Macroeconomic and Distributional Effects of Income Tax Changes

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Abstract

Colombia has an total revenue lower than its public expenses, leading to a fiscal deficit and putting the sustainability of its finances at risk. One possible way to increase tax revenue could be to raise income tax collection, especially from individuals, whose contribution to this type of revenue is low. However, tax changes have effects on the macroeconomic variables and income distribution. To estimate those effects, I use a general equilibrium model with heterogeneous agents and simulate two different scenarios of permanent tax changes: first, there is an increase in personal income tax; second, personal income tax raises while corporate income tax is reduced simultaneously. Results suggest that the first scenario would lead to an improvement in income distribution, but economic activity falls due to the lower income received by households, reducing their consumption, savings, capital and investment, especially in higher income households. On the other hand, the second scenario would achieve larger returns on capital that increase income and consumption in households, contributing to a raise in production and mitigating negative effects of higher individual income tax. Under this scenario, not only income distribution improves, but also there is a positive effect on macroeconomic variables.

Key Words: Heterogeneous agents, general equilibrium, fiscal policy, income distribution, macroeconomic effects.

1 Introduction

Government tax revenues are crucial for the nation because they reflect the sustainability of fiscal accounts, finance public expenses, and enable the operation of the government. Other alternative to finance public expenses is debt, but if the fiscal accounts are not sustainable, that mean, revenues are not enough to pay debt services and the rest of expenses, interest would be increasing in the time leading to a worse scenario. Therefore, it is important that government has appropriate revenues to finance their policies.

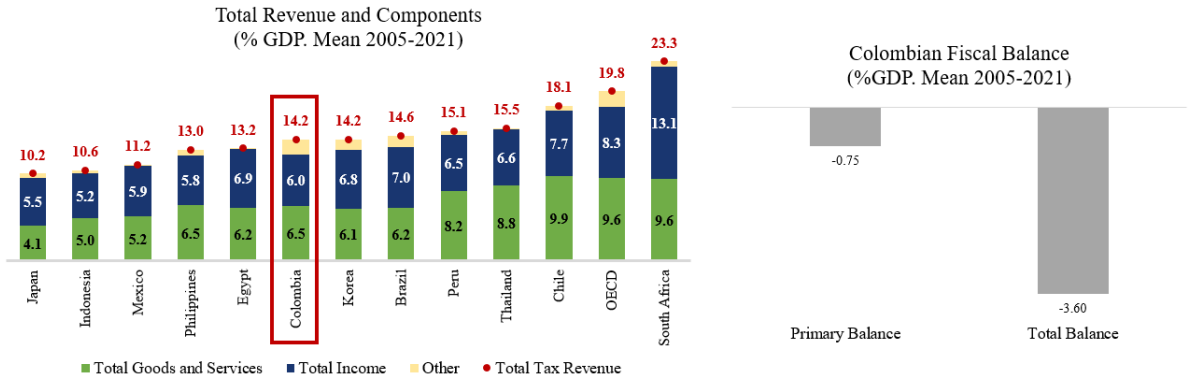


Figure 1: Total Revenue and Colombian Fiscal Balances
Source: Author's calculations based on OECD tax data base.

In the case of Colombia, see figure (1) tax revenues are low compared with higher income countries like OECD and even lower than similar countries like Peru and Chile. Consequently, weak revenues impose a budget restriction to finance social programs or increase public expenditures according to political programs. Talking about expenditures, in Colombia are bigger than revenues, so there is a total and primary deficit (see figure 1). As long as revenues continue to be less than expenditures, with hight deficits, fiscal accounts sustainability would be in risk. Therefore, it is important to think about different alternatives to improve fiscal accounts, and keeping in mind that most of the expenditures is inflexible as is mentioned by Melo, L., Ramos, J., Gómez, C. (2020), one way could be increase fiscal revenues.

Tax revenue from Total Goods and Services in Colombia is similar to economies like Brazil, Korea, Philippines or Egypt, while it is lower than Peru, Chile or more advanced countries like OECD. On the other hand, Total Income revenue is lower than the countries mentioned above and, even more, is one of the lowest revenue compared with the rest of the countries (see figure 2). Also, Colombia has the particularity that in income revenue, corporate incomes contributes with the 80% of the total income revenue, while personal income just the rest 20%. This fact become Colombian taxation system in one of the most excessive over corporate, compared for example with similar countries like Brazil, Peru and Chile where corporate income contributes 56%, 72% and 76% respectively (see figure 2).

From the perspective of effective taxes, it is also possible to show the higher contribution of corporate income compared to personal income in the Total Income Revenue. Between 2005 and 2019, the effective tax to corporate capital income have increased by about 3 percentage points (pp), reaching 21.1pp, while effective personal income tax have increased by about 2pp, now standing at 18pp (where this increase is mainly due to the rise in security payments) (Delgado, M., Rincón, H. (2017) Rincón, H. (2021)).

Given the low participation of individuals in income tax revenue and the aim to increase tax collection to enhance the financing of public expenses and the stability of fiscal accounts, reducing fiscal deficit, one way could be increase taxation on individuals. Besides, due to the effect of direct taxes on the reduction of inequality, higher individual tax income could improve the distribution of wealth and incomes in the country (Nuñez, J: Olivieri, S., Parra, J., Pico, J. (2020)).

However, higher income taxes lead to distortions on the decisions of households and firms, and therefore, on the rest of the economy. Consequently, when individual taxes increase both effects on income inequality and economic activity (such as GDP, consumption and investment) have to be considered. For these reason, this paper looks for analyze and estimate the effects on macroeconomic variables and on income distribution in front of higher individual income taxes in Colombia.

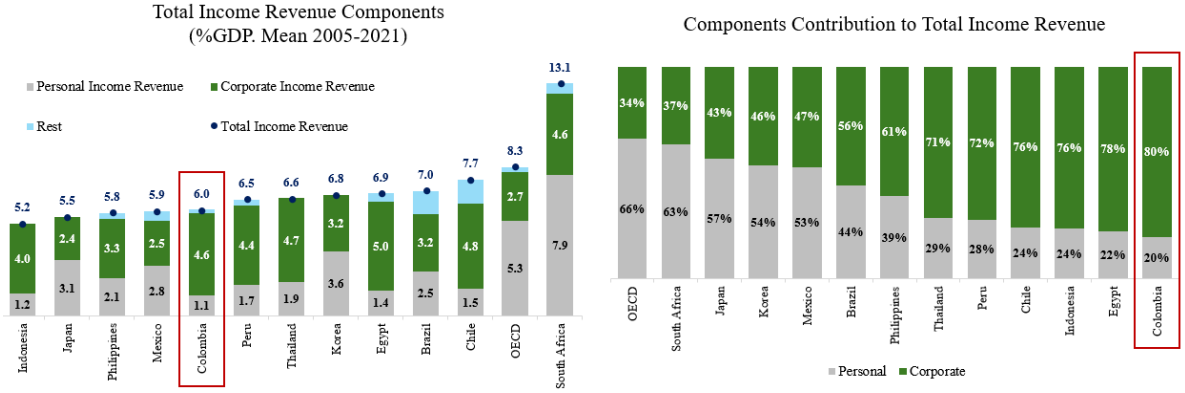


Figure 2: Total Income Revenue and Its Components
Source: Author's calculations based on OECD tax data base.

