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Abstract

The COVID-19 pandemic produced a shock to public finances throughout the world. In the case of Colombia, the public debt to GDP ratio increased from 39.8% to 65.0%. We use a two-country neoclassical general equilibrium model to determine which one-shot tax reforms make the new debt level sustainable. Our analysis shows that Colombia was on the wrong side of the Laffer curve for capital and labor income taxes before the crisis and hence would need to reduce those taxes to repay its current debt. Specifically, reducing the capital tax by four percentage points and the labor tax by three percentage points restores sustainability. In contrast, the analysis suggests that the economy is on the upward-sloping side of the Laffer curve for the consumption tax. An increase of 10 percentage points in the consumption tax generates a future path of primary surpluses big enough to repay the post-COVID level of debt. The results suggest that behavioral changes and general equilibrium effects are sizeable. Therefore, ignoring them will bias fiscal consolidation analysis.[1]

JEL classifications: E62, F41, F42, H63

Keywords: Debt sustainability, Sovereign debt, Open-economy taxation, COVID-19, Emerging markets

[1]Corresponding author: Juan M. Hernández (juanhe@iadb.org). The opinions expressed here belong solely to the authors, and they do not represent the official view of the Inter-American Development Bank, its Governors, Board of Directors or those of Ministerio de Hacienda y Credito Publico. We thank Andrés Herrera, Juan Felipe Herrera and Fredy Castañeda for superb research assistance. All remaining errors are ours.

1 Introduction

The COVID-19 pandemic had unprecedented consequences on economic activity all around the world. Fiscal authorities were obliged to run enormous deficits for two main reasons. First, the drop in economic activity came hand-in-hand with lower revenues. Second, addressing the public health and social challenges caused by the pandemic required significant spending increases. As a result, countries will have more prominent public debt stocks after the pandemic. In particular, Colombia's central government debt to GDP ratio will increase by 25.2 percentage points.

In this paper, we ask which tax increases are consistent with repaying the after-COVID level of debt in Colombia and the macroeconomic consequences of each alternative. To answer the question, we construct *dynamic Laffer curves*, in a two-country neoclassical economy, as in D'Erasmo et al. (2016). The dynamic Laffer curve shows the net present value of primary surpluses consistent with every possible tax rate. The net present value of primary surpluses equals, in turn, the maximum amount of debt that the country can support without modifying the current fiscal mix (taxes and expenditures).

We conduct the tax experiments in a two-country, general equilibrium model, where the government can raise taxes on consumption, capital, and labor income. Households in both countries can save abroad, and hence, the after-tax returns on investment must be equal between countries in equilibrium. We calibrate the home economy to Colombia, and the foreign economy as a combination of Mexico and Chile, arguably Colombia's main competitors in external financing markets.

We find that the Colombian (formal) economy is on the wrong side of the Laffer curve for the capital income tax and the labor income tax. Reducing those taxes would restore the sustainability of the public debt and at the same time increase welfare. Specifically, reducing the standard corporate income tax rate from its current level of 31% to 27% would equate the present value of primary surpluses to the after-COVID face value of the public debt (65% of GDP). As for the labor income tax, sustainability requires decreasing the current rate by three percentage points. In contrast, the Colombian economy is on the increasing side of the consumption tax Laffer curve. As a result, Colombia would have to increase its consumption tax from 19% to 29.3% to repay the debt via this tax. In this case, the effects on welfare and GDP are negative.

The rest of the paper is organized as follows. In the second section, we present the model. Then, in the third section, we describe the calibrations and the model parameters. Section four presents the results, and we conclude in Section Five.

2 The Model

We use a two-country general equilibrium model similar to Mendoza y Tesar (1998). Both economies (Home (H) and Foreign (F)) are composed of a representative household that lives forever and a representative firm. The firm produces a single tradable good used for public consumption (g), private consumption (c) consumption, and capital investment (x). The production technology combines units of utilized capital ($\widetilde{k} = mk$) and labor l, where m is the rate of capital utilization and k is the stock of capital. These inputs are immobile between countries. Besides, in each economy, there is a government collecting revenue from taxes on consumption (τ_c), capital income (τ_k) and labor income (τ_l), and issuing public debt to finance (unproductive) public consumption. The two countries trade goods -the numeraire- and one-period bonds (b) -at a price q. All markets are perfectly competitive. In what follows, all variables in the Foreign economy have an asterisk. For example, consumption abroad is denoted c^*.

As in Mendoza y Tesar (1998), the economies grow at an exogenous rate γ. Balanced growth requires that the household's discount factor be $\widetilde{\beta} = \beta(1+\gamma)^{1-\sigma}$, where β is the standard discount factor, and σ is the coefficient of risk aversion of CRRA preferences.

2.1 Households

The representative household orders consumption (c_t) and leisure ($1 - l_t$) baskets according to:

$$\sum_{t=0}^{\infty} \widetilde{\beta}^t \frac{1}{1-\sigma} (c_t(1-l_t)^a)^{1-\sigma} \tag{1}$$

$$\sigma > 1;\ a > 0;\ 0 < \widetilde{\beta} < 1$$

$\frac{1}{\sigma}$ is the inter-temporal elasticity of substitution of consumption, while a determines both the Frisch elasticity and the inter-temporal elasticity of labor supply.

