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Taxation and Economic Growth in Colombia

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Abstract*

This Working Paper assesses the impact on investment of a reduction in corporate taxes and the impact on employment, labor formality, and growth of a reduction in non-wage labor costs in Colombia. First, and following Hall and Jorgensen (1967), we estimate an investment function, which depends on the user cost of capital, one of whose determinants is the corporate tax rate. Our estimations suggest that a reduction of the corporate tax rate from 33 to 23 percent—as originally envisioned by the government in early 2012, but finally not included in the reform submitted to Congress—has very different short and long-term effects on investment in machinery and equipment. While the user cost of capital declines 0.9 percent, investment (excluding the oil and mining sector) increases on impact only 28 bps in relation to GDP, an increase that does not compensate the fiscal cost incurred. In the long term, however, it is likely that the significant boost in investment (of around 5 percent of GDP) makes such a policy intervention fiscally sustainable. Second, using a computable general equilibrium model calibrated for Colombia, we estimate that the reduction of the “pure tax” component of non-wage labor costs approved in late 2012 is associated with a 0.5 percent increase in overall employment and, more importantly, with a 1.4 percent increase in formal sector employment. Our estimations indicate that this is achieved at no fiscal cost since government revenue increases as a result of higher output and employment.

JEL Classification: D58, E22, H30, J32, 05

Keywords: Computable general equilibrium models, Investment, User cost of capital, Corporate taxation, Non-wage labor costs

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1. Introduction

Despite the fact that the Colombian economy has enjoyed comparatively low volatility, it has failed to achieve a sustained rate of growth above 4.5 percent. During the last 20 years, average growth has not surpassed 5 percent over a five-year period (Steiner, Clavijo, and Salazar, 2009). The structural constraints on sustained growth include poor-quality infrastructure, low human capital levels, and the likelihood of high distortions and inefficiencies that stem from the tax system. Public policy could, in principle, improve the tax structure in the short term, compared with the former two constraints.

A review of Colombia's tax policy over the past two decades supports the view that the objectives to enhance tax revenue and improve its administration have taken precedence over the fundamental principles of pursuing economic efficiency and enhancing equity. As Perry (2010) and Steiner and Cañas (2013) indicate, this policy has resulted in a combination of distortionary taxes, such as a financial transaction tax, a wealth tax and considerably high payroll taxes. On the other hand, companies do pay a significant portion of the tax burden compared to individuals, which presumably affects business competitiveness and almost certainly compromises progress.¹ The statutory rate currently paid by corporations is 34 percent,² slightly higher than the regional average of 31 percent and well above the world average, which has fallen steadily in recent years (Figure 1).

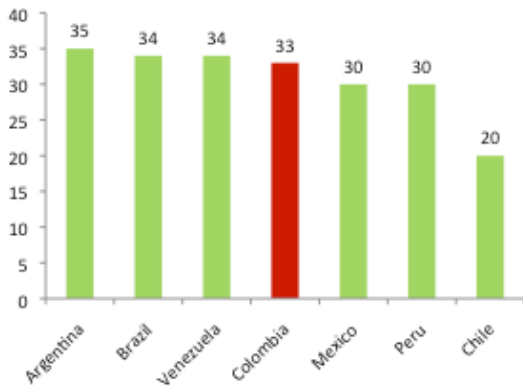
In addition to distortions emanating from the tax burden distribution, tax benefits are prominent. While in principle these have been aimed at promoting investment, encourage savings, and make the tax system more equitable, they have in reality distorted resource allocation, generated inequalities between sectors, and made the tax system far more complex. Needless to say, the benefits have come at a significant fiscal cost. In 2011 this cost amounted to 1 percent of GDP (compared with an income tax revenue of 5.4 percent of GDP), while the cost of value added tax (VAT) exemptions reached 2.2 percent of GDP, compared with a tax revenue of 5.7 percent of GDP (Ministerio de Hacienda y Crédito Público, 2012). It is, therefore, no surprise that tax productivity in Colombia is significantly low in comparative terms (Figure 2).

¹ In 2011 income taxes accounted for 40 percent of total tax revenue. Of this, 34 percentage points (or 4.7 percent of GDP) was contributed by companies and only 6 percentage points (0.8 percent of GDP) by individuals.

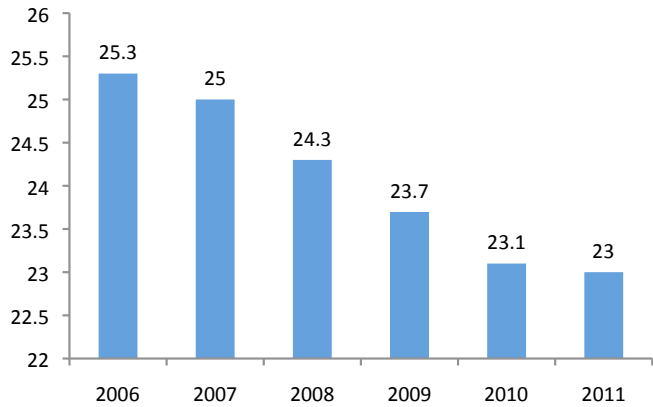
² It was 33 percent until 2012 and was established in relation to taxable income (i.e., profit less several exemptions). It was recently increased to 34 percent in two tranches: (i) 25 percent on taxable income to fund the government's general budget; and (ii) 9 percent on profits to fund social security.

Figure 1. Income Tax Rates

A. Maximum Income Tax Rate in Latin America, 2011
(in percent)



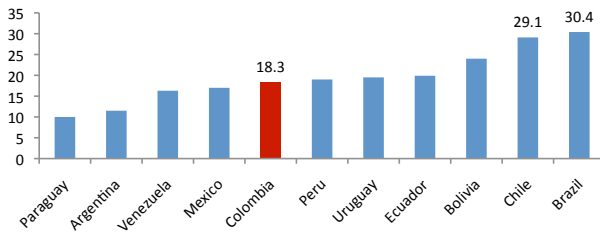
B. Average Income Tax Rate throughout the World, 2006–2011
(in percent)



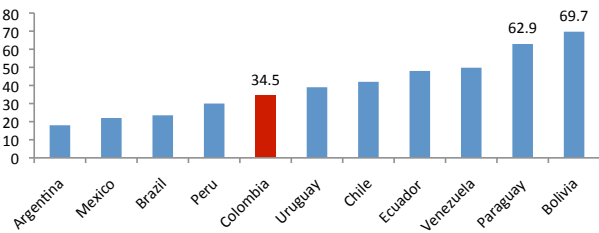
Source: KPMG International, Corporate and Indirect Tax Survey (2011).

Figure 2. Tax Productivity, 2009

A. Income Tax Productivity



B. VAT Productivity



Source: Economic Commission for Latin America and the Caribbean (ECLAC).

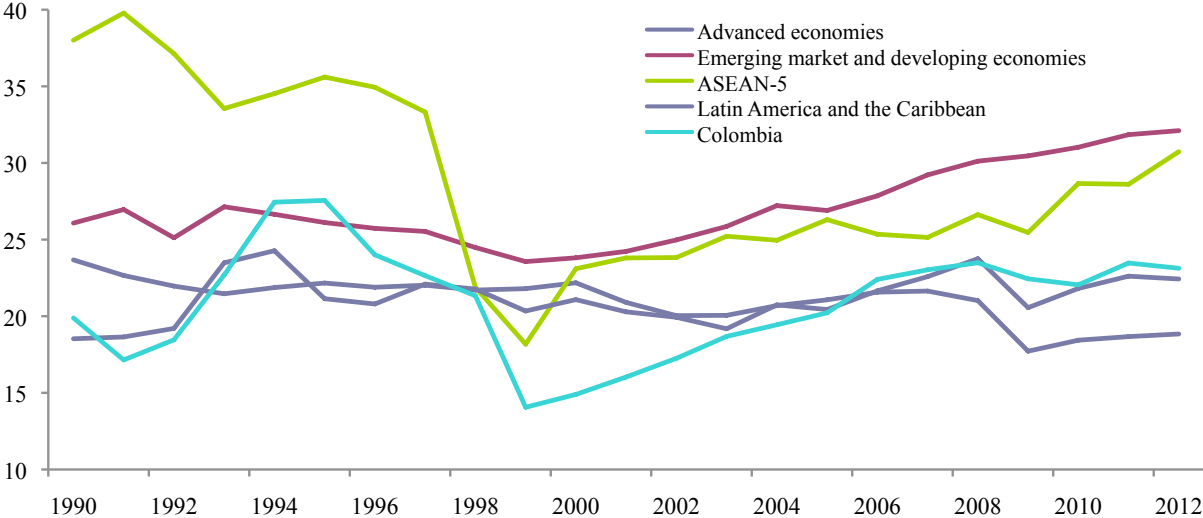
This paper explores the likely effects that changes on the tax code will have on economic activity. The paper has four sections, including this Introduction. The second section, following the methodology outlined by Hall and Jorgenson (1967), will include an estimate of the impact that reduced corporate income tax could have on private investment. The third section will test the impact that decreased non-wage labor costs can have on employment and the informal labor

market, using a CGEM. The fourth section will include the conclusions of the evaluations and will present some policy recommendations.

2. The Impact of Reducing Corporate Income Tax on Investment

Investment in Colombia has increased during the last 12 years—in line with developments in most emerging markets (Figure 3). Although it has not reached the average level of investment in emerging economies, it approximates the Latin American average, in spite of a major collapse in the second half of the 1990s.