To analyze those effects, this paper supposes a permanent change on taxes and a general equilibrium model with heterogeneous agents will be used, where households and firms pay income taxes. General equilibrium models allow to capture the distortions on the agents decisions in front of the higher taxes. However, when the model only has a representative agent, it is not possible to estimate effects on income distribution, so is necessary to include heterogeneity on agents, in this case, on households. Other kind of general equilibrium models include two kind of households, one richer than the other, but these models also suppose a fixed exogenous proportion of the two households. On the other hand, when the model assumes a large heterogeneity with idiosyncratic shocks, motivating precautionary savings, allows to endogenous adjustments in wealth distribution over time, making possible to estimate or capture another transmission channels that can not be captured in a model with one representative agent or with two agents. These new feature improves the analysis of economic policies and the effects on economy (Debertoli, D., Galí, J. (2018)).

The related literature can be divided into two sides: On one hand, there are papers that use general equilibrium models with heterogeneous agents to analyze fiscal policy effects on economic variables; on the other hand, there are papers that estimate tax changes effects on economy and income distribution in Colombia. In the first group of papers, it's important to note that these studies have not been done for medium income countries with high income inequality. Additionally, these models include taxes to personal labor income and capital income, but do not simultaneously include corporate income tax. In the second group of papers, other authors have estimated the macroeconomic effects of tax changes in Colombia using different approaches such as dynamic stochastic general equilibrium (DSGE) models o econometric models, but their contributions to understanding the effects on income distribution are scarce.

Therefore, the present paper contributes to the literature mainly in two aspects: first, the general equilibrium model with heterogeneous agents is calibrated for a medium income country like Colombia, contributing to both literature related to these kind of models and the work done in Colombia about macroeconomic and distributional effects of tax changes. Second, this paper includes corporate income tax simultaneously with personal income tax, improving the approximation in this kind of models of tax structure to a real tax system.

As mentioned above, tax changes are permanent and a final steady state is calculated. To estimate macroeconomic and distributional effects in the long run, first it is necessary to find an initial steady state to compare final state. The initial state is calibrated using the average of the main macroeconomic and fiscal variables between 2005 and 2021 from de National Department of Statistics (DANE), Ministry of Finance (MHCP) and OECD. Income distribution calibration is done using the Great Integrated Household Survey (GEIH)

published by DANE.

From the initial steady state, two exercises are simulated: 1) increase in 0.5pp in personal income tax revenue as a share of GDP; 2) a re-composition of tax revenue where total income revenue remains constant, but corporate income tax revenue is reduced while personal income increases to compensate. In each exercise, larger personal income revenue is achieved in different ways, such as taxing higher income households or broadening personal income tax base to include households with slightly low incomes. Tax revenue is used to finance lump sum transfers to households.

Results suggest that the first exercise would lead to an improvement in income distribution due to the government's redistributive policies. However, there is a contraction in economic activity since the increase in personal income taxes reduce disposable income, thereby reducing consumption and capital assets accumulation, especially in households with higher income. The effects on consumption would be mitigated by the increase in transfers from the government to lower income households. On the other hand, when personal income taxes increase simultaneously with corporate income tax reduction, there is a incentive on firm production, so productive factors demand increases and thereby rising wages, capital rent and households income. Similar to the previous exercise, effects would be mitigated by higher personal income tax, but those policies would lead to an improvement in income distribution better than the first exercise and a grow in macroeconomic variable levels.

The rest of the document is organized by the literature review, model structure, exercise simulation and conclusions.

2 Literature Review

Due to general equilibrium models with heterogeneous agents have not been done for Colombia, the literature review is divided in two groups: First, those papers that have used these kind of models to analyze tax policies effects on macroeconomic and income distribution and second, those papers that have estimated tax changes effects in Colombia.

In the first group of papers, literature has found different tax effects on macroeconomic variables and income distribution. Talking about macroeconomic effects, there is a negative relation between higher taxes and economic activity. Domeij, D., Heathcote, J (2004) found that a reduction in capital income taxes leads to an increase in GDP, consumption and investment due to greater incentives to capital investment. However, the positive effects depend on the increase in labor income taxes to replace lower capital income tax revenue, since labor supply would be reduced and thereby production. Similarly, Sun, H., Zhou, C. (2018) found that higher taxes reduce consumption ans economic activity due to bigger savings made by households for precautelative motives and hence reduce their consumption.

On the other hand, other authors have studied macroeconomic and distributional effects from progressive tax systems. Conesa, J., Kitao, S. ,Krueger, D. (2009) found that a progressive tax system improves social welfare and income distribution, but negative labor and capital supply effects are not compensated due to higher taxes, so there is a worse economic activity, GDP and lower consumption. Similarly, Heathcote, J., Storesletten, K., Violante, G. (2017), Heathcote, J., Storesletten, K., Violante, G. (2020a) and Heathcote, J., Storesletten, K., Violante, G. (2020b) remark that a progressive tax system has positive redistributive effects, but higher marginal taxes will disincentive labor supply while lower inequality leads to lower worker training and thereby reduce productivity and production. Alternatively, Ferriere, A., Navarro, G. (2022) mention that in a progressive system, when higher income households pay higher income taxes, public expense effects on macroeconomic variables is greater because those households have lower labor elasticities and lower marginal propensity to consumption, therefore tax increases do not completely affect labor supply.

Additionally, these results may vary depending on how the government decides to allocate the additional revenue from the tax increase to public expenses. Yao, Q., Hou, D., Cheng, L. (2021) conclude that poverty

subsidies, simultaneously with progressive tax systems, lead to a better income distribution. Meanwhile Dyrda, S., Pedroni, M (2022) point that public transfers not only allow income redistribution reducing income inequality, but also improve labor assignment and the correlation between productivity and labor hours, leading to a better economic performance.

The studies mentioned above are calibrated to high income countries such as United States or economies like China. Besides, those are focused on labor and capital income received by households, but corporate income is not taxed. Therefore, this paper seeks to contribute to this kind of literature applying general equilibrium models with heterogeneous agents to medium income countries with high income inequality such as Colombia. Besides, a corporate income tax is modeled simultaneously with labor income tax, improving the tax structure in the model with the aim to replicate better the tax system in the country. Besides, previous studies are also focused in the long run effects and not in the dynamic or variable convergency to the new economy state. This paper look for analyze variable dynamics to have a better understanding of income tax changes effects on macroeconomic variables and income distribution.

In the second group of papers, those which study tax effects on Colombian economy, many methodologies have been used. Lozano, I., Rodríguez, K. (2009) use autorregresive vectors to analyze effects in the short run given fiscal shocks, including direct taxes, and found a negative and persistent effect on investment, GDP and consumption. The effect would be significative in the firsts quarters, but in the medium run losses significancy. Similarly Steiner, R. (2014) found a positive effect on investment when corporate taxes are reduced since the incentives on investment in machinery and equipment leading to a improve in production. Government balance will be worse given the tax reduction, but in the medium term it will recover thanks to the better economic activity.

On the other hand, Rincón, H., Rodríguez, D., Toro, J., Téllez, S. (2014) use a dynamic stochastic general equilibrium model to simulate transitory public expenses and tax shocks. The authors suggest a negative relation on aggregate demand given higher taxes, similar to Lozano, I., Rodríguez, K. (2009), where consumption tax and labor income tax would have more persistent effects. In the same way, Rincón, H., Ángel Mojica, J. (2023) made a model with two kind of households and concluded that there is a positive relation between corporate tax reduction and economic growth, however, the effects may be uneven in consumption, welfare and households income and depend on the fiscal variable the government decides to use to recover lower tax revenue due to the corporate tax reduction.