Households decide the amount of investment and capital utilization. They rent units of utilized capital and labor to firms. Capital depreciation is endogenous and increases with the rate of utilization, according to the following function: $\delta(m) = \chi_0 m^{\chi_1}/\chi_1$, with $\chi_1 > 1$ and $\chi_0 > 0$. Notice that $0 \leq \delta(m) \leq 1$.

The law of motion of capital stock is:

$$x_t = (1+\gamma)k_{t+1} - \big(1 - \delta(m_t)\big)k_t + \phi(k_{t+1}, k_t, m_t) \tag{2}$$

The function $\phi(k_{t+1}, k_t, m_t)$ represents quadratic adjustment costs on the investment:

$$\phi(k_{t+1}, k_t, m_t) = \frac{\eta}{2}\left(\frac{(1+\gamma)k_{t+1} - \big(1-\delta(m_t)\big)k_t}{k_t} - z\right)^2 k_t \tag{3}$$

η is the adjustment cost parameter, and z is the long-run ratio between investment and capital stock. Therefore the adjustment cost is zero in steady-state.

The representative household maximizes the discounted value of its utility by choosing the inter-temporal sequences of consumption, labor, investment, domestic government bonds (d) and international bonds, subject to the law of motion for capital and the following budget constraint:

$$(1+\tau_t^c)c_t + x_t + (1+\gamma)q_t^g d_{t+1} + (1+\gamma)q_t b_{t+1} = \dots$$
$$\dots(1-\tau_t^l)w_t l_t + (1-\tau_t^k)r_t m_t k_t + \theta\tau_t^k\bar{\delta}k_t + d_t + b_t + e_t^l + \pi_t \quad (4)$$

where q_t^g is the government bond price, w_t is the wage, r_t is the capital interest rate, e_t^l is a lump-sum transfer and π_t are the profits of firms. The left side of the budget constraint shows all the household income uses (expenses), and the right-side includes all the (after taxes) sources. The expression $\theta\tau_t^k\bar{\delta}k_t$ represents the proportion θ of capital depreciation $\bar{\delta}$ that is allowed to be deducted from the capital income tax. Following D'Erasmo et al. (2016), we assume that only a fraction of the depreciation of capital is deducted from income tax because, in practice, depreciation allowances do not apply for residential capital. It is important to note that, in general, the rate at which capital depreciates ($\delta(m)$) does not coincide with the depreciation allowance in the income tax ($\bar{\delta}$). The latter is constant, while the former is endogenous to the capital utilization rate. In practice, for tax purposes, firms must apply a constant depreciation rate to the book value of the capital, while the real depreciation depends on the intensity of use.

2.2 Firms

Firms operate under perfect competition. They rent units of utilized capital and hire labor from households, to maximize their profits:

$$\pi_t = y_t - w_t l_t - r_t\widetilde{k}_t. \quad (5)$$

The production function is a Cobb-Douglas:

$$y_t = F(\widetilde{k}_t, l_t) = \widetilde{k}_t^{1-\alpha} l_t^{\alpha}, \quad (6)$$

where α is the labor share ($0 < \alpha < 1$). Optimal demands on production inputs are determined by the following conditions:

$$r_t = (1-\alpha)\frac{y_t}{\widetilde{k}_t}, \quad (7)$$
$$w_t = \alpha\frac{y_t}{l_t}. \quad (8)$$

Due to the linear homogeneity of the production function, the benefits are zero in equilibrium ($y_t = w_t l_t + r_t\widetilde{k}_t$).

2.3 Government

The government follows a budget constraint, where primary expenditures consist of public consumption (g_t) (which is unproductive because it does not affect the utility of households or the production function) and lump-sum transfers to households e_t^l. These two variables are assumed to be exogenous. On the revenue side, the government collects the consumption tax (τ_c), labor income tax (τ_l), and capital income tax (τ_k) (net of the depreciation allowance on applicable capital). The tax rates are assumed to be exogenous and time-invariant. In addition to tax collections, the government receives a stochastic endowment (oil_t) calibrated to replicate the Colombian government's oil revenues. This endowment is assumed to be exogenous and follows an autoregressive process.

Finally, the government issues debt that is purchased by domestic households. The debt instrument (d_t) is a one-period bond, which the government commits to repay. Therefore, the budget constraint that the government must satisfy is:

$$d_t - (1+\gamma)q_t d_{t+1} = \tau_t^c c_t + \tau_t^l w_t l_t + \tau_t^k (r_t m_t - \theta\bar{\delta})k_t + oil_t - (e_t^l + g_t). \tag{9}$$

the right-hand side represents the primary fiscal balance, and the left-hand side represents its financing sources, namely the change in debt, net of debt service.