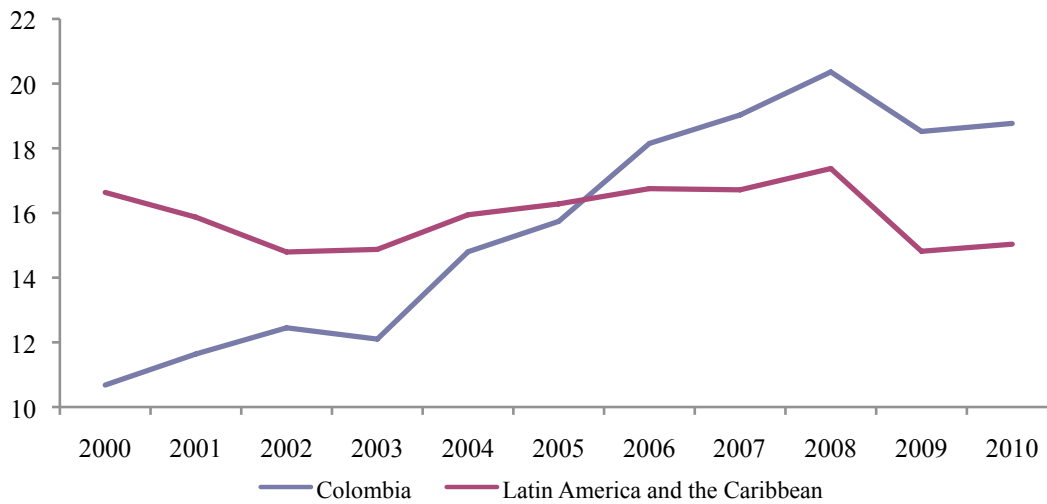
Figure 3: Total Investment
(in percent of GDP)



Source: IMF (2012).

Private investment recovered from 10 percent of GDP in early 2000 to 18 percent in 2010 (Figure 4), with Colombia now higher, as a percent of GDP, than the Latin American average (which has hovered at approximately 15 percent).

Figure 4: Gross Fixed Capital Formation, Private Sector
(in percent of GDP)



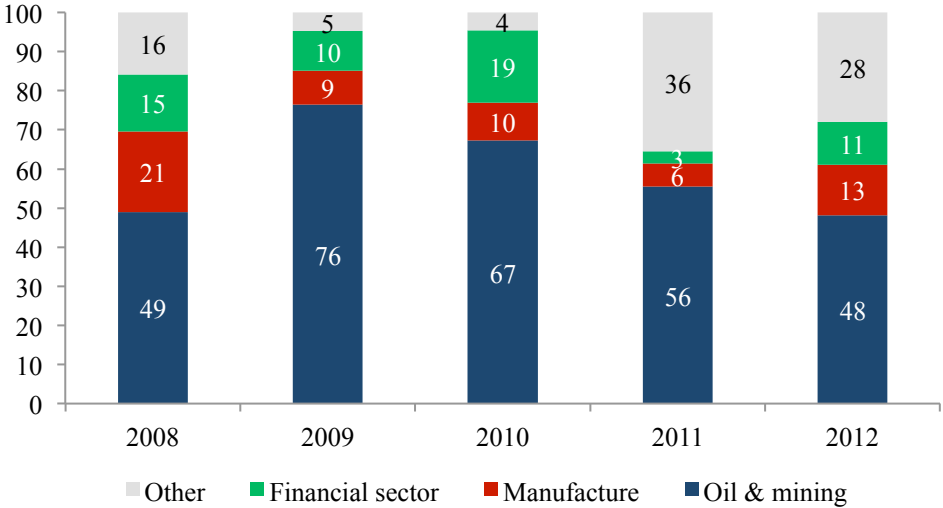
Source: Finance Minister of Colombia and the World Bank.

The recovery in both total investment and private investment is presumed to relate to four factors: (i) the very significant boost to the oil and mining sector, driven by regulatory changes, high commodity prices, relatively low revenue to the government, and considerable improvement in security conditions; (ii) the general recovery of the world economy following the crisis at the end of the 1990s, in particular for emerging economies; (iii) the improvement of security conditions not only affecting oil and mining, but also business in general and, in particular, agriculture and transportation; and (iv) the tax stimulus of 2004 (eliminated in 2010) arising from the 30 percent (and then 40 percent) discount of the purchase of fixed assets from corporate tax obligations. These four factors could be interrelated and details will be provided with regard to the surge in oil and mining, enhanced security conditions, and the changes to the tax regime.

Investment in oil and mining has surged in Colombia in recent years. A very high proportion of foreign direct investment, for example, has targeted oil and mining (Figure 5) which, in 2009, reached 76 percent. This boost to the oil and mining sector, to a large extent, is associated with the comprehensive regulatory reform that took place in Colombia 2003. Until then, the state-run oil company (Ecopetrol), fully owned by the Government, was the policymaker and main producer, primarily through association contracts. In 2003 the National

Hydrocarbons Agency (Agencia Nacional de Hidrocarburos (ANH)) was established as the policy-making body, whereby Ecopetrol had to compete with other (mainly foreign) companies in an attempt to level the playing field; concession contracts were reinstated and a minority stake in Ecopetrol was sold to private investors (Perry 2010). Between 2003 and 2010, as a consequence, the number of exploratory wells increased from 28 to 112 per annum, oil production rose from 541,000 to 785,000 barrels per diem, and foreign direct investment in oil surged from US\$278 million to US\$2.8 billion per annum.

Figure 5: Foreign Direct Investment in Colombia
(in percent)



Source: Banco de la República (BdR) de Colombia.

Despite the change in the regulatory system, the investment boom in oil may not have taken place had it not been for the surge in oil prices—and in commodity prices, in general. The West Texas Intermediate (WTI) price, for instance, rose from US\$31 a barrel in 2003 to US\$80 a barrel in 2010, while the price of thermal coal increased from US\$27 to US\$77 a ton in the same period. Colombian coal production expanded from 39 million tons in 2002 to 85 million tons in 2011.

While the enhanced security conditions have benefitted all sectors of the Colombian economy, the oil and mining sector has benefitted from it most. A 2012–13 survey of mining companies by the Fraser Institute shows that the main factor discouraging mining companies in Colombia had been the security situation, followed by the uncertainty over which areas would be

protected by the legal system. Interestingly, taxation ranked 18 out of 19 considerations, which is consistent with Colombia's government not having retained a high proportion of the revenue stemming from this sector.

Table 1 illustrates the average fiscal revenue to governments in the region for each barrel of crude oil sold (Manzano and Monaldi, 2008). Colombia's government revenue was the second lowest following Bolivia, and it was much lower than those of Venezuela, Ecuador, and Mexico.

Table 1: Fiscal Revenue for Each Barrel Sold
(percentage of international price)

Country	1996–98	1999–2001	2002–04
WTI (USD per barrel)	19	25.1	32.9
Argentina	No data	20	24
Bolivia	37	24	15
Colombia	22	21	22
Ecuador	66	46	51
Mexico	42	38	52
Trinidad and Tobago	37	16	23
Venezuela	51	47	53

Source: Manzano and Monaldi (2008).

As previously mentioned, the increase in total investment may have been as a result of the improved security. Between 2002 and 2006 homicides declined 39 percent, blackmail and kidnapping by 83 percent, and terrorist attacks by 61 percent. This trend is associated with an increase in defense and security spending, which increased from 4.2 percent of GDP in 1998 to 5.3 percent of GDP in 2007 (Ministerio de Defensa Nacional, 2009). Experts claim that this additional expenditure was in parallel to major improvements in efficiency.

Finally, the positive dynamics of private investment during the last decade may have been associated with tax policy. In order to encourage private investment, in 2004 the Colombian government approved an exemption on income tax of 30 percent for the purchase of machinery and equipment. This exemption was raised to 40 percent in 2006 and eliminated in 2010 due to fiscal considerations. After controlling for year effects (i.e., the capture of macroeconomic conditions and capital flows), Galindo and Meléndez (2013) were unable to identify any positive effect of this tax benefit on private investment. It appears that this has been the only rigorous

evaluation of this policy intervention, one which, to a certain extent, will be replicated in this Working Paper.

In order to assess the impact of changes in the corporate income tax rate on investment, in the following sections we proceed as follows. First, we derive and explain the concept of the user cost of capital. Second, we calculate each of the several components of the user cost, for two different types of investment goods (machinery and equipment and construction, which is a non-tradable concept that does not include civil works and housing). Third, for each type of investment good, we estimate an investment function that depends on the user cost which, *inter alia*, depends on the corporate rate of taxation.

2.1. User Cost of Capital

User cost of capital has been of particular interest due to the strong relationship it has with investment. Hall and Jorgenson (1967) provided the first theoretical development of this concept, which has been extensively used in the case of Colombia.³ Following Cohen (1968), the user cost of capital (C) is derived by way of maximizing profits and it is defined as:⁴

$$C = \frac{P^I}{P} \left(i + \delta - \frac{\Delta P^I}{P^I} \right) \frac{1 - k - \tau z}{1 - \tau} \quad (1)$$

where P^I is the price index of investment goods, P is the producer price index, δ is the depreciation rate, $\Delta P^I / P^I$ is the P^I rate of growth, k are investment tax credits, τ is the corporate income tax, z is the present value of deductions for depreciation, and i is the nominal rate of interest. The user cost can be broadly understood as having three components:

³ Fainboim (1990) developed the first series of the user cost for Colombia, covering the period 1950-87. Cárdenas and Olivera (1995) disaggregated the variable into three effects: relative price of capital, real discount rate, and taxes. Steiner and Soto (1998) analyzed a 1996 representative sample of companies from the Superintendency of Companies and estimated the user cost of capital, differentiating by type and source of funding. Pombo (1999) estimated the user cost for the manufacturing sector by type of capital good for the 1970-95 period. More recently, Rhenals (2005) started from the maximization of benefits and took into consideration the concept of funding sources. Finally, Botero, Ramirez, and Palacio (2007) followed the methodology proposed by Cardenas and Olivera and estimated the user cost during the period 1990–2007.