Finally, Nuñez, J: Olivieri, S., Parra, J., Pico, J. (2020) analyze tax and public expenses effects on the reduction in income inequality in Colombia in 2017. The authors found that those fiscal instruments have contributed in the reduction of inequality, but the country still has several problems in this topic. Previous studies about Colombia do not analyze simultaneously effects on macroeconomic effects and income distribution and their relation. For that reason, the present paper looks for contribute to this literature using a general equilibrium model with heterogeneous agents to analyze both economic activity and distribution.

3 Model Description

In this section, the general equilibrium with heterogeneous agents used in this paper is described. These kind of models capture the different economic distortions due to the higher taxes and also the transmission channels over agents (households and firms). This characteristic is important to analyze the effects on macroeconomic variables when income tax changes. Simultaneously, these models allow to analyze income distribution changes and estimate effects on income inequality, since the household heterogeneity in the model is given by the income distribution. In other words, in the model is supposed a continuum of households where each one solves the same utility maximization problem subject to a budget constraint, but each household has a different income calibrated to replicate the income distribution observed in data taken from the Great Integrated Household Survey (GEIH) published by the Statistic Department (DANE). Therefore, some households are richer than others and have a higher budget constraint. This last feature is not captured by general equilibrium models with a representative agent, because there is not income heterogeneity, so the

analyzes of distribution and inequality is limited.

The model is composed by 3 agents: A household distribution that consumes goods, pays taxes, has a labor supply and saves in assets; a representative firm that pays taxes and demand labor and capital to produce goods; and a government that collects taxes and finances lump sum transfers to households. Figure (3) describes the model structure.

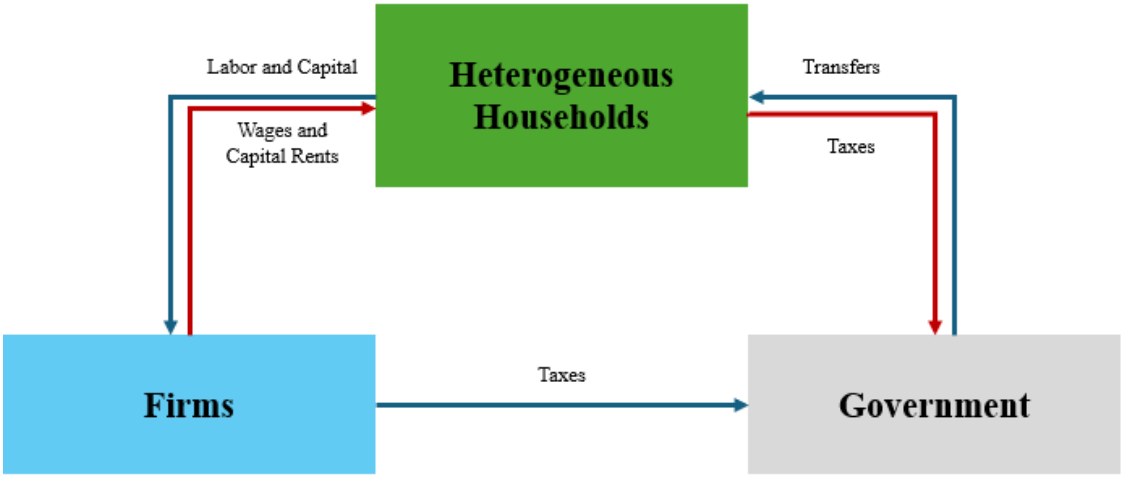


Figure 3: Model Structure

3.1 Households

The model is based on Aiyagari, S. R. (1994) where suppose a distribution of heterogeneous households with a producer firm, but there is not a government that tax agents or distributes transfers. Besides, that model is constructed in discrete time, but the present model is solved in continuous time following Yves, A., Jiequn, H., Lasry, J-M., Lions, P-L., Moll, B. (2022), since the computational solution is easier[1].

A continuum of households who live in infinitely is supposed. Households offer a quantity of labor in each period, which depends on the labor hours and their productivity $y_t \in Y = \{y_1, y_2, ..., y_N\}$. These labor productivity corresponds to the labor endowment possible values and it's stochastic, that say, follows an exogenous process Ornstein-Uhlenbeck:

$$dy_t = \theta(\bar{y} - y_t)d_t + \sigma dB_t$$

Stochastic labor productivity is bounded to $[\underline{y}, \overline{y}]$, θ is the persistency of the process, $\overline{y}$ is the mean, σ is the variance and B_t is a Brownian process. Besides, each household has a wealth distribution a_t that belongs to the set A (possible values set of assets, $A = [0, \infty)$. Assets accumulation depends on disposable income that each household has.

The problem of the households consist in maximize the expected value of their utility across the time

$$E_0\left[\int_0^\infty e^{-\rho t}u(c_t)dt\right]$$

ρ is the discount rate and $u(c_t)$ follows a CRRA function with an inelastic labor supply

$$u_t(c) = \frac{c_t^{1-\gamma}}{1-\gamma}$$

[1]Codes are based on codes from Benjamin Moll disposable on his website `https://benjaminmoll.com/codes/`

c_t is the consumption and γ is the risk aversion. The utility is maximized subject to the budget constraint expressed in continous time

$$da_t = ((1-\tau_t^n)w_t y_t + r_t a_t + tr_t - c_t)dt$$

$(1-\tau_t^n)w_t$ are wages after personal income tax and tr_t are lump sum transfers made by government to each household. Therefore, Hamilton-Jacobi-Bellman equation (HJB), that describes households optimal choices, can be expressed as

$$\rho V_t(a,y) = \max\left\{u(c) + [(1-\tau^n)wy + ra + tr - c]\frac{\partial V}{\partial a} + \frac{\sigma^2}{2}\frac{\partial^2 V}{\partial y^2}\right\}$$

and Kolmogorov Forward equation, that describes the distribution evolution in time, is:

$$\frac{\partial g}{\partial t} = -\frac{\partial}{\partial a}[((1-\tau^n)wy + ra + tr - c)g_t(a,y)] - \frac{\partial}{\partial y}[\theta(\overline{y}-y)g_t(a,y)] + \frac{1}{2}\frac{\partial^2}{\partial y^2}[\sigma^2 g_t(a,y)]$$

$g_t(a,y)$ is the probability density function of the income stochastic process.