To guarantee the sustainability of the public debt, the government must satisfy a no-Ponzi condition (eq. 10): the present value of its primary balance must be equal to the initial public debt (d_0). The no-Ponzi condition ensures that the government can repay its debt with future primary balances (pb_t).

$$\frac{d_0}{y_{-1}} = \psi_0 \left[\frac{pb_0}{y_0} + \sum_{t=0}^{\infty} \left(\left[\prod_{i=0}^{t} \upsilon_i \right] \frac{pb_t}{y_t} \right) \right], \tag{10}$$

where $\upsilon_i = (1+\gamma)\psi_i q_i^g$ and $\psi_i = y_{i+1}/y_i$.

By Walras' Law, combining the household and government budget constraints, as well as the firms' profits, results in the aggregate resource constraint of the home economy:

$$y_t - c_t - g_t - x_t = (1+\gamma)\, q_t b_{t+1} - b_t \tag{11}$$

2.4 Equilibrium

We assume that the two economies modeled do not account for the entire world. The rest of the world supplies a positive amount of bonds $\bar{b}$.

A competitive equilibrium is a sequence of prices $\{r_t, r_t^*, q_t, q_t^g, q_t^{g^*}, w_t, w_t^*\}$ and allocations $\{k_{t+1}, k_{t+1}^*, m_{t+1}, m_{t+1}^*, x_t, x_t^*, l_t, l_t^*, b_{t+1}, b_{t+1}^*, d_{t+1}, d_{t+1}^*\}$ for $t = 0, ..., \infty$ such that: households in both economies maximize utility subject to budget constraints, firms maximize profits subject to the production technology, the government budget constraints hold for exogenous tax rates and sequences of government consumption, and the following market clearing conditions for goods and bonds markets:

$$\omega\left(y_t - c_t - x_t - g_t\right) + (1-\omega)\left(y_t^* - c_t^* - x_t^* - g_t^*\right) = r_t \bar{b}, \tag{12}$$

$$\omega b_t + (1-\omega)\, b_t^* = \bar{b}, \tag{13}$$

where ω denotes the relative size of the two economies.

In equilibrium, as there is a global bond market, interest rate parity holds between countries, giving way to the following no-arbitrage conditions (omitting capital adjustment costs):

$$(1-\tau_k)\, F_1\left(m_{t+1}k_{t+1}, l_t\right) m_{t+1} + 1 - \delta\left(m_{t+1}\right) + \tau_k \theta \bar{\delta} = \frac{1}{q_t} = \frac{1}{q_t^g} \tag{14a}$$

$$(1-\tau_k^*)\, F_1\left(m_{t+1}^* k_{t+1}^*, l_t^*\right) m_{t+1}^* + 1 - \delta\left(m_{t+1}^*\right) + \tau_k^* \theta \bar{\delta} = \frac{1}{q_t} = \frac{1}{q_t^{g^*}} \tag{14b}$$

$$\frac{(1+\gamma)\, u_1\left(c_t, 1-l_t\right)}{\widetilde{\beta} u_1\left(c_{t+1}, 1-l_{t+1}\right)} = \frac{1}{q_t} = \frac{(1+\gamma)\, u_1\left(c_t^*, 1-l_t^*\right)}{\widetilde{\beta} u_1\left(c_{t+1}^*, 1-l_{t+1}^*\right)} \tag{14c}$$

The above conditions imply that $q_t = q_t^g = q_t^{g^*}$. In addition, the after-tax returns on capital of both economies must be equal.

3 Calibration

Typically, the literature has used the methodology developed by Mendoza et al. (1994) to calibrate tax rates in advanced economies. Essentially, they calibrate effective rates as the ratio of the tax revenue to the tax base.

However, many developing economies feature high statutory rates and low tax revenues. The reason for this apparent contradiction is that developing economies have high informality and evasion rates. To address this observation, we calibrate marginal tax rates using the statutory rates because they reflect the marginal distortion that is relevant for compliers. Nevetheless, the statutory rate would be inconsistent with revenue if applied to the entire tax base because of informality and evasion. Consequently, we allow for a transfer from the government to households to have realistic values for both tax bases and tax revenues.

3.1 Statutory Rates

We calibrate the consumption tax (τ_c) using the standard rate for VAT, which is 19% for the Colombian case. Needless to say, not all goods and services are taxed at this rate because of exclusions, exemptions, and reduced rates, and also because of informality and evasion. Hence, an addition to the transfer from the government to households is introduced for the model to hit both the tax base, rate and revenue. Our underlying assumption is that governments will adjust their budgets by modifying the standard statutory rates instead of limiting tax benefits or evasion. The consumption rates in Mexico and Chile are 16% and 19%, respectively.

For the capital income tax (τ_k), we use the statutory corporate income tax rate, which amounts to 31% in Colombia, 30% in Chile, and 25% in Mexico. As for the labor income tax rate (τ_l), we use the top marginal rate of the personal income tax. This rate is highest in Colombia, 39%, followed by Chile, 35.5%, and Mexico, 35%. The table below displays all the values.