⁴ See Appendix 1 for derivation of this equation.

- 1) The relative price of capital goods P^I/P : since most investment goods are tradable and the producer price index includes non-tradable goods, an appreciation of the exchange rate generally reduces the user cost of capital.
- 2) The effective discount rate $(i + \delta - \Delta P^I/P^I)$: an increase in the nominal interest rate or in the rate of depreciation implies a higher cost of capital, while the relative appreciation of capital goods reduces C .
- 3) The tax effect $((1 - k - \tau z)/(1 - \tau))$: the user cost of capital increases whenever the corporate income tax rate (τ) increases or when tax credits on investment decline.

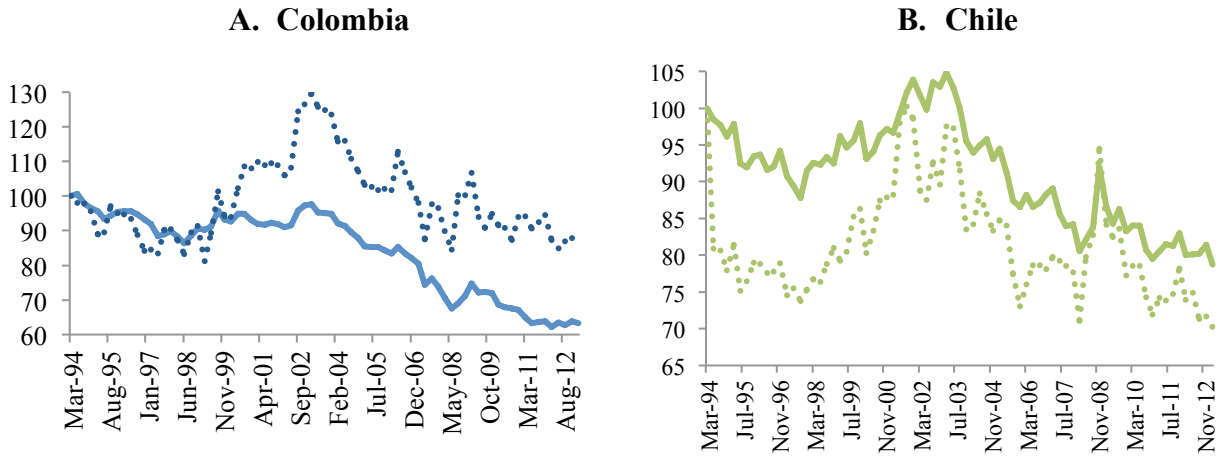
The following includes an estimate of the main components of the user costs of capital in Colombia for machinery and equipment and construction, using quarterly data for the period 1990-2012. Appendix 2 provides a definition of all the variables employed, including their sources.

2.1.1. The Relative Price of Capital Goods

Figure 6 shows the investment goods component of the Producer Price Index (PPI) and the relative price of investment goods (P^I/P). Highlighted is the fact that between 2003 and 2012, the relative price of investment goods declined by 35 percent, in tandem with the appreciation of the currency.⁵ This trend is similar to that of Chile, in which both the relative price of investment goods and the Real Effective Exchange Rate (REER) have declined steadily since 2001.

⁵ The peso/dollar exchange rate changed from 2,958 at the beginning of 2003 to 1,768 at end 2012, a nominal appreciation of 40 percent.

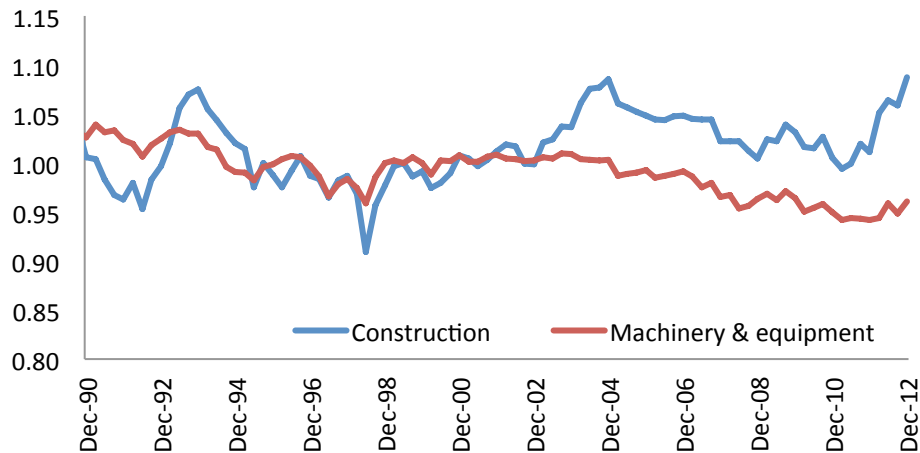
Figure 6: Peru and Chile: P^I/P and REER



Source: Estimates based on the BdR. Solid lines represent P^I/P ; dashed lines represent the Real Exchange Rate Index.

Figure 7 illustrates the relative price relating to the two investment goods under study (machinery and equipment and construction).⁶ Since 2002, when there was a significant change, the relative price of machinery and equipment declined while that for capital goods for construction was somewhat volatile.

Figure 7: P^I/P for Machinery and Equipment and Construction



Source: Calculations are based on the Colombian National Statistics Bureau (Departamento Administrativo Nacional de Estadística (DANE)).

⁶ P is the overall PPI estimated by DANE. The price index for capital goods relating to construction is proxied by the price index for construction materials; the price index for capital goods relating to machinery and equipment is proxied by the price index for all capital goods.

2.1.2. *The Effective Discount Rate*

Figure 8 presents the nominal rate of interest (i.e., the fixed interest rate on a 90-day CD, issued by commercial banks). This rate declined significantly at the end of the 1990s—associated with the sharp decline in inflation—from 32 percent in 1990 to 4 percent in 2006.

Figure 8: Nominal Interest Rate i
(in percent)



Source: BdR, Colombia.

A different depreciation rate is applied for each type of capital goods (8 percent for machinery and equipment and 2.5 percent for construction) to estimate the varying user costs. The recent surge of the aggregate depreciation rate (calculating the stocks related to each type of capital goods) is due to an increase in investment in transport equipment and in machinery and equipment (Table 2), both of which have a higher depreciation rate.

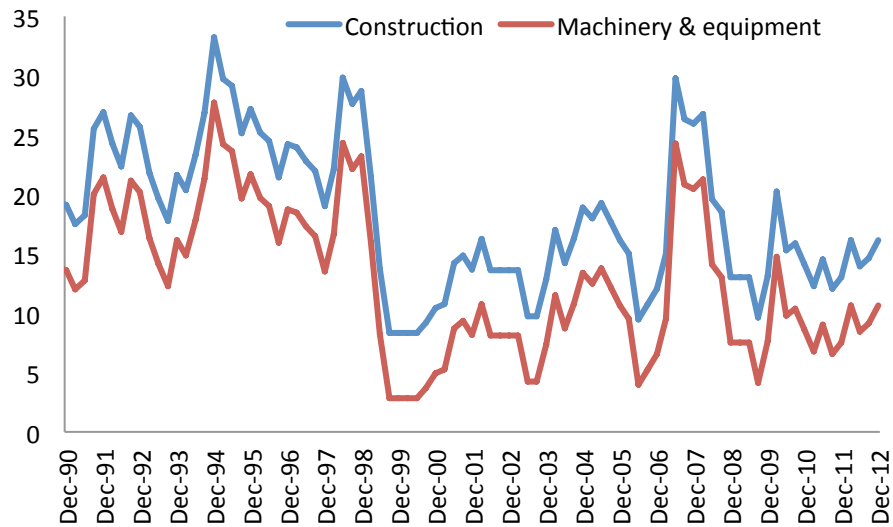
Table 2: Gross Investment by Type of Capital Good
(in percent)

	Agriculture	Machinery and equipment	Transport equipment	Construction	Civil works	Services
2001–04	3.8	23.0	8.1	31.6	31.1	2.5
2005–07	2.8	27.3	10.8	30.1	27.0	2.0
2008–10	2.4	29.6	11.0	27.3	28.0	1.7
2011–12	2.1	31.6	13.8	22.4	28.6	1.5

Source: DANE.

The above information (nominal interest rate, rate of change in the price of investment, and depreciation rate) is used to estimate the effective discount rate for each type of investment good (Figure 9).