3.2 Firms

Representative firm uses capital and labor to produce goods with a Cobb Douglas production function

$$f(K,L) = K_t^\alpha L_t^{1-\alpha}$$

The firm problem consists in maximize its benefits (B_t) taking account the corporate income tax τ_t^f following McGrattan, E., Prescott, E. (2005)

$$B_t = f(K,L) - r_t^k K_t - w_t L_t - \tau_t^f[f(K,L) - \delta K_t - w_t L_t]$$

The corresponding productive factors demands are

$$r_t^k = (1-\tau_t^f)\alpha K_t^{\alpha-1} L_t^{1-\alpha} + \tau_t^f \delta$$

$$w_t = (1-\alpha)K_t^\alpha L_t^{-\alpha}$$

3.3 Aggregation

Aggregate assets held by households correspond to the aggregate capital in the economy

$$K_t = \int_0^\infty \int_{\underline{y}}^{\overline{y}} a_t dy da$$

Similarly, aggregate labor demanded by firms is the aggregate labor endowment equaled to one

$$L_t = \int_0^\infty \int_{\underline{y}}^{\overline{y}} y_t dy da = 1$$

3.4 Government

The government collects personal income taxes and corporate income taxes to finance lump sum transfers to households

$$\tau_t^w w_t \int_0^\infty \int_{\underline{y}}^{\overline{y}} y_t dy da + \tau_t^f[f(K,L) - \delta K_t - w_t L_t] = TR_t$$

TR_t are the aggregated transfers $TR_t = \int_0^\infty \int_{\underline{y}}^{\overline{y}} tr_t dy da$

Variable to GDP	Observed	Calibrated
Consumption	79%	79.3%
Investment	21%	20.7%
Corporate Income Tax Revenue	4.8%	4.8%
Personal Income Tax Revenue	1.1%	1.08%

Table 1: Macroeconomic and Fiscal Variables to GDP
Source: Data taken from DANE, OECD and Saint Louis Federal Reserve.

4 Model Calibration

Macroeconomic variables are calibrated to replicate some features of the Colombian economy, for example, consumption and investment to GDP between 2005 and 2021. Second, income taxes are calibrated to represent the average revenue in the last years for each type of tax. Finally, the parameters of the stochastic labor productivity process are calibrated to match the labor income distribution in households by deciles. Once the calibration is done, the initial state of the model is found.

With the aim of calibrating consumption and investment, data is taken from DANE and the average of each variable to GDP is calculated between 2005 and 2021. Similarly, capital to GDP is found using data series from DANE and the Saint Louis Federal Reserve. On the other hand, model taxes are calibrated to replicated the average revenue to GDP of corporate income and personal income taxes using OECD from 2005 and 2021. Table (1) shows the observed macroeconomic and fiscal variables to GDP and the values calibrated in the model. It should be noted that tax revenues are entirely spent on lump sum transfers to households, which implies that in model aggregation, production is only allocated in consumption and investment:

$$f(K, L) = C_t + I_t$$

Otherwise, heterogeneity in the model is featured by the stochastic labor productivity that define labor income of each household. Therefore, the distribution of these labor productivity should replicate the labor income distribution observed in Colombia. The survey GEIH-2022, at national level, is used to estimated household income by employed population deciles (since all households in the model work). Calibration in the model follows Granda, C., Hamann, F. (2020) where authors estimate the participation of each labor income decile in the total labor income. Calibration is shown in figure (4), panel A. The model manages to get close to the observed labor income distribution, where the 10th decile represents about 40% of total labor income while the lower deciles, like 1st and 2nd decile, have almost zero participation, highlighting the great income inequality in the country. These feature can also be appreciated with the high value of the Gini coefficient, see figure (4) panel B.

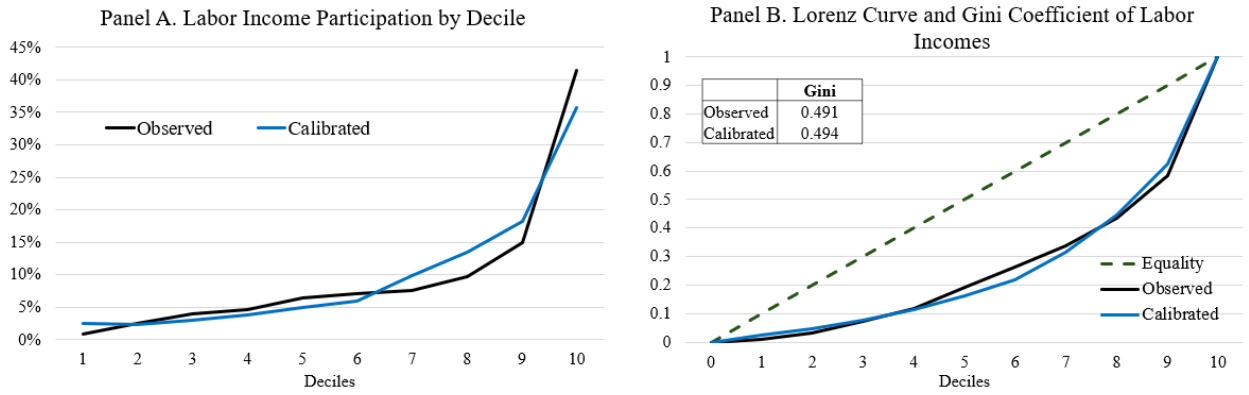


Figure 4: Calibration of Labor Income Distribution by Deciles
Source: Own elaboration based on survey GEIH-DANE.

	Observed		Calibrated	
Deciles	**Participation**	**Revenue by Decile (%GDP)**	**Participation**	**Revenue by Decile (%GDP)**
1	0.5%	0.01%	0.1%	0.00%
2	0.5%	0.01%	0.1%	0.00%
3	0.6%	0.01%	0.2%	0.00%
4	0.0%	0.00%	0.1%	0.00%
5	0.5%	0.01%	0.4%	0.00%
6	0.2%	0.00%	0.3%	0.00%
7	0.2%	0.00%	0.4%	0.00%
8	0.7%	0.01%	0.6%	0.01%
9	3.1%	0.03%	3.7%	0.04%
10	93%	1.03%	94%	1.02%
Total	100%	1.1%	100%	1.08%

Table 2: Personal Income Tax Payments by Decile
Source: Own elaboration based on survey GEIH.

The great survey of households GEIH is also used to calibrate the personal income tax payments and transfers by decile. For the personal income tax calibration, the survey has a question about the tax payments, and keeping the employed population criterion, the participation of each decile in the tax payment is found. Later, this participation is used to distribute total personal income revenue to GDP reported in table (1). Therefore, if personal income tax payments by decile is summed, it should be equal to the total personal income tax revenue to GDP collected by the government. For the transfers calibration, a similar methodology is used, but this time a question about different subsidies from the government is taken.

The results of personal income tax payments and transfers are shown in table (2) and table (3), respectively. As well as 10th decile concentrates the greatest participation in labor incomes, it is not surprising that the higher personal income tax payments is also focused in this decile, contributing with almost 90% of the total personal income tax revenue. On the other hand, transfers in 10th decile are the lowest while 1st, 2nd and 3rd deciles concentrate a large part of the subsidies given by the government (almost the 50% of total transfers).

Finally, for the calibration of the other parameters of the model, some are taken from literature or calibrated to replicate previous targets on macroeconomic or fiscal variables. Risk aversion is taken from Prada Sarmiento, J.D., Rojas Dueñas, L.E. (2009) while capital participation in production function is taken from González, A., López, M., Rodríguez, N., Téllez, S. (2013). Besides, model calibration looks for an interest rate similar to 2.5% used by Granda, C., Hamann, F. (2020) and a depreciation rate of 0.075 cited by Granda, C., Hamann, F., Tamayo, C. (2019). Table (4) shows the calibration of these parameters.

5 Simulations and Results

Once the initial state of the economy is calibrated, permanent tax changes can be simulated. Since the tax changes are permanent, the economy would have a new state, therefore, variable levels are compared from the final state to the initial state to estimate effects of the higher taxes. Subsequently, dynamic transition between initial and final state is calculated to analyze the short-medium term effects and the convergency to the new state of the economy.