Statutory Tax Rates for Colombia, Mexico and Chile			
	Consumption (τ_c)	**Capital (τ_k)**	**Labor (τ_l)**
Colombia	19.0%	31.0%	39.0%
Mex-Chl Average	16.5%	29.2%	35.1%
Mexico	16.0%	30.0%	35.0%
Chile	19.0%	25.0%	35.5%

3.2 Tax Bases and Revenue

Following Mendoza et al. (1994), to compute tax bases and revenues, we use data published by OECD[2], and we complement them with national accounts and tax revenue statistics from domestic sources when needed. Tax revenue data come from the Global Revenue Statistics Database (referred to using numbers in what follows), and macroeconomic aggregates come from National Accounts (referred to using capital letters). See Data Appendix A.1 for further details. In what follows, B_x denotes the base for tax x and R_x its revenue, where x can stand for capital (k), labor (l) or consumption (c).

The tax base for the consumption tax B_c is constructed according to the following formula,

$$B_c = C + G + GW - 5110 - 5121$$

where C is the final consumption expenditure of households, G is the final consumption expenditure of the general government, and GW stands for discounted wages and salaries of public administration and defense, compulsory social security, education, human health. As for the subtracting terms, the 5110 account includes general taxes on goods and services, and the 5121 account is excises.

Consumption tax revenues are constructed by adding general taxes on goods and services and excises,

$$R_c = 5110 + 5121$$

[2] Statistics available at https://stats.oecd.org/.

The base for the capital income tax is composed of the operating surplus of the economy, that is, the gross operating surplus net of consumption of fixed capital. Since Latin American economies are highly informal, a large share of the mixed-income comes from the informal economy, where the main factor of production is labor. On that basis, we exclude mixed-income from the base of the capital income tax.

$$B_k = OS \tag{15}$$

Computing the capital income tax revenue requires splitting the total income tax on households into its capital and labor components. For it, we first calculate the households' average tax rate on income (16). This rate takes in the numerator taxes on income, profits, and capital gains of individuals (1100) and the denominator operating surplus of private unincorporated enterprises (OSPUE), household property, and entrepreneurial income (PEI) and wages and salaries (W).

$$\tau_h = \frac{1100}{OSPUE + PEI + W} \times 100 \tag{16}$$

Once we have the average rate of the income tax, we apply it to the capital sources of income, namely operating surplus and property. In addition, the capital income revenue includes the receipts from taxes income, profits, and capital gains of corporations (1200), recurrent taxes on immovable property (4100), and taxes on financial and capital transactions (4400).

$$R_k = \tau_h(OSPUE + PEI) + 1200 + 4100 + 4400 \tag{17}$$

Last, we include in the labor income tax base wages and salaries (W) and the employer's contribution to social security (2200),

$$B_l = W + 2200 \tag{18}$$

For the revenue, we add social security contributions (2000), taxes on payroll, and workforce (3000) to the share of the income tax corresponding to labor income ($\tau_h W$)

$$R_l = \tau_h W + 2000 + 3000 \tag{19}$$

The calibration strategy allows us to replicate the observed revenues and to recognize, at the same time, that changes in distortions are associated with the marginal rate, which we assume to be the statutory rate.

Counterfactual exercises would overstate the change in revenue if we computed by multiplying statutory rates by the basis. So instead, we address the issue by adjusting the transfer from the government to households when we increase statutory rates.

The values for the transfers needed to equate observed revenue with the products of tax rates and basis, in steady-state, are 5.6% and 17.1% in Colombia and Chile-Mexico, respectively.

3.3 Parameters

We use data from the World Bank, the statistical agencies of each country, and the OECD's LA-KLEMS to calibrate the model's parameters. Table 1 presents the calibrated parameters where the value for the foreign economy (Mexico - Chile) corresponds to a weighted average of the PPP-adjusted GDP between 1996-2019.

To calibrate the balanced growth path per capita growth rate, γ, we use the weighted average between 1996-2019 from World Bank for the three countries. The result is a quarterly rate of 0.38%, corresponding to a yearly rate of 1.5%. The risk aversion coefficient, σ, is set to 2 following the literature, and we use a Frish elasticity of 3.3 as estimated by Prada-Sarmiento y Rojas (2009) for Colombia. We calculate the capital and investment ratios using the series of capital stock, private investment and GDP in constant prices from DANE (Colombia), INEGI (Mexico) and FRED (Chile).

The capital share of output $(1-\alpha)$ was used to calibrate the capital to GDP ratio in the steady state. The capital depreciation parameter, δ, was used to calibrate the investment to GDP ratio, using the law of motion of capital stock at the steady state $\frac{x}{y} = (\gamma + \delta(m))\frac{k}{y}$ and normalizing $m = 1$. The value of θ is set as $\theta = \left(\frac{REV_k^{corp}}{REV_k}\right)\left(\frac{K^{NR}}{K}\right)$ where $\frac{REV_k^{corp}}{REV_k}$ is the ratio of revenue from corporate capital income taxes to total capital income tax revenue, and $\frac{K^{NR}}{K}$ is the ratio of non-residential fixed capital to total fixed capital. Using data from OCDE, 2018 data from DANE, 2017 data from LA-KLEMS and 2013 data from INEGI, the value of θ is 0.25 for Colombia and 0.17 for Chile and Mexico.