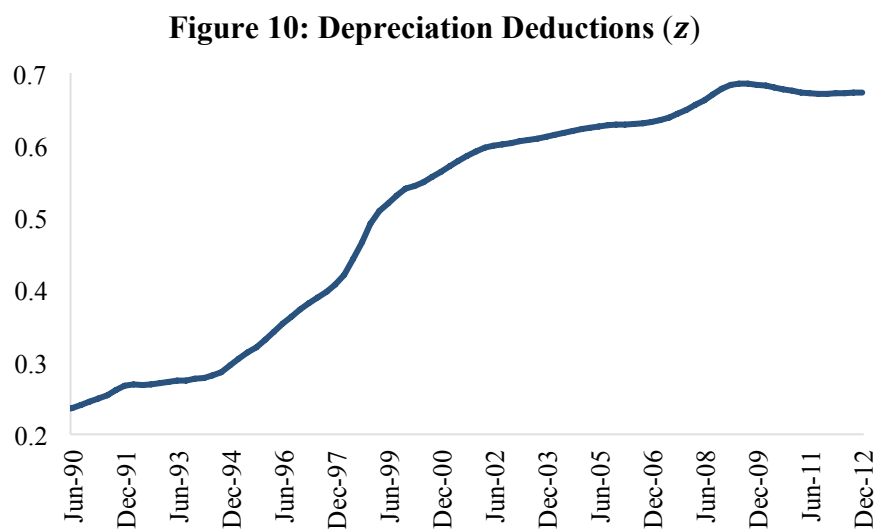
Figure 9: Effective Discount Rate
(in percent)



Source: Authors' calculations.

2.1.3. Tax Component

Depreciation deductions have increased in the last 20 years (Figure 10). They are calculated as the discounted value of depreciation charges stemming from capital expenditures (expressed in pesos at current prices). Lower interest rates explain the increase in these deductions since discounting by them implies a higher present value of depreciations.

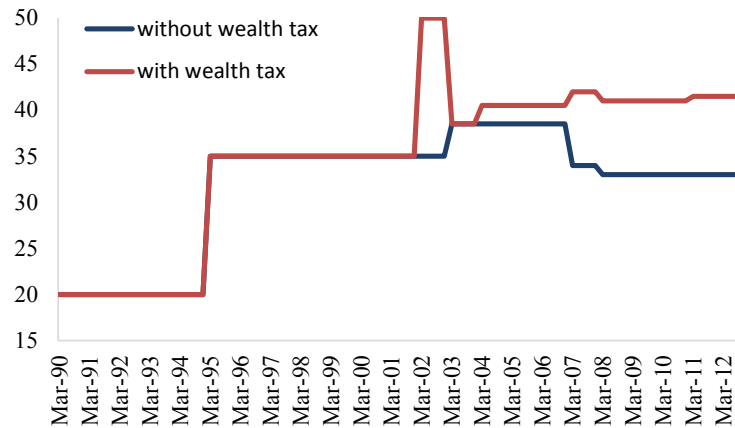


Source: Author's calculations.

Figure 11 relates to the corporate tax rate, including and excluding a wealth tax introduced in 2002 on individuals and businesses. While wealth tax is based on the net worth of a firm, it is paid out of current revenue and is equivalent to a higher corporate tax rate. In order to establish the income tax equivalent of the net worth tax, net income is assumed to be one tenth of corporate wealth. Previous to 2007, a tax rate of 0.3 percent was imposed on wealth over 3 billion pesos (US\$1.6 million); subsequently, it was raised to 1.2 percent.⁷

⁷ In 2010, due to an unusual rainy season, both the base and the rate were expanded to include individual wealth over 1 billion pesos (US\$55 million) and a tax rate of 3 percent for wealth over 3 billion pesos (US\$165 million).

Figure 11: Corporate Tax Rate (τ)



Source: DIAN.

As is the case in many countries, there is a significant difference between the statutory corporate tax rate and the effective tax rate paid by corporations. This is due to a number of tax benefits and exemptions, which vary according to sector, firm size, and geographic location. Using data for 2011, Steiner and Cañas (2013) estimated that the effective rate of corporate taxation was 28.2 percent, with a significant variation across sectors—ranging from 19.1 percent in the case of other services to 32.1 percent relating to mining. The effective rate of taxation was 27.3 percent in manufacturing and 29 percent in construction. These rates compare with the 33 percent statutory rate.

Colombia has four different types of tax benefits (Steiner and Cañas, 2013): (i) revenues that do not constitute taxable income, including dividends and shares in companies and the capitalization of profits; (ii) tax deductions, such as that relating to investment in real fixed assets, which was in place between 2003 and 2010;⁸ (iii) tax exemptions;⁹ and (iv) tax discounts.¹⁰ Given that Colombia’s tax regime includes a plethora of tax benefits which vary significantly through time, sector, and business it will not be feasible to include them in a time

⁸ Other important deductions are related to scientific research and investment projects in agriculture.

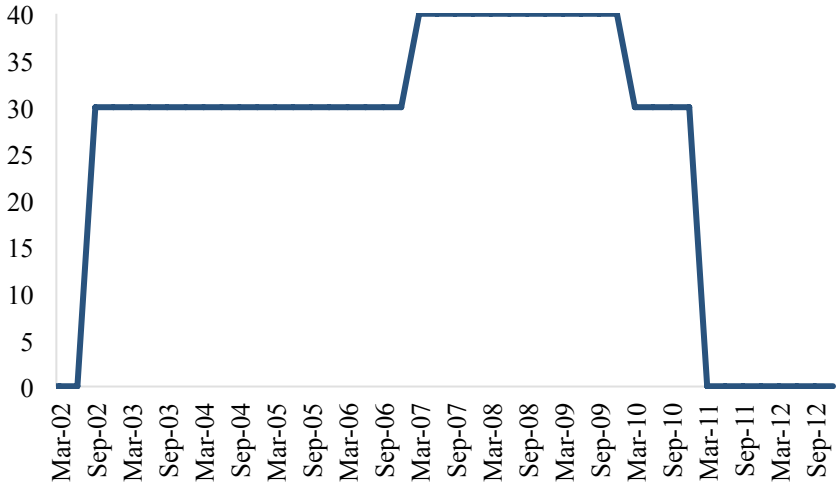
⁹ Including services to build or remodel hotels in place since 2002, the sale of electricity generated with wind, biomass or other agricultural resources, and interest received on government bonds.

¹⁰ For example, discounts related to the payment of sales tax on imports of industrial machinery for basic industries, discounts for portfolio investment in agriculture stocks, and discounts of 40 percent of the value of investments undertaken by utilities.

series econometric framework. Exception, however, will be made in relation to the tax exemption on machinery and equipment investment in 2003, which was significant and is straight forward and simple to include (

Figure 12). This exemption was removed in 2010.

Figure 12: Tax Investment Credits (k)
(in percent)



Source: Law 863 (2003), Law 1111 (2006), Law 1370 (2009) and Law 1430 (2010).

Figure 13 shows the tax component of the user cost with and without considering wealth tax. This component was relatively stable in the 1990s, while tax credits had a significant impact during 2002–10.

Figure 13: Tax Component of the User Cost of Capital

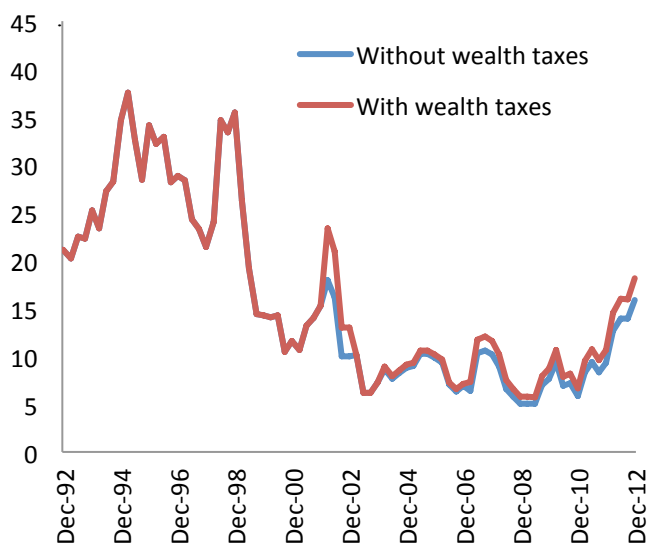


Source: Author's calculations.

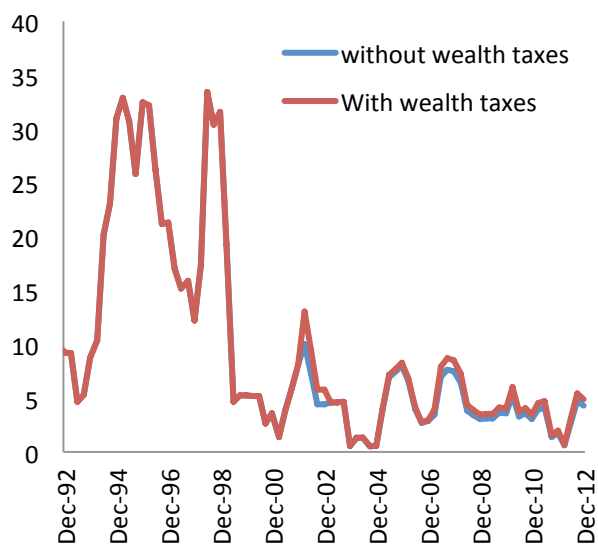
Calculation (by using Equation (1)) shows that the user costs of capital (Figure 14) remained high—though unstable—between 1990 and 1997 and declined sharply in the late 1990s, in tandem with the decrease in interest rates. Subsequent to 2000, the volatility in the user costs of capital can be associated with fluctuations in the exchange rate and changes in tax regulations, given the relative stability of interest rates. Despite the fact that in recent years the appreciation of the peso has contributed to the reduction in the relative price of capital goods (machinery and equipment and construction), this reduction has been offset by the introduction of the wealth tax and the elimination of tax deductions relating to investment.

Figure 14: User Cost of Capital

A. Machinery and Equipment
(in percent)



B. Construction
(in percent)



Source: Author's calculations.