The simulation consists in two exercises: first, an increase of 0.5pp in the personal income tax revenue to GDP, so revenue to GDP would go from 1.1% to 1.6%. Second, a re-composition in the total income revenue where this revenue keeps constant, 5.9%, but personal income tax revenue to GDP increases 0.5pp while corporate income tax revenue to GDP reduces 0.5pp, that mean, corporate income tax revenue to GDP would go from 4.8% to 4.3% (consequently, the participation of firms in the total income tax would go from 80% to 73%, similar to Peru or Chile).

Decile	Observed	Calibrated
1	24%	23%
2	20%	20%
3	15%	16%
4	11%	11%
5	8%	6%
6	7%	7%
7	6%	6%
8	5%	5%
9	2%	2%
10	2%	2%
Total	100%	100%

Table 3: Transfers Participation by Decile
Source: Own elaboration based on survey GEIH.

Parameter	Value	Reference
From Literature		
Risk Aversion	2.35	Prada Sarmiento, J.D., Rojas Dueñas, L.E. (2009)
Capital Participation	0.3	González, A., López, M., Rodríguez, N., Téllez, S. (2013)
Calibrated to Replicate Macroeconomic Variables		
Depreciation Rate	0.08	
Discount Rate	0.03	
Interest Rate	2.43	

Table 4: Parameters Calibration
Source: Own elaboration.

Furthermore, in each exercise, the increase in personal income tax revenue to GDP is implemented following three alternatives: first, the increase is applied to 8th, 9th and 10th deciles, where 8th decile contributes 10% of total tax revenue increase, 9th decile contributes 30% and 10th decile contributes the remaining 60%. Second, the higher revenue is concentrated in 10th decile. Finally, the increase is applied from the 7th to the 10th decile, where each decile contributes 5%, 20%, 50% and 25% of total tax revenue increase, respectively. These alternatives are designed to show different ways the government can use to increase personal income revenue y compare the effects on macroeconomic and distributive variables.

Remember that the tax revenue is used by the government to finance lump sum transfers to households. In the first exercise there is an increase in total revenue, so transfers would be higher and these are distributed between households following the initial calibration showed in table (3). In the second exercise, there is not an increase in transfers since the total revenue keeps constant.

Aggregate macroeconomic variables results of 1st exercise are shown in table (5). In aggregate terms, higher personal income tax would lead to a decrease in households income, reducing consumption and thereby production. Therefore, there is a lower demand for productive factors (labor and capital). Wages will decrease, contributing to further fall in households incomes. Since assets accumulation depends on households income, and 10th decile is the richest decile, 10th decile has the largest assets accumulation in the model. When this decile is affected by higher personal income tax, both its income and its assets accumulation would reduce, so investment will fall and contribute to the contraction of the economic activity. For example, in 2nd alternative personal income tax increase is focused only in 10th decile and consequently household income in this decile falls further than the other alternatives, so capital and investment have also greater effects and contribute to a bigger contraction in production and GDP. In this case, labor demand and wages decrease more than the other alternatives, so macroeconomic effects would be more negative.
Although aggregated results do not vary between the alternatives, the heterogeneity in household incomes

	Exercise 1		
	Alternative 1	Alternative 2	Alternative 3
GDP	-0.04	-0.05	-0.04
Consumption	-0.01	-0.02	-0.01
Investment	-0.12	-0.15	-0.12
Capital	-0.12	-0.15	-0.12
Interest Rate*	0.0012	0.0015	0.0011
Wages	-0.04	-0.05	-0.04
Corporate Income Tax Revenue (% GDP)*	0.01	0.01	0.01
Personal Income Tax Revenue (% GDP)*	0.50	0.50	0.50

Table 5: Aggregate Macroeconomic Variables Results. Exercise 1.
Percentage Change from Initial State.
Source: Own elaboration. *Percentage Difference from Initial State.

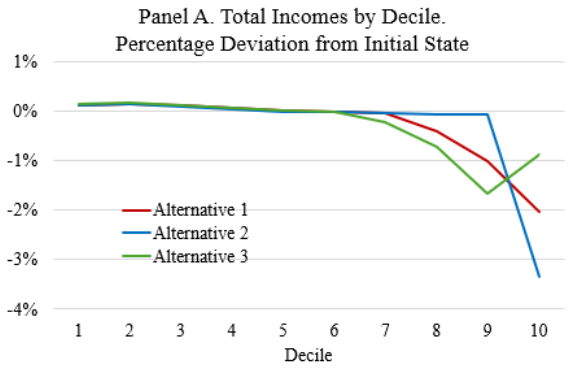
allow to estimate differentiated effects into the deciles for each alternative. Figure (5) shows effects on consumption by decile (panel A) and total incomes by deciles (panel B). Given lower wages, labor incomes will reduce for all deciles, specially for higher deciles where the increase in taxes is focused. However, the increase in transfers for lower deciles mitigates the decrease in labor incomes, so total income in the first deciles is not so affected and it is possible to conserve a similar level of consumption at the initial state. These differentiated effect on consumption would help to explain the effect on aggregate consumption, since contraction in higher deciles will be compensated by the consumption in the other deciles, such that aggregate consumption does not have a large variation.

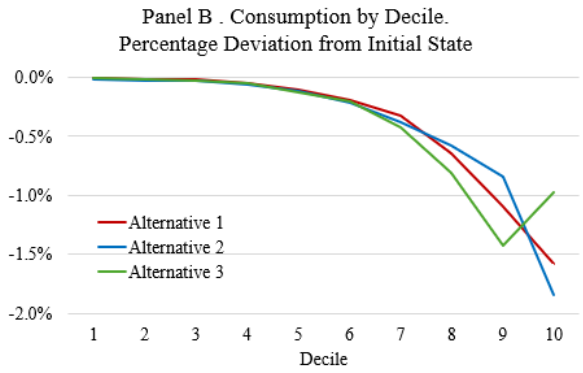
Furthermore, aggregate effects in 1st and 3rd alternative are similar, but the effects on consumption and investment by decile show that in 3rd alternative, the fall in 7th, 8th and 9th decile is deeper than in 1st alternative due to higher tax payments in those deciles with respect to the first alternative. Meanwhile, the reduction in consumption and incomes in 10th decile will be bigger in 1st alternative than 3rd alternative since in the first alternative 10th decile pays more taxes.

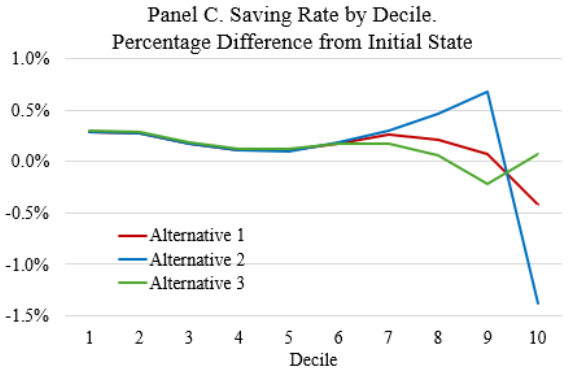
Effects on consumption and incomes by deciles can also be observed in the saving rate for each decile. Figure (5), panel C, shows the difference in the saving rate by decile with respect the initial state, where in 1st and 3rd alternative the households in lower deciles could increase their savings due to the increase in transfers from the government. This saving would be mitigated by the contraction in higher decile savings due the higher taxes paid by these deciles (specially in 2nd alternative where tax payments are focused in 10th decile).