We obtain the value of χ_0 from the optimality condition for utilization at steady state $\chi_0 = (1-\tau_k)(1-\alpha)\frac{y}{k}$. Given χ_0, χ_1 follows from the depreciation rate function in steady state $\delta(m) = \frac{\chi_0 m^{\chi_1}}{\chi_1}$. We get a value for χ_0 of 0.039 for Colombia, and 0.05 for Chile-Mexico. χ_1 is 2.3 for Colombia and 2.9 for Chile-Mexico.

Finally, the discount factor is calculated to calibrate the interest rate to the 10-year bond rate observed in data. For this purpose, we use a steady state Euler equation for capital accumulation $\frac{1+\gamma}{\tilde{\beta}} = 1 - \delta(m) + (1-\tau_k)(1-\alpha)\frac{y}{k} + \theta\tau_k\bar{\delta}$ and the equation of adjustment discount factor $\tilde{\beta} = \beta(1+\gamma)^{1-\sigma}$.

4 Simulation

The impact of the COVID-19 pandemic on the Colombian economy caused a reduction in government revenues and put pressure on public spending to respond to the economic and health emergency. As a result, the government's primary deficit increased, and so

Parameter	Description	Colombia	Mexico and Chile
β	Discount factor	0.9886	0.9886
σ	Risk aversion	2	2
a	Labor supply elasticity	3.3	3.3
α	Labor income share	0.55	0.55
η	Capital adjustment cost	2.0	2.0
$\widetilde{m}$	Capacity utilization	1	1
$\delta(\widetilde{m})$	Depreciation rate	0.0162	0.0162
χ_0	$\delta(m)$ coefficient	0.0303	0.0319
χ_1	$\delta(m)$ exponent	1.8687	1.7948
ω	Country size	0.19	0.81
θ	Depreciation allowance limitation	0.25	0.25

Table 1: Parameters Values

did the public debt. Specifically, in the 2020 Medium-Term Fiscal Framework (MTFF 20), the Colombian government projected that the central government's public debt to GDP ratio would increase by 15.2pp in 2020, reaching 65.0%. The purpose of the simulations presented below is to evaluate different fiscal policy alternatives to generate the future primary balances needed to guarantee public debt sustainability. Additionally, we explore the welfare gains or losses of alternative adjustments to find which one is optimal.

Following D'Erasmo et al. (2016), we simulate changes in the three taxes of the model (capital, labor, and consumption), one at a time, keeping the other taxes unchanged. Given the tax changes, we quantify the effects on the dynamics of primary balances to calculate the sustainable debt levels achieved with each tax rate and the effects on social welfare in both economies. Additionally, we compare the results obtained in closed and open economies.

Based on Mendoza y Tesar (1998), the model is solved numerically as a first-order approximation of the equilibrium conditions around the steady-state. The authors develop a shooting algorithm that simultaneously determines the stationary equilibrium and the model's initial conditions because the steady-state is not determined without the latter.

4.1 Dynamic Laffer Curves

In line with D'Erasmo et al. (2016), we construct dynamic Laffer curves showing the effects of changes in taxes rates on the present value of primary balances. In particular, while the standard Laffer curve shows the level of revenue achieved by each tax rate, the dynamic Laffer curve shows the present value of the primary balances, as a percentage of pre-reform GDP (y_{-1}), for each tax rate (consumption, labor, and capital). Debt is sustainable when the present value of future primary balances equals the initial debt level (eq. 10). As a result, the changes in the present value inform us about the sustainable debt levels that the new set of tax rates can support in equilibrium.

In an open economy, changes in taxes in the home economy alter the agents' decisions and, therefore, primary balances through revenue collection in the foreign economy. Thus, as in D'Erasmo et al. (2016), we assume that the foreign economy reacts and keeps constant the present value of its primary balances by adjusting the labor tax.

4.1.1 Dynamic Laffer Curves for Capital Taxes

Figure 1 shows the Dynamic Laffer Curve for capital. The solid blue line corresponds to the open economy case, while the dashed green represents a closed economy simulation. The horizontal dotted black line represents the new level of public debt caused by the COVID-19 pandemic in the Colombian economy, and the horizontal dotted red line shows the before-COVID debt-to-GDP ratio.