2.2. Investment Model

Following Hall and Jorgenson (1967)—and under the assumption of a constant depreciation rate—a firm's investment function adopts the form

$$I_t = \sum_{s=0}^{\infty} \mu_s \Delta K_{t-s}^* + \delta K_t \quad (2)$$

Gross investment is the weighted sum of past changes in the optimal capital and the depreciation. This equation can be written in terms of net investment (N_t) as

$$N_t = I_t - \delta K_t = \sum_{s=0}^{\infty} \mu_s \Delta K_{t-s}^* \quad (3)$$

Taking the first two terms of $\{\mu_s\}$ as arbitrary and the remaining as a geometric sequence, the final form of the function is

$$N_t = \gamma_0 \Delta K_t^* - \omega N_{t-1} \quad (4)$$

where γ_0 , and ω are parameters, which characterize the $\{\mu_s\}$ sequence. For a Cobb-Douglas production function, the optimal level of capital can be written as follows:

$$K_t^* = \alpha \frac{Y_t}{C_t} \quad (5)$$

where α is the elasticity of output with respect to capital. If (5) is substituted in (4) and an error term is included, the following can be obtained:

$$N_t = \alpha \gamma_0 \Delta \frac{Y_t}{C_t} - \omega N_{t-1} + \epsilon_t \quad (6)$$

where ϵ_t is an i.i.d. error term. Note that in estimating (6) lags of $\Delta \frac{Y_t}{C_t}$ are implicitly incorporated.

In sum, investment depends upon the optimal capital stock and its past changes. This in turn depends on output, user cost of capital, and technological parameters. The effect of the tax structure enters into the investment function through the user cost. A change in tax rates affects the user cost and, therefore, the optimal level of capital. An adjustment in net investment is needed to reach this optimal capital stock (Hall and Jorgenson, 1967).

2.3. Investment Functions Estimations

This section will include the estimations of the investment equation for Colombia, using quarterly data for 1990-2012. Recent studies on the determinants of investment include Villegas (2009), Botero, Ramirez, and Palacio (2007) and Posada (2010). Using a dynamic data model at the firm level with a sample of 17,396 observations for the period 1995-2007, Villegas (2009) estimates that for every 1 percentage point increase in the user cost of capital, firm-level investment will decline by 8 percentage points. This effect is large and statistically significant. According to Botero, Ramirez, and Palacio (2007), a 10 percentage point increase in the user cost of capital will cause a 1 percentage point decline in investment. On the other hand, Posada (2010) found no relationship between the user cost and investment, although this is likely due to specification problems, since the set of regressors includes, along with the user cost, the real rate

of interest. None of these studies isolates the effect on investment of changes in the corporate tax rate.

Table 3 presents the estimation of Equation (6), with net investment in machinery and equipment (Columns (1) and (2)) and construction (Columns (3) and (4)) as the dependent variables. These series come from DANE's national accounts database. Our series on construction excludes civil works and housing, as previously mentioned. Investment on machinery and equipment and construction each accounts for 8.6 percent of GDP. The user costs were constructed in two ways: (i) excluding wealth tax (C_{1t}) and including wealth tax (C_{2t}), according to Equation (1) from the previous section for each type of investment goods. Y_t was approximated with the real GDP series from DANE.

Equation (6) was estimated using ordinary least squares (OLS) for time series data without a constant as specified by this equation. When net investment in machinery and equipment is used as a dependent variable (Columns (1) and (2)), the current value of the optimal capital is positive and significant at the 5 percent level of significance, while the lag is not significant. These results are robust when the user cost is taken into account without the wealth tax (Column 1) or with the wealth tax (Column 2). In general, the sensitivity of net investment to the user cost of capital is always negative,¹¹ but it is not a constant since it depends on the level of the latter. That being the case, the coefficient cannot be interpreted as an elasticity (or a semi-elasticity). Despite this fact, this sensitivity can be estimated for the end of the sample, given the level of the user cost of capital at that point in time.¹² On the other hand, when investment in construction is used as the dependent variable, the only variable that is significant is the lag of net investment. This result suggests that neither the user cost nor its determinants (in other words, the relative price of investment goods, discount rate, and tax regime) are a relevant explanatory variable.

¹¹ For an increase in one unit of the user cost of capital, net investment increases by $-0.72/C_t^2$, where C_t is the current level of the user cost.

¹² The positive and significant coefficient of lagged net investment shows the well-known positive serial correlation in the investment series.

Table 3: Investment Function with Different User Costs

Variables	(1)	(2)	(3)	(4)
	Machinery and equipment		Construction	
$\Delta(Y_t/C_{1,t})$	0.6034** (0.3148)		-0.0003 (0.028)	
$\Delta(Y_t/C_{2,t})$		0.6743** (0.341)		0.000006 (0.003)
N_{t-1}	0.9559*** (0.0390)	0.9568*** (0.039)	0.9962*** (0.017)	0.9962*** (0.017)
Observations	91	91	91	91
R-squared	0.8708	0.871	0.984	0.984

Source: Author's calculations.

Note: Standard errors are in parentheses. Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

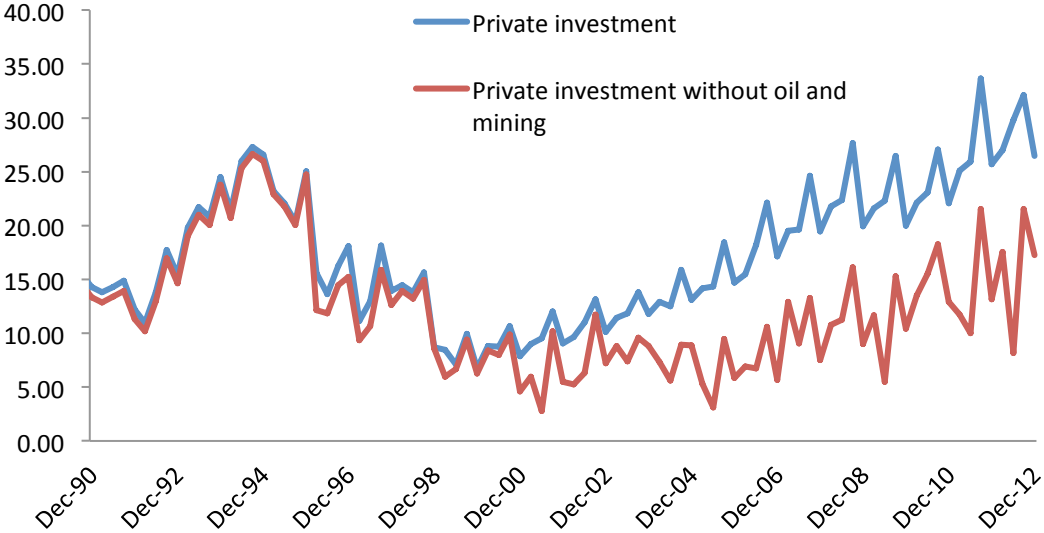
The results reported in

Table 3 refers to investment in two types of capital goods undertaken by the aggregate of all sectors in the economy. It is of interest to undertake additional estimations in which investment undertaken by firms operating in the oil and mining sector is excluded. After all, the determinants of investment in these two activities have very specific determinants, including the price of commodities and, more importantly, a complex tax regime (including royalties) in which the corporate income tax is only one of its components.

This exclusion is not straightforward, given that the DANE database on investment is not presented on a sectoral basis. The procedure followed included information on the U.S.-dollar value of foreign direct investment in oil and mining, as reported by Colombia's BdR. This was

transformed into pesos (using market exchange rates) and then converted to constant 1975 pesos (using the consumer price index (CPI) as a deflator). Given that, in principle, this new series is comparable to the private investment series in DANE’s National Accounts, the investment in oil and mining (Figure 15) has been excluded from each type of investment. The results, reported in Table 4, are broadly similar to those reported for investment without excluding the oil and mining sector. The coefficient for the Y/C term is now smaller, thereby implying that investment in machinery and equipment is slightly more sensitive to changes in the user cost of capital (and to changes in taxes, as well).

Figure 15: Investment, Excluding the Oil and Mining Sector
(COP billion, 1975 pesos)



Source: Author’s estimates based on National Planning Department (Departamento Nacional de Planeación, or DNP), DANE and BdR.

Table 4: Investment Function, excluding Oil and Mining¹³

	(1)	(2)	(3)	(4)
Variables	Machinery and equipment		Construction	
$\Delta(Y_t/C_{1,t})$	0.5174*		0.008	
	(0.2153)		(0.011)	
$\Delta(Y_t/C_{2,t})$		0.559*		0.0002
		(0.234)		(0.0022)
N_{t-1}	0.946***	0.946***	0.9855***	0.9855***
	(0.0452)	(0.045)	(0.018)	(0.017)
Observations	91	91	91	91
R-squared	0.8308	0.8307	0.9707	0.9708

Source: Author's calculations.

Note: Standard errors are in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

2.4. Impact on Investment as a Result of a Decline in Corporate Income Tax

Using the sensitivity parameter estimated above, a calculation is made on the impact of a reduction in the corporate income tax rate on investment in machinery and equipment (excluding the oil and mining sector). In this exercise, the tax rate decreases from 33 percent to 23 percent as of the first quarter of 2013, while all other variables remain constant. This change in the corporate tax rate reduces the user cost of capital by 0.9 percent and has a positive *impact effect* on investment (excluding oil and mining) of 1.37 percent (equivalent to 0.28 percent of GDP on a yearly basis). Given the large coefficient of the auto-regressive term, the *long-term effect* on investment is much higher (i.e., around 5.2 percent of GDP). On the other hand, a reduction in the corporate income tax from 33 percent to 23 percent brings about, *ceteris paribus*, a 0.395 percent of GDP decline in tax collections for the first quarter of 2013, equivalent to a decline of 1.58 percent of GDP on a yearly basis. Evidently, while the reform is costly in the short term, it is quite likely to pay for itself in the long term.