These heterogeneous effects on incomes, consumption and savings would not be captured in a model with representative agent with inelastic labor supply, since higher personal income tax payments wouldn't have distortions on labor decisions and lower labor income will be compensated by higher transfers, so the household budget constraint keeps constant. As result, in this framework, effects on macroeconomic variables are null and effects on distribution can not be estimated since there is only one representative household (for details, see appendix 7).

The effects on income distribution are shown in figure (5) panel D. The figure shows the difference in Gini index of total incomes and consumption from the initial state. Results suggest that due to the effects mentioned above on labor incomes and transfers from the government to lowest deciles, fiscal policy would contribute to a reduction in income inequality tha would lead to a slight decrease in Gini index, specially in 2nd alternative where the increase in tax payments focus in 10th decile. Meanwhile, 3rd alternative would have the lower decrease in income distribution since tax increase is not big enough compared to the other alternatives. Nevertheless, the positive effects on income distribution will be accompanied by the contraction in economic activity since the reduce in disposable incomes, savings, consumption and investment explained above. Finally, dynamic transition to final state are shown in figure (6). Results suggest that the convergency to the new state will be delayed, but the main effects will be concentrated in the short and medium term.







Panel D. Difference from Initial Gini Index

Exercise 1	Total Income Gini Index	Consumption Gini Index
Alternative 1	-0.0042	-0.0039
Alternative 2	-0.0059	-0.0041
Alternative 3	-0.0027	-0.0030

Figure 5: Results by Decile. Exercise 1
Source: Own elaboration

Aggregate macroeconomic variables results of the second exercise are shown in table (6). Results suggest that a reduction in corporate income tax would have positive effects on firms production since there is an increase in capital returns. Therefore, household incomes will also be higher leading to a raise in consumption that encourage goods production and thereby the demand for productive factors. These increase in factor demand would contribute to an increase in wages that all households receive in the different population deciles. Those positive effects will be partially compensated by higher personal income taxes, as could be observed in the first exercise, reducing household income and consumption specially in those households where the tax increase is focused. However, the effects of the combination between corporate and personal income taxes would be positive on the aggregate macroeconomic variables.

Similar to the first exercise, when the increase in personal tax is focused in 10th decile, household incomes in this decile will be lower than the other alternatives and thereby capital accumulation and investment will be deteriorated. Therefore, in this alternative, consumption, investment, capital and GDP will have lower growth compared to the other alternatives. On the other hand, the aggregate effects in 1st and 3rd alternatives will be similar, but there will be slight differences in distributive and disaggregated variables.

Macroeconomic and distributive effects of second exercise are shown in figure (7). The effects on total household incomes are similar to 1st exercise since higher incomes are reduced, due to the increase in personal tax payments, leading to a contraction in the consumption of these households. However, the reduction in total incomes in higher deciles is lower than the 1st exercise because of the increase in wages and capital returns, which in turn, contribute to the growth in total incomes in lower deciles. Higher incomes in lower deciles will lead to higher consumption that compensate the contraction in richer deciles consumption, so aggregate consumption will have a slight increase with respect the initial state.

Those effects in income and consumption by deciles can also been observed in the saving rate (see figure (7), panel C). Figure shows that in lower deciles, the saving rate will increase due to higher wages and capital returns (transfers keep constant in this exercise). Meanwhile, in richer deciles there is a contraction

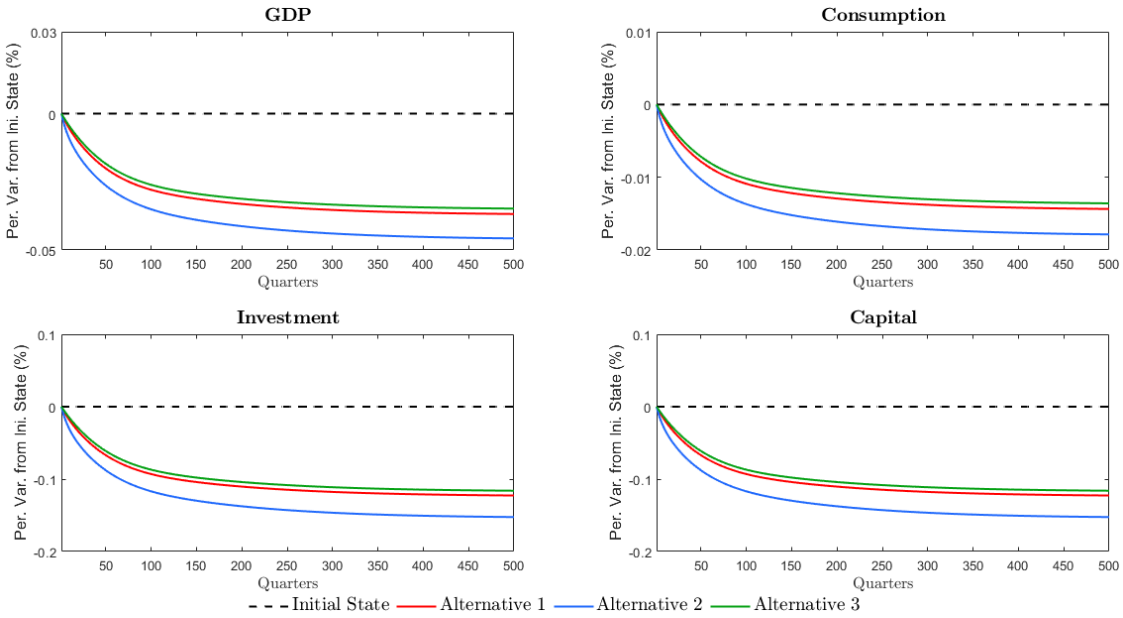


Figure 6: Transition Dynamics. Exercise 1
Source: Own elaboration

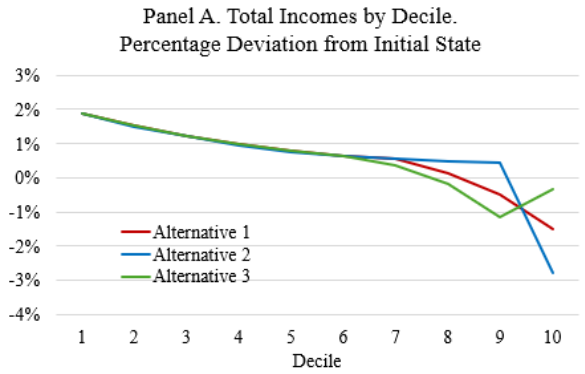
	Exercise 2		
	Alternative 1	Alternative 2	Alternative 3
GDP	0.16	0.15	0.16
Consumption	0.06	0.06	0.06
Investment	0.54	0.51	0.55
Capital	0.54	0.51	0.55
Interest Rate*	0.04	0.04	0.04
Wages	0.16	0.15	0.16
Corporate Income Tax Revenue (% GDP)*	-0.50	-0.50	-0.50
Personal Income Tax Revenue (% GDP)*	0.50	0.50	0.50

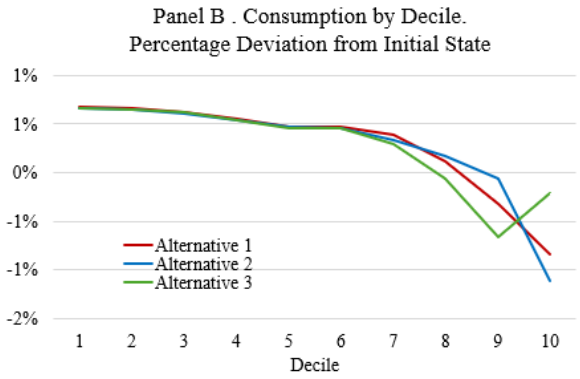
Table 6: Aggregate Macroeconomic Variables Results. Exercise 2.
Percentage Change from Initial State.
Source: Own elaboration. *Percentage Difference from Initial State.