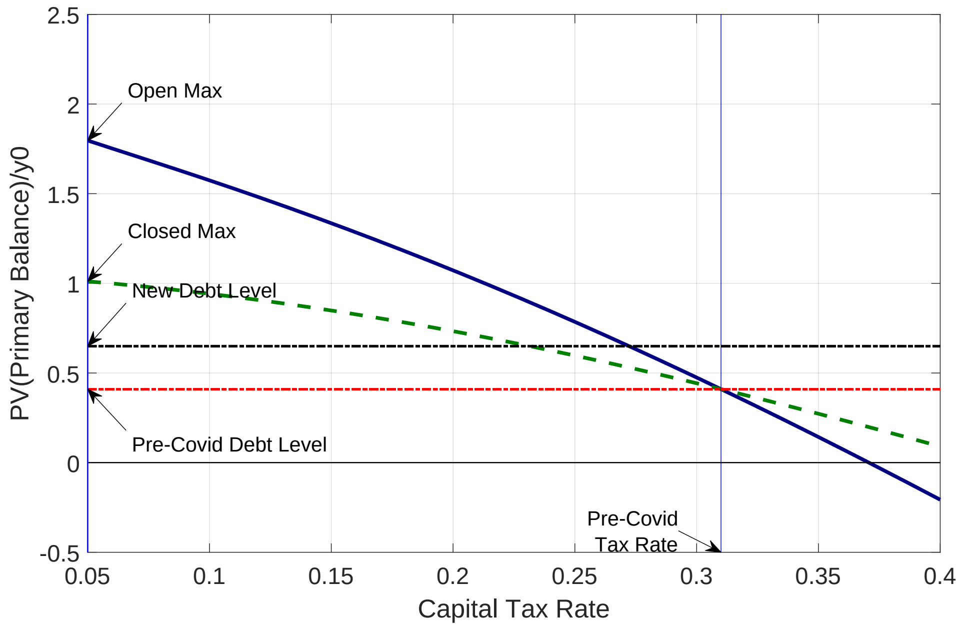
Interestingly, according to the model, the Colombian economy has a downward-sloping Laffer curve for the relevant set of capital tax rates. The former is true both for the open and the closed economy exercises. As a result, to increase revenue, the government has to *decrease* the capital tax. Moreover, the open economy dynamic Laffer curve is steeper than the closed economy curve. The reason is that when the economy is open and international bond trading is allowed, a lower tax at home incentivizes foreign households to save in the home country, which helps finance local investment and increases the tax basis. As a result, the revenue increase will be higher for an equal tax cut in the open-economy case.

Figure 1 shows that decreasing the tax rate on capital income to 27.2% would increase the net present value of primary balances to 65% of GDP, guaranteeing the sustainability of the debt. If instead, we had modeled Colombia as a closed economy, the corresponding result would be 23.1%, reflecting the fiscal impact of attracting capital from the foreign economy. Moreover, decreasing the rates below those levels keeps increasing total revenues monotonically. More specifically, for a tax rate of 5%, the present value of total revenues reaches 180% of GDP in the open economy and 101% of GDP in the closed economy.

4.1.2 Dynamic Laffer Curves for Labor Taxes

Figure 2 illustrates the Dynamic Laffer Curve for the labor tax. Again, the open-economy case features a higher slope than the closed-economy case. In an open economy, labor is not mobile between countries, and the returns to labor do not equalize. The amplification of the negative effect of higher taxes in an open economy occurs indirectly through the complementarity of capital and labor. A higher tax on labor reduces household supply and lowers the marginal productivity of capital, affecting investment

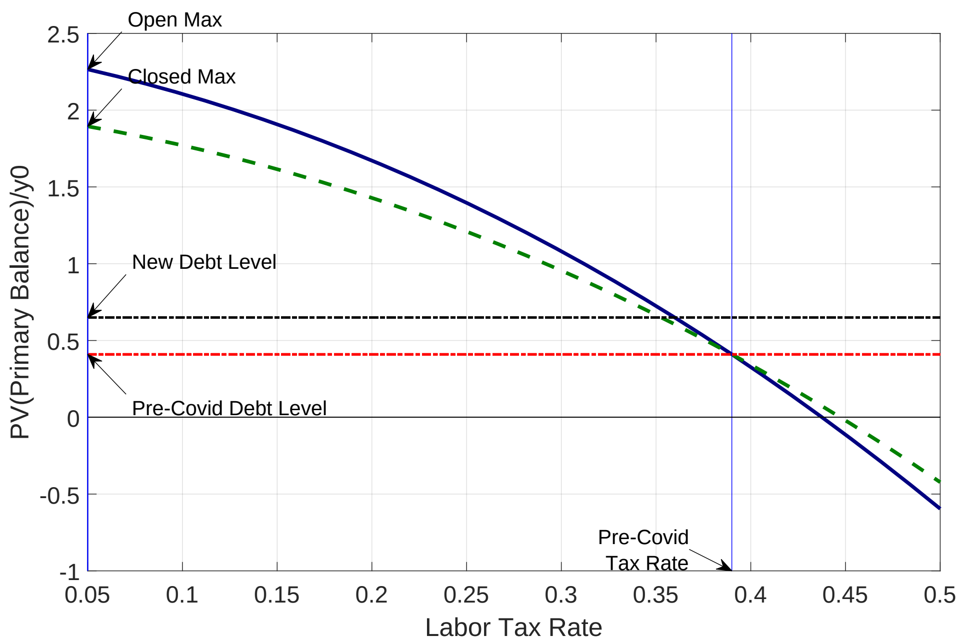
Figure 1: Dynamic Laffer Curves for Capital Taxes



and encouraging households to demand foreign assets.