¹³ The user cost is taken into account excluding the wealth tax (Column 1) and including the wealth tax (Column 2).

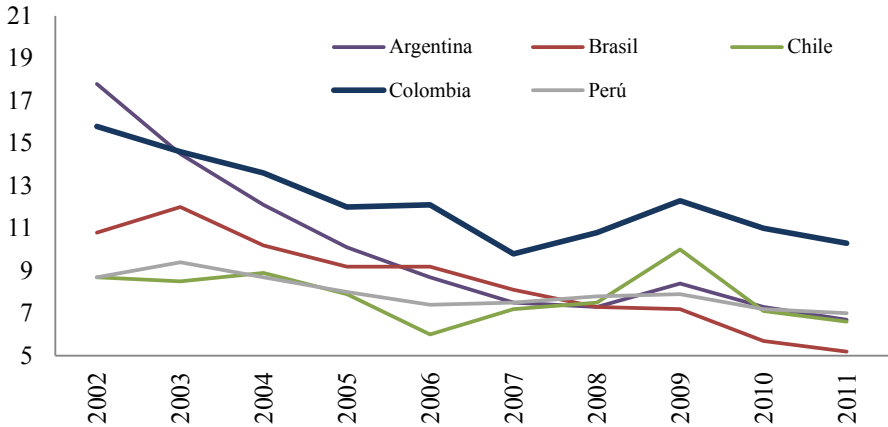
3. The Impact on Employment of Lowering Payroll Tax

This section is divided into three subsections. The first provides some stylized facts regarding Colombia’s highly distorted labor market, followed by a highlight of the main features of the model to be used in the simulations. The last section presents the simulation results.

3.1. Colombia's Labor Market

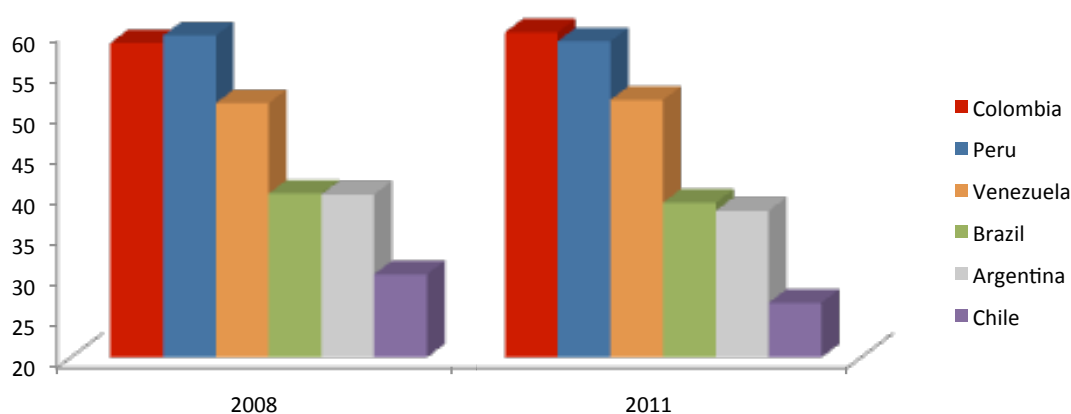
Colombia’s unemployment rate is the highest in the region, in spite of GDP growth in Colombia being generally better than the regional average. In December 2011 unemployment in Colombia was 10.3 percent, while the regional average was less than 7 percent (Figure 16). On the other hand, labor informality is among the highest in the region (Figure 17). Reasonably solid growth and timid institutional and regulatory changes have done little to improve the quality of labor outcomes.

Figure 16: Unemployment Rate
(in percent)



Source: ECLAC and authors’ calculations.

Figure 17: Urban Employed in Low-Productivity Sectors, Informal Sector
(in percent of total population employed)



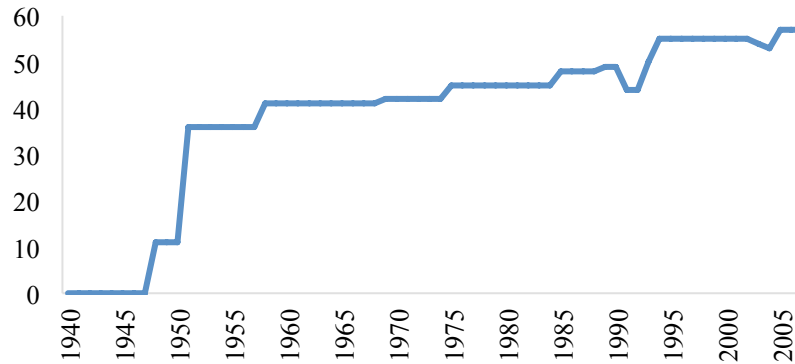
Source: ECLAC

In Colombia non-wage labor costs—that is, charges paid by the employer other than direct compensation—represent between 60 and 70 percent of wages (Figure 18). A portion of these charges, equivalent to approximately 14 percent of wages,¹⁴ do not provide direct benefits to the worker and are, therefore, considered to be a “pure tax”.¹⁵ These non-wage labor costs are associated with greater labor informality, less formal employment, and lower wages (Kugler and Kugler, 2009). These costs affect the labor market, both from the point of view of the supply curve (there exist higher hiring costs) and the demand curve (workers have greater incentives to evade these charges by involving themselves in informal activities).

¹⁴ This includes a 2 percent charge (over wages) to finance the national vocational education program (Servicio Nacional de Aprendizaje, or SENA); 4 percent to fund a privately operated system that provides services and transfers resources to formally employed workers and their families (Cajas de Compensación Familiar, or CCF); 3 percent to fund the family welfare fund (Instituto Colombiano de Bienestar Familiar, or ICBF); and between 1.2 percent and 3.5 percent as solidarity within the health and pension systems. The first three components, totaling 9 percent, are the so-called “*parafiscales*” (i.e., earmarked quasi-taxes).

¹⁵ The bulk of non-wage labor costs are contributions to the pension and health systems, which include private direct benefits to the worker in whose name the contribution is made. These costs are part of a worker’s compensation package and, therefore, are not “pure taxes”.

Figure 18: Non-Wage Labor Costs
(in percent of payroll)



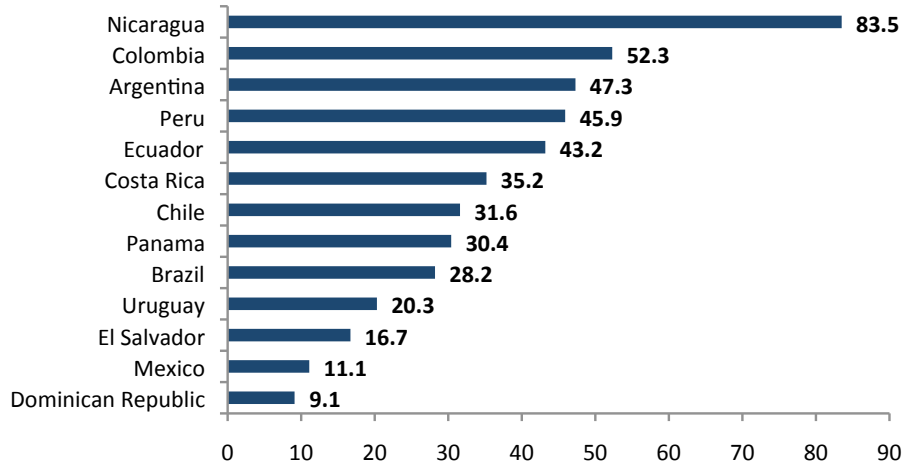
Source: Santa María et al. (2010).

According to Santa Maria, Steiner, and Schutt (2010), informality is a result of exclusion and escape processes. On one hand, exclusion is driven by the segmentation of the labor market, which prevents the migration of lower-skilled workers to the formal sector. On the other hand, small firms have incentives to keep workers in informal agreements or contracts, as they evade taxes that they would have to pay in the formal sector. Therefore, escape processes are the result of a cost-benefit analysis made by agents in connection with the enforcement capacity of the State. Non-wage costs generate a perverse cyclical effect on the labor market. An increase in payroll taxes encourages informality, especially via escape processes. This reduces the tax base and, therefore, fewer resources are generated. To cope with this deficit, an increase in the tax rate is decreed, which repeats the cycle at the expense of ever higher levels of informality.