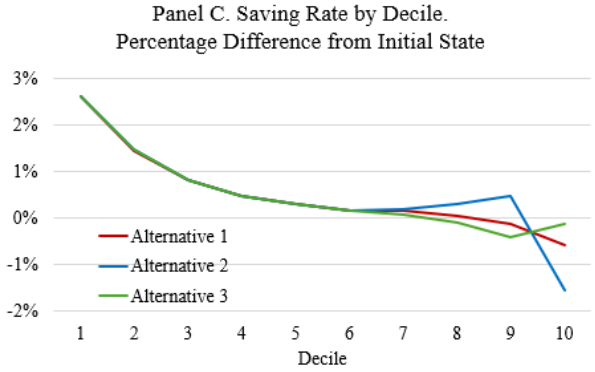
in saving rate because personal income tax increase for those households, but the reduction is lower than the first exercise given the effects on wages and capital returns.

Positive effects on incomes in lower deciles allow to a reduction in income inequality larger than in the first exercise. Figure (7), panel D, shows that the difference in the Gini index of total incomes for each alternative in exercise 2 is higher than the 1st exercise, in other words, a combination of a tax policy that seeks a reduction in corporate income tax and an increase in personal income tax would lead to a further decrease in income inequality than a tax policy that only increase personal income tax. Similarly, in second exercise, when personal tax increase is focused in richer decile, the reduction in Gini index in higher. Therefore, unlike 1st exercise, tax policies adopted in 2nd exercise not only improve income inequality, but also allow to have a better economic activity reflected in higher GDP levels, consumption and investment with respect the initial state.

Figure (8) shows the transition dynamics in the second exercise. Similarly to the first exercise, the conver-







Panel D. Difference from Initial Gini Index

Exercise 2	Total Income Gini Index	Consumption Gini Index
Alternative 1	-0.0059	-0.0036
Alternative 2	-0.0075	-0.0039
Alternative 3	-0.0043	-0.0026

Figure 7: Results by Decile. Exercise 2
Source: Own elaboration

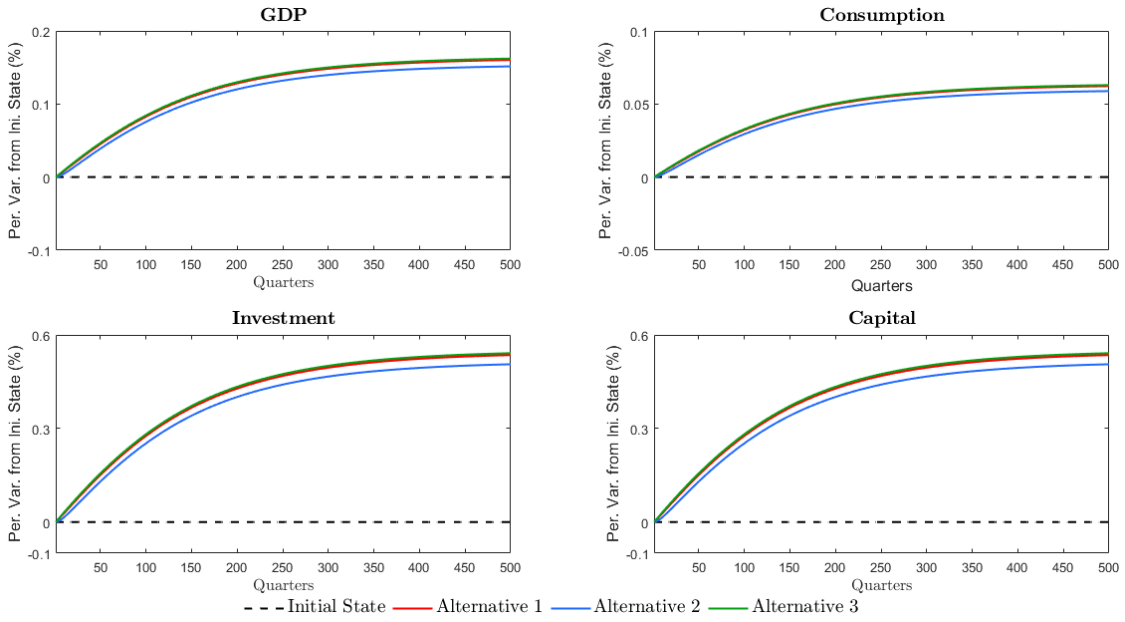


Figure 8: Transition Dynamics. Exercise 2
Source: Own elaboration

Decile	Exercise 1			Exercise 2		
	Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3
1	-0.09	-0.21	-0.10	6.77	6.65	6.75
2	-0.28	-0.60	-0.32	16.67	16.38	16.63
3	-0.69	-1.08	-0.77	20.46	20.10	20.38
4	-1.89	-2.23	-2.07	20.89	20.58	20.70
5	-4.16	-4.24	-4.64	17.76	17.71	17.26
6	-6.65	-7.43	-7.03	16.03	15.21	15.65
7	-5.88	-6.95	-7.79	7.11	6.02	5.17
8	-7.94	-7.21	-10.06	1.35	2.07	-0.81
9	-9.45	-7.18	-12.27	-2.77	-0.51	-5.63
10	-5.40	-6.33	-3.29	-2.85	-3.78	-0.71
Mean Welfare	-4.24	-4.35	-4.83	10.14	10.04	9.54

Table 7: Welfare Analysis. Difference from Welfare in Initial State
Source: Own elaboration.

gency to the final state of the aggregate variables will be delayed. In this exercise, effects are not concentrated in the short term (as in the first exercise) but in the medium term, possibly due to both corporate tax and personal tax shocks that change the distribution od assets, incomes and wealth bigger than in the first exercise.

Finally, an analysis on welfare by deciles and aggregate welfare is done with the two exercises showed above[2]. Results are shown in table (7) and suggest that in the first exercise, due to the decline in economic activity and reduced incomes, welfare would be lower relatively to the initial state and the differences are bigger in the deciles where tax payments are focused. Meanwhile, the increase in public transfers to lower deciles would contribute to mitigate the decline in labor incomes and consumption, and thereby, mitigate the decrease in welfare for those deciles. In aggregate terms, welfare would be lower. On the other hand, in the second exercise, there is an increase in welfare for most deciles due to the growth in wages and capital returns that would lead to an improvement in incomes and consumption. In the deciles where personal tax payments are focused, the welfare will be reduced, but it will be compensated by the improvement in the rest of decile, so aggregate welfare will increase.

It is important to note that in the exercises presented above, increase taxes on only one decile, for example the richer decile, could improve income distribution, but simultaneously the decline in economic activity is bigger than other scenarios. Other alternatives could include an extension of the tax base where more households participate in personal income tax payments, also leading to a decrease in income inequality and an improvement in macroeconomic variables.[3]

[2]Welfare is calculated as a function of utility for each household: $W(u) = \frac{u(c)}{1-\beta}$ where β depends on the discount rate

[3]One must keep in mind that inside 10th decile there is a huge income and savings heterogeneity, so broadening tax base could be focused in attend these heterogeneity looking for lower effects on macroeconomic variables and do not increase tax base focused in lower deciles.