Again, the Laffer curves are monotonically decreasing for the range of taxes considered. Therefore, to achieve the sustainability of the debt after the COVID shock, Colombia needs to reduce the tax rate from 39% to 36% basis points in the open economy and 35% in the closed economy. Furthermore, by reducing the labor income tax to 5%, Colombia could sustain debt-to-GDP ratios above 200%.

Figure 2: Dynamic Laffer Curves for Labor Taxes

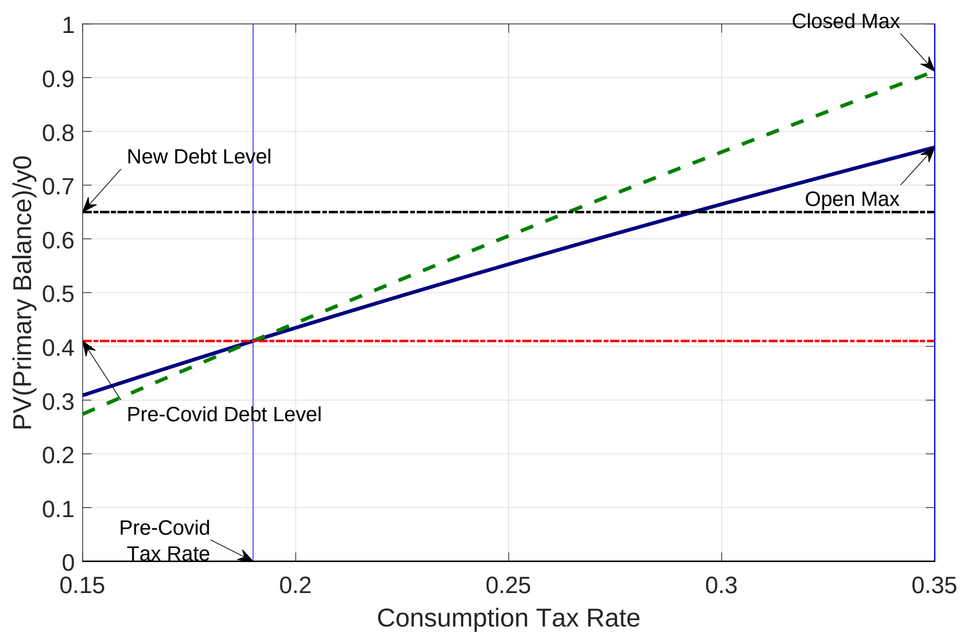


4.1.3 Dynamic Laffer Curves for Consumption Taxes

Figure 3 shows the Dynamic Laffer Curve for the consumption tax. The results suggest that it is sufficient to increase the consumption tax rate by 10pp (to 29.3%) in the open economy and by 7pp (to 26.4%) in the closed economy to generate the primary balances required to sustain the public debt after the COVID-19 shock.

On the other hand, the curve has not reached its maximum below 35%. When the tax rate increases to 35%, the present value of primary balances can sustain debt levels of 77% of pre-crisis GDP. The analog result for the closed economy is 91%.

Figure 3: Dynamic Laffer Curves for Consumption Taxes



4.2 Welfare and Macroeconomic Effects of Tax Rate Changes

This section quantifies the welfare implications and macroeconomic variables of the fiscal adjustments needed to make the post-COVID public debt level sustainable in the open economy. In particular, we analyze the effects of the tax changes shown in the previous section.

Since all taxes distort agents' decisions and the competitive equilibrium in the economy under study is a Pareto optimum, higher taxes will decrease welfare, everything else equal. As a result, when the economy is on the wrong side of the Laffer curve, the fiscal consolidation will improve welfare, and the opposite will happen when repaying the higher debt requires higher tax rates.

Table 2 shows the welfare change, in terms of consumption, of the three tax adjustment alternatives presented in the previous section. The necessary adjustment in the capital tax to guarantee debt sustainability generates the most significant welfare gain in terms of consumption (2.7%). On the other hand, the adjustment through the labor tax causes a smaller welfare gain of 2.4%. As shown in the previous section, if the consumption tax were to be adjusted, debt sustainability would require a tax *increase*.

As a result, this adjustment generates a welfare loss (-4.2%).

The result on welfare is closely related to the negative effect on household consumption and leisure. Consumption increases both when we reduce the capital and the labor tax. Lower taxes mean higher disposable income for households, lower distortions, and higher GDP. However, when we reduce the labor tax, the increase in consumption is higher (4.3%) compared to the case in which we reduce the capital tax (3.8%). The reason is, when the labor tax decreases, the return to working increases, and households substitute leisure with consumption. In contrast, the fiscal adjustment by increasing the consumption tax generates a drop in consumption of 4.2%.