On the other hand, in the Latin American context, Colombia has the second highest minimum wage (MW) as a percentage of per capita GDP (Figure 19). While per capita GDP in the United States is 11 times higher than in Colombia, the (average) MW is only five times higher. In the last twenty years, the MW as a proportion of the average wage has increased by 40 percent, indicative of the fact that the MW has grown much faster than average labor productivity. Indeed, during the period 1997–2006, the average minimum wage grew at rates close to the rate of inflation (i.e., there was no meaningful increase in average labor productivity) (Figure 20). However, during the same time span, the MW rose 36 percent above inflation, paying for a higher productivity that really did not occur. Having a high MW that is a rising proportion of the average wage can help explain the fact that the proportion of workers earning

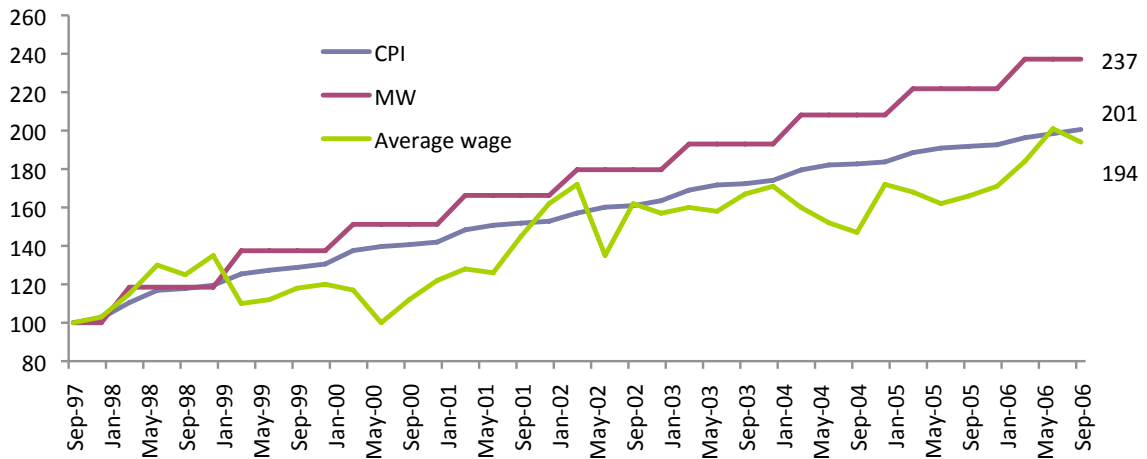
less than the MW (i.e., in the informal sector) is also high and increasing, from around 26 percent two decades ago to approximately 35 percent today (Figure 21).

Figure 19: Minimum Wage
(as a percent of per capita GDP)



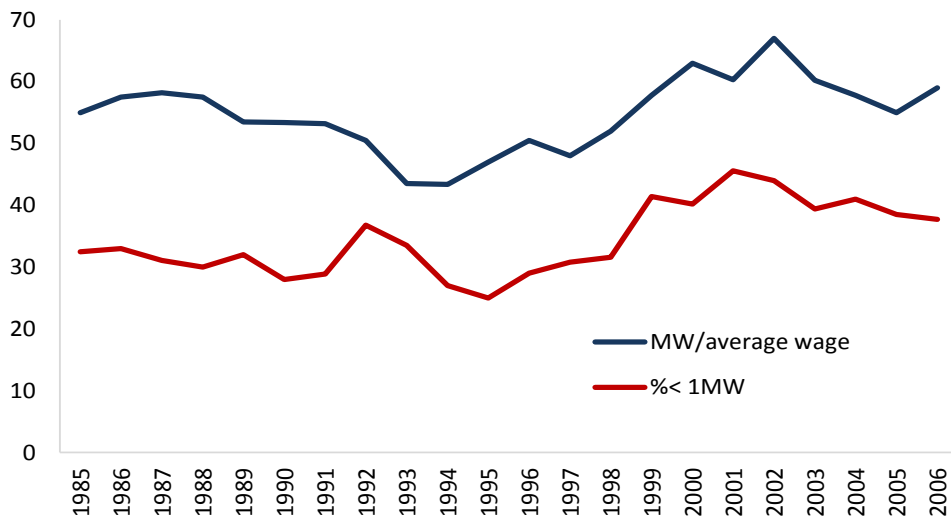
Source: Santa María, Steiner, and Schutt (2010).

Figure 20: Average Wage, MW, and Consumer Price Index (CPI)
(1997=100)



Source: Santa María, García, and Mujica (2008), cited by Santa María, Steiner, and Schutt (2010).

Figure 21: Minimum Wage
(as a percent of average wage)



Source: Santa María, Steiner, and Schutt (2010).

Santa María, García, and Mujica (2008) estimated the effects of non-wage labor costs over employment and found that a 1 percent increase in these costs caused a 2.9 percent decrease in relative¹⁶ employment. Not surprisingly, this effect is strengthened in the presence of a binding minimum wage—that is, the adjustment in the formal labor market to the higher tax has to be done through quantities (employment) rather than through prices (wages). Montenegro and Pagés (2004) found that both the minimum wage and non-wage labor costs reduced employment of the young and the unskilled. They estimated that a 10 percent increase in non-wage costs reduces by 6.6 percent the likelihood of a young person of finding a job, in comparison to older workers.¹⁷

In what follows, a CGEM is used to simulate the impact of a reform that reduces non-wage labor costs and replaces them, if needed, with less distortionary taxes such as the VAT.¹⁸ In particular, the effects on employment, labor formality and fiscal revenue of the implementation of the tax reform (approved by Congress in late 2012) are explored.

¹⁶ Defined as the ratio of employees to freelancers.

¹⁷ For the case of Peru, Saavedra and Torero (2004) showed that a 1 percent increase in labor taxes reduced labor demand by 0.19 percent.

¹⁸ In the Colombian context, the use of a CGEM to analyze the labor market is not new (see, for example, Steiner, Forero and Rojas, 2012).

3.2. General Framework: CGEM

The CGEM is a set of equations and assumptions that allow the simulation of the transition of an economy from an initial economic equilibrium to a final equilibrium after it has been subjected to exogenous shocks (see Appendix 3 for details). In particular, the general equilibrium model for Colombia is calibrated for the year 2007, based on the Social Accounting Matrix produced by the National Planning Department. These models are widely used for the evaluation of policies and projects and allow for the interrelationships between all markets of the economy (i.e., they take into account both the direct as well as the indirect effects of policy interventions).

As has been already described, Colombia has a labor market that is segmented in a formal and an informal component. The formal segment receives social security benefits¹⁹ and is governed by a rather high minimum wage. The informal segment is flexible and provided 60 percent of jobs in 2011.²⁰ The CGEM captures these elements: the labor market is composed of a formal and an informal sector following Todaro (1969). In the formal sector, unemployment exists and the real minimum wage is a binding constraint (Hutton and Ruocco, 1999). In this segment, firms determine the level of employment. On the other hand, the informal labor market is assumed to be perfectly competitive (i.e., there is full employment, with flexible real wages). In the formal segment, unemployment can be an equilibrium outcome because there is a part of the economically active population that prefers to remain unemployed since its remuneration in the informal sector is deemed to be very low.

With the following orthogonal condition, it is straightforward to introduce this segmentation in the labor market (van der Mensbrugghe, 2005). Let W_{MIN} represent a minimum wage and UE_{MIN} be unemployment (for a certain segment):

$$(W - W_{MIN})(UE(W) - UE_{MIN}) = 0$$

In the formal sector the minimum wage is higher than the equilibrium wage. In this case, unemployment ($UE(W_{MIN})$) is higher than a minimum unemployment level (UE_{MIN}), and the prevailing wage, W , is set to the minimum wage. In the informal sector, there is no binding minimum wage, so $W_{MIN} = 0$ and the market clears with $UE = UE_{MIN}$.

¹⁹ Formal sector workers receive health and pension benefits. Most informal sector workers, if poor, are affiliated to a subsidized health insurance program.

²⁰ According to ECLAC.

The “pure tax” component of non-wage labor costs (ICBF, SENA, CCF) are represented as a tax (τ^{xfl}) on net wages received by formal sector employees (NW). Total wages paid by employers (W) is equal to

$$W = (1 + \tau^{xfl})NW$$

The tax reform approved by Congress in late 2012 is analyzed below. The reform reduced from 3 percent to 0 contributions to SENA, from 2 percent to 0 contributions to ICBF, and from 8.5 percent to 0 health contributions. In all, the ‘pure tax’ component was reduced permanently from 29.5 percent to 16 percent. Though such a policy could potentially produce a decline in fiscal revenues, this is not the case for Colombia.

3.3. Simulation Results

Table 5 shows the results of the simulations, based on this study’s CGEM. Column (2) includes the calibrated values for 2012 for GDP, government revenue, non-wage labor costs, government expense, fiscal deficit as a share of GDP, employment, unemployment rate, net wage, formal and informal employment. These calibrated values are consistent with both the CGEM's equations and what actually happened in 2012.²¹ Column (3) presents the values for all these variables for 2013, had there not been a reform—these simulations are referred to as “business as usual”. Column (4) describes the simulations when τ^{xfl} is reduced, what is known as “lowering payroll taxes” simulations. Finally, column (5) reports the changes between the two simulations (percentage difference and participation over GDP, depending on the variable).

In the first year of the reform, the level of real GDP is 0.23 percent higher when compared with the business-as-usual simulation. This is a once-and-for-all permanent effect. This increase in GDP is possible due to a 0.5 percent increase in overall employment, which means that the unemployment rate falls 0.5 percentage points (from 3 percent to 2.5 percent). It is important to note that the unemployment rate in the CGEM is the unemployment rate *above*

²¹ For instance, the model calibrated a 2.4 percent of GDP fiscal deficit, which was actually 2.3 percent (*Marco Fiscal de Mediano Plazo*, Ministerio de Hacienda y Crédito Público, 2012). While the model calibrated 21.9 million workers, DANE reports 21 million workers; informality is calibrated at 62 percent of the labor force, close to the 59 percent reported by ECLAC.

the non-accelerating inflation rate of unemployment (NAIRU), estimated at 10.8 percent for Colombia (Arango, Posada, and García, 2007). Furthermore, formal employment increases by 1.4 percent, while informal employment falls 0.06 percent. Likewise, government revenue increases more than government expenditure and the fiscal balance marginally improves; in other words, the reform pays for itself.

