilled	Unskilled	Skilled				
Urban	U1	0.3	0.0	1.6	0.2	1.0	3.5	0.2	1.3
	U2	1.8	0.1	4.7	0.9	1.9	3.5	0.9	1.0
	U3	4.7	0.4	6.8	1.8	2.6	4.4	2.2	1.7
	U4	7.3	0.9	8.2	2.7	3.5	6.5	3.3	2.3
	U5	10.5	2.0	9.2	4.2	4.5	6.2	5.0	2.8
	U6	12.9	3.6	10.1	6.5	5.9	7.7	6.8	4.7
	U7	14.3	6.2	10.2	8.6	8.1	9.0	8.8	6.0
	U8	14.6	9.5	9.8	11.2	10.2	11.0	10.8	8.8
	U9	12.5	18.0	9.4	17.9	15.9	13.3	15.5	12.7
	U10	8.9	56.6	7.0	42.2	37.9	27.8	38.7	54.7
Rural	R1	0.3	0.0	2.7	0.1	1.2	0.9	0.2	0.4
	R2	1.1	0.0	4.2	0.2	1.2	1.1	0.7	0.4
	R3	1.8	0.1	3.8	0.2	0.9	1.0	1.0	0.5
	R4	1.9	0.1	3.1	0.3	0.8	0.8	1.0	0.7
	R5	1.7	0.1	2.5	0.3	0.7	0.8	1.0	0.4
	R6	1.6	0.2	2.1	0.3	0.7	0.5	0.9	0.3
	R7	1.3	0.3	1.7	0.4	0.5	0.4	0.8	0.3
	R8	1.2	0.3	1.4	0.2	0.6	0.3	0.7	0.3
	R9	0.9	0.5	1.0	0.5	0.8	0.3	0.7	0.4
	R10	0.4	0.8	0.5	1.4	1.1	0.8	0.7	0.4

Source: GEIH and ENCV - DANE (2014). Own calculations

Table 13: Growth rate of total annual GDP and per capita GDP at constant prices for Latin America

	GDP				Per capita GDP			
	2012	2013	2014	2015	2012	2013	2014	2015
Latin America and the Caribbean	2.8	2.9	0.9	-0.5	1.7	1.7	-0.2	-1.6
Latin America	2.9	2.9	0.9	-0.5	1.7	1.7	-0.2	-1.6
The Caribbean	1.3	1.5	0.4	-0.5	0.7	0.9	-0.2	-1.1
Argentina	-1.1	2.3	-2.6	2.4	-2.1	1.2	-3.5	1.4
Bolivia	5.1	6.8	5.5	4.8	3.4	5.1	3.8	3.2
Brazil	1.9	3.0	0.1	-3.9	0.9	2.1	-0.8	-4.7
Chile	5.5	4.0	1.9	2.1	4.3	2.9	0.8	1.0
Ecuador	5.6	4.6	3.7	0.3	4.0	2.9	2.1	-1.2
Mexico	4.0	1.4	2.2	2.5	2.6	0.0	0.9	1.2
Panama	9.2	6.6	6.1	5.8	7.4	4.9	4.4	4.1
Paraguay	-1.2	14.0	4.7	3.0	-2.6	12.5	3.3	1.7
Peru	6.1	5.9	2.4	3.3	4.7	4.5	1.0	1.9
Uruguay	3.5	4.6	3.2	1.0	3.2	4.3	2.9	0.6
Venezuela	5.6	1.3	-3.9	-5.7	4.2	0.0	-5.1	-6.9

Source: ECLAC: Economic Commission for Latin America and the Caribbean - based on official sources