6 Conclusions

The main objective of this paper is to estimate the effects on macroeconomic and distributive variables when households have larger participation in total income tax payments in Colombia. Therefore, a general equilibrium model with heterogeneous agents is used because not only allows to capture the distortions given higher taxes, but also it is possible to analyze the effects on income distribution. Furthermore, the model includes a fiscal agent that tax corporate income and personal income, contributing to a better approximation to real tax systems and improving tax structure in those models.

The model is calibrated for Colombia, a country with medium income and high inequality. After setting the initial state, the simulation includes two exercises with permanent tax changes: first, increasing personal income tax revenue to GDP by 0.5 percentage points; second, adjusting total income tax revenue to GDP by increasing personal income tax revenue by 0.5 percentage points and reducing corporate income tax revenue by the same amount. In each exercise, different ways to increase personal tax revenue are tested by taxing various income groups to explore how the government can boost household contributions to total income tax and estimates their effects on the economy. These tax changes are permanent, so the economy will eventually reach a new state, and the variables are compared to the initial state. Additionally, the transition from the initial state to the final state is calculated, estimating the effects not only in the long term but also in the short and medium term.

Results suggest that an increase in personal income tax on higher deciles would lead to a decline in economic activity in the long run, due to a reduction in the incomes of these deciles and thereby a contraction in consumption and aggregate demand, decreasing production and productive factors demand which in turn reduce wages, contributing to a further decline in household incomes. Besides, these lower incomes reduce savings, capital accumulation and investment, contributing to the decline in production. However, higher tax revenue is used to finance public transfers, specially distributed in lower deciles. These transfers partially compensate the decrease in labor incomes for lower deciles, so their consumption does not have a further contraction. Therefore, aggregate consumption does not look that affected while the decline in investment would lead the contraction in economic activity. The increase in personal income tax on richer deciles of the population, and the redistribution of these additional revenues between lower deciles with public transfers, would lead to a reduction in income inequality, but simultaneously a decline in economic activity described above.

On the other hand, reducing corporate income tax would lead to an improvement in capital returns and a positive effect on the decisions made by the agents, specially the firms who increase production and productive factors demand. Therefore, wages and total household incomes also increase, and thereby consumption. However, those positive effects are mitigated by higher personal income taxes, specially in richer deciles, similar to the previous exercise. At aggregate level, there is an increase in macroeconomic variables and also an improvement in income distribution greater than the first exercise described above. Besides, results suggest that when the increase in personal income tax is focused in the richest decile, the decrease in income inequality is higher than in other scenarios, but simultaneously the decline in economic activity is further. Therefore, a possible way the government can take is to extend personal income tax base looking for an improvement in income inequality and in the macroeconomic variables.

Finally, based on the previous results, income tax changes would affect household welfare. In the scenario where only personal income tax increases, the contraction in macroeconomic variables, incomes, and consumption would lead to a decline in overall welfare, especially in higher income groups where the tax increase is focused. Public transfers would help mitigate the decline in welfare for lower income groups. Meanwhile, when personal income tax increases and corporate income tax decreases simultaneously, the improvement in economic activity, wages, incomes, and consumption would result in a smaller decline in welfare for higher income groups compared to the first scenario, and an increase in welfare for lower income groups, leading to an overall improvement in aggregate welfare.

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7 Appendix. General Equilibrium Model with Representative Agent

To compare the results found with the general equilibrium model with heterogeneous agents, a general equilibrium model with representative agent is developed with a similar structure. Therefore, representative household has an utility function CRRA with inelastic labor supply:

$$U = \frac{c_t^{1-\sigma}}{1-\sigma}$$

and a budget constraint composed by consumption and investment expenses while incomes correspond to labor incomes after personal income tax, capital incomes and lump sum transfers from the government:

$$c_t + I_t = (1-\tau_t^n)w_t n_t + r_t k_t + TR_t$$

Representative firm has the same maximization problem showed in model description, so there is a Cobb-Douglas production function with capital and labor:

$$y_t = k_t^{\alpha} n_t^{1-\alpha}$$

and profit maximization involves the corporate income tax:

$$d_t = y_t - r_t k_t - w_t n_t - \tau_t^k \left[y_t - \delta k_{t-1} - w_t n_t\right]$$

The government collets corporate and personal income taxes to finance lump sum transfers to the representative household:

$$\tau_t^k \left[y_t - \delta k_{t-1} - w_t n_t\right] + \tau_t^n w_t n_t = TR_t$$

Model is calibrated to match the mean of principal macroeconomic variables to GDP between 2005 and 2021 for Colombia, similar to the model described in the paper. In this case, there is not a calibration of income distribution since there is not heterogeneity between agents. Calibration is shown in the table (8):

Variable to GDP	**Observed**	**Calibrated**
Consumption	79%	80%
Investment	21%	20%
Corporate Income Tax Revenue	4.8%	4.8%
Personal Income Tax Revenue	1.1%	1.1%

Table 8: Macroeconomic and Fiscal Variables to GDP. Representative Agent Model
Source: Data taken from DANE, OECD and Saint Louis Federal Reserve.

The calibration of the rest of the parameters is similar to the heterogeneous agents model to make easier the comparison between models:

Parameter	**Value**	**Reference**
From Literature		
Risk Aversion	2.35	Prada Sarmiento, J.D., Rojas Dueñas, L.E. (2009)
Calibrated to Replicate Macroeconomic Variables		
Capital Participation	0.35	
Depreciation Rate	0.08	
Discount Rate	0.01	
Interest Rate	0.03	

Table 9: Parameters Calibration. Representative Agent Model
Source: Own elaboration.

	Alternative 1	Alternative 2	Alternative 3	RAM
GDP	-0.04	-0.05	-0.04	0.00
Consumption	-0.01	-0.02	-0.01	0.00
Investment	-0.12	-0.15	-0.12	0.00
Capital	-0.12	-0.15	-0.12	0.00
Interest Rate*	0.00	0.00	0.00	0.00
Wages	-0.04	-0.05	-0.04	0.00
Corporate Income Tax Revenue (%GDP)*	0.01	0.01	0.01	0.00
Personal Income Tax Revenue (%GDP)*	0.50	0.50	0.50	0.50

Table 10: Aggregate Macroeconomic Variables Results. Representative Agent Model.
Percentage Change from Initial State.
Source: Own elaboration. RAM: Representative Agent Model. *Percentage Difference from Initial State.

With the representative agent model, the first exercise is simulated: an increase in 0.5pp in personal income tax revenue to GDP. Results show that the increase in personal income tax would not have any effect on macroeconomic variables, due to the inelastic labor supply that is not distorted by higher taxes, while the budget constraint is not affected since the increase in lump sum transfers compensate exactly lower labor incomes after taxes. Therefore, household total income does not change, and thereby his consumption remain constant as does production and investment, in other words, effects on economic activity are null. Note that in the heterogeneous agent model, the effects on households incomes would lead to changes in their consumption and savings decisions, and therefore in aggregated demand, but those channels are not captured in representative agent models since the absence of household heterogeneity.