This highest increase in GDP occurs with a capital tax rate adjustment: a reduction of 6.5 percentage points. It comes from a substantial rise in the capital stock (11.2%) and a more modest increment in the total hours worked (2.3%). In this scenario, the lower tax on capital increases its after-tax return at home, fostering capital investment. The complementary between labor and capital pressures the wage upwards, motivating households to work more hours. Of course, there is also a wealth effect, coming from higher disposable income, but it is smaller in magnitude, and, in equilibrium, the hours worked increase.

With an adjustment through labor tax, the GDP rises substantially (4.3%). Once again, the lower tax increases disposable income, allowing households to consume more and save more (at home and abroad). Moreover, the higher after-tax wage induces households to supply more work hours. That additional labor increases the marginal return to capital before taxes, spurring investment at the home economy. In the equilibrium steady-state, both capital and labor increase by (4.3%).

Last, when the fiscal adjustment occurs by increasing the consumption tax, the disposable income of households decreases. As a result, overall consumption and savings fall. Moreover, as consumption goods become more expensive, households substitute goods by leisure time, and hence the labor amount decreases. The return to capital investment at home falls as well. Quantitatively, GDP, labor, and capital fall by 7%, and consumption decrease by 7.1%. The increase in leisure somewhat dampens the reduction in welfare.

Variable of fiscal adjustment	Welfare	Consumption	GDP	Labor	Capital
τ_k	2.7%	3.8%	6.5%	2.3%	11.2%
τ_l	2.4%	4.3%	4.3%	4.3%	4.3%
τ_c	-4.2%	-7.1%	-7.0%	-7.0%	-7.0%

Table 2: Effects on Welfare and Main Macroeconomic Variables

5 Conclusion

The COVID-19 pandemic resulted in a shock to public finances throughout the world. In the case of Colombia, the combination of lower revenues and higher spending resulted in a public debt increase of 25.2 percentage points, from 39.8% to 65.0% of GDP.

We ask which one-shot tax reforms make the new debt level sustainable. Our analysis shows that an increase of 10 pp in the consumption tax generates a future path of primary surplus that is necessary to repay the post-COVID level of debt.

Through the lens of our model, the labor and capital income taxes were too high in Colombia, even before the COVID shock. In particular, for these taxes, the economy was on the wrong side of the Laffer curve, and reduction of the tax rates would generate a higher present value of primary surpluses. Decreases of four percentage points in the capital income tax and three percentage points in the labor income tax, respectively, generate enough revenue to repay the debt.

The decentralized equilibrium is Pareto optimal in our model, and higher tax rates always decrease welfare. As a result, the fiscal consolidation via capital and labor income taxes improves welfare. The welfare increment is not very different in magnitude, but the resulting economy is. When we make the adjustment using the labor tax, the result is higher GDP and higher consumption at the cost of more work hours. When we adjust the capital income tax instead, leisure plays a more important role in welfare. This result is in line with Prescott (2004).

Sooner rather than later, governments in the region and worldwide will have to enact tax reforms to repay the increase in debt that resulted from the COVID-19 pandemic. For the case of Colombia, our structural model predicts strong behavioral and general equilibrium responses to tax changes. If these predictions are correct, it would be highly advisable for finance ministries to use structural analysis to forecast the revenue generated by reform proposals. Therefore, if tax revenue predictions ignore behavioral and general equilibrium responses, they may differ greatly from the actual results.

A Appendices

A.1 Data

We use data from the OECD national accounts, complemented by the integrated accounts reported by Central Bank in Chile, and DANE in Colombia, and the accounts by institutional sectors reported by INEGI, in Mexico.

OECD provides the "gross operating surplus and gross mixed income," which we divided between its gross operating surplus and its gross mixed income components. We subtracted from the OECD data the mixed income data from DANE of integrated economic accounts for Colombia and that for Mexico from INEGI of the accounts by institutional sectors. For Chile, given that mixed income is not reported as a single account, we calculate the average weight of Colombia and Mexico within the "Gross operating surplus and gross mixed income" category, and we use the value corresponding to this proportion.

The variables are defined according to the data published in the National Accounts, volume II[3]:

OSPUE – Operating surplus of private unincorporated enterprises (13.5 – 13.20)

- 13.5 – Gross operating surplus and mixed income from Generation of income account of Simplified accounts for households and NPISH
- 13.20 – Consumption of fixed capital from Capital account of Simplified accounts for households and NPISH

PEI – Household property and entrepreneurial income (13.8 – 13.9)

- 13.8 – Property income, receivable from Distribution of income account of Simplified accounts for households and NPISH
- 13.9 – Property income, payable from Distribution of income account of Simplified accounts for households and NPISH

OS – Operating surplus of the economy (3.15 – 4.6)

- 3.15 – Gross operating surplus and mixed income from GDP: income approach table
- 4.6 – Consumption of fixed capital from Disposable income table

The OECD reports gross operating surplus and mixed income in the "Gross operating surplus and mixed-income" category. We use data from the Integrated Economic Accounts published by DANE[4] for Colombia and the Central Bank for Chile to split the two sources. There are no data available on mixed-income separate from operating surplus for Mexico, so we split the 3.25 account using the average proportion of mixed-income in Colombia and Chile.

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