Table 5: Simulations Results
(in billions of 2007 pesos)

	Business as Usual		Lowering Payroll Taxes	Difference between Two Scenarios
	2012	2013	2013	2013
GDP	524.2	546.7	548.0	0.236 percent
Non-wage costs (percent wage)	29.5	29.5	16.0	
Fiscal deficit /GDP (percent)	-2.3	-2.373	-2.371	-0.002 percent
Employment (m. people)	21.8	22.15	22.26	0.497 percent
Unemployment rate (percent) ⁱ	3.0	3.0	2.5	-0.5 percentage points
Formal employment (m. people)	8.3	8.5	8.62	1.4 percent
Informal employment (m. people)	13.6	13.65	13.64	-0.06 percent

Source: Fedesarrollo's CGEM.

It is important to provide some intuition regarding these results. A reduction in non-wage labor costs reduces labor costs in the formal sector while maintaining take-home pay constant (NW in Equation (1)). This enhances the demand for formal workers, which implies a higher net wage, thereby increasing compensation in the formal sector relative to the informal sector (Equation (2)).

$$W = (1 + \tau^{xl})NW \quad (1)$$

$$AWAGE_{l,gz} = (1 - UE_{l,gz}) \frac{\sum_{i \in gz} NW_{i,l} L_{i,l}^d}{\sum_{i \in gz} L_{i,l}^d} \quad (2)$$

The migration of workers between the informal and formal sectors is governed by Equation (3) and is a function of relative wages. On account of the proposed reform which, by reducing “pure taxes,” increases relative wages on 2013 from 1.56 to 1.6, the migration goes up to 105,320 (some 0.5 percent of total employed people). The reform has an impact effect by which real wages in the formal sector increase 4.29 percent in the first year. On account of “general equilibrium” considerations, they then increase 2.2 percent per year.²² With the reform, the real wage in the formal sector is 1.8 percent higher than in the baseline.

$$MIGR_l = X_l^{migr} \left(\frac{AWAGE_{l,for}}{AWAGE_{l,inf}} \right) \omega^m \quad (3)$$

The incidence of informality varies across sectors. In a selected few (i.e., financial sector and civil works) there is no informality. On the other extreme, almost three fourths of output in agriculture is informal (Table 6). Consequently, the effect of the proposed reform should not be expected to be uniform throughout sectors; its direct effect on fully formal sectors is nil. In agriculture, the reform is expected to have a significant effect.

Table 6: Informality per Sector 2012

Sector	Participation in GDP (in percent)	Informal production as a percent of total production
Agriculture	7.28	73.88
Mining	5.74	9.25
Light manufacture	5.58	19.84
Services	28.10	29.37
Edifications	3.57	24.09
Civil works	3.39	0
Refining	2.19	0
Machinery and equipment	0.98	0
Financial sector	4.05	0
Other services	21.59	18.01

Source: Fedesarrollo’s CGEM

²² In the baseline, real wages grow at an average yearly rate of 2.2 percent. The reform has an impact effect by which real wages increase 4.2 percent in the first year.

One interesting feature of the proposed reform—making it a win-win situation from a political economy perspective—is that, in fiscal terms, it “pays for itself”. According to DNPs’ 2007 Social Accounting Matrix, corporate income taxes represented 8.6 percent of GDP. These resources, of course, are contributed solely by formalized businesses. According to these estimations, the faster pace of formal production that is induced by the elimination of the pure tax component of non-wage labor costs would enhance corporate tax collections in an amount similar to the cost of funding the social programs historically paid with the “*parafiscales*”.

4. Conclusions and Recommendations

This paper has included estimates of the likely effects on investment, employment, and labor formalization of a reduction in corporate income tax from 33 percent to 23 percent and of the elimination of the “pure tax” component of non-wage labor costs. The main findings are:

- (i) While in the short term, the fiscal costs associated with a decline in corporate taxes out-weigh any potential benefit in terms of enhancing investment, the long-term impact on non-oil and mining investment is significant. Therefore, the policy issue at hand is how to finance the transition of a policy that is fiscally costly in the short term but, in all likelihood, is self-sustainable in the long term.
- (ii) Eliminating the “pure tax” component of non-wage labor costs increases formal sector employment, a policy that essentially pays for itself.

These results would seem to lend support to key elements of the recent tax reform, proposed and enacted by Congress. The reform, passed in December 2012, basically left corporate taxes unchanged, but reduced the “pure tax” component of non-wage labor costs almost in half. The reform was to be revenue-neutral and was expected to boost formal sector employment. For the first half of 2013, overall tax collections (COP\$58.8 trillion) were slightly lower than for the first half of 2012 (COP\$ 58.9 trillion). Preliminary data²³ suggests, however, that tax collections in July and August evolved very favorably, with August 2013 collections

²³ <http://justiciatributaria.co/recaudo-tributario-llego-a-715-billones-en-agosto/> and <http://www.elespectador.com/noticias/economia/recaudo-tributario-agosto-va-71-billones-articulo-372902>.

surpassing August 2012 collections by as much as 25 percent. This evolution throughout 2013 is attributed to the fact that the government took much more time than expected in issuing the necessary decrees to make key elements of the tax reform operative.

On the other hand, the labor component of the reform—in other words, the reduction in the “pure tax” component of non-wage labor costs—which came into effect on May 1, 2013, already seems to be yielding very positive results. In particular, for the 13 largest metropolitan areas during the 3-month period May–July, total employment increased 204,000 in comparison to the same period in 2012. Interestingly, while formal sector employment increased 367,000, informal sector employment declined by 163,000.

Given the recent positive evolution of the labor market and taking into consideration the supporting evidence provided in this paper, there is no reason other than political expediency to not have fully eliminated the “pure tax” component of non-wage labor costs. There is merit and no fiscal cost in completely eliminating the “pure tax” component of non-wage labor costs. In fact, if the reform had indeed eliminated all non-wage costs, the unemployment rate would be lower and formal workers would have a higher relative wage.

Finally, an important caveat is in order. While it is true that the short-term fiscal costs of a sharp reduction in corporate tax is huge whereas the increase in investment is only marginal, there is another powerful reason to consider a fiscally neutral reform that shifts income taxes away from corporations and towards individuals. Colombia has one of the most unequal income distributions in the world and taxation (not to mention ill-targeted public expenditure) does little to change this. Since some taxes lend themselves better than others to improve income distribution, the case can be made that, without compromising efficiency, shifting the income tax burden from corporations to individuals could go a long way to improve income distribution—even if this does not have a significant effect on corporate investment.

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Appendix I. Derivation of the User Cost Equation

Following Cardenas and Olivera (1995), a firm's net cash flow is defined as

$$X_t = (1 - \tau)(p_t F(K_t, L_t) - w_t L_t) - (1 - k - \tau z)q_t I_t$$

The cash flow is equal to income earned (net of wages), income tax, and the cost of capital goods purchased by the company (including investment tax credits and depreciation). τ is the income tax rate²⁴, p_t the product price, w_t wages, q_t the cost of a unit of capital unit, k deductions for investment in fixed assets, and z depreciation deductions.

The company seeks to maximize profits, so the optimization problem is as follows:

$$\text{Max} \int_t^{\infty} X_t e^{-rt} dt$$

The restriction of the problem is given by the neoclassical capital accumulation equation:

$$\dot{K}_t = I_t - \delta K_t$$

The Hamiltonian is as follows:

$$H_t = e^{-rt} X_t + u_t \dot{K}_t$$

When both sides are multiplied by e^{rt} and taking into account that $\lambda_t = u_t e^{rt}$ (λ_t the shadow price of a unit of capital):

$$H_t^* = H_t e^{rt} = X_t + \lambda_t \dot{K}_t = (1 - \tau)(p_t F(K_t, L_t) - w_t L_t) - (1 - k - \tau z)q_t I_t + \lambda_t (I_t - \delta K_t)$$

The derivative of the Hamiltonian with respect to the control variables (in this case I and L) must be equal to zero:

²⁴ The wealth tax can be included here as $(1 - \tau - x)$, where x is the wealth tax transformed by assuming a return on assets of 10 percent.

$$\frac{\partial H_t^*}{\partial I_t} = \lambda_t - (1 - k - \tau z)q_t = 0$$

$$\lambda_t = (1 - k - \tau z)q_t$$

$$\frac{\partial H_t^*}{\partial L_t} = (1 - \tau)p_t F_L - w_t = 0$$

$$(1 - \tau)p_t F_L = w_t$$

$$F_L = \frac{w_t}{(1 - \tau)p_t}$$

The second order condition is

$$\frac{dH}{dK_t} = -\dot{u}_t$$

which is equivalent to

$$\frac{dH_t^*}{dK_T} = r\lambda_t - \dot{\lambda}_t$$

solving

$$(1 - \tau)p_t F_K - \delta\lambda_t = r\lambda_t - \dot{q}_t(1 - k - \tau z)$$

$$(1 - \tau)p_t F_K = r\lambda_t + \delta\lambda_t - \dot{q}_t(1 - k - \tau z)$$

From the first order condition it is known that $\lambda_t = (1 - k - \tau z)q_t$

$$(1 - \tau)p_t F_K = r(1 - k - \tau z)q_t + \delta(1 - k - \tau z)q_t - \dot{q}_t(1 - k - \tau z)$$

Multiplying and dividing the last term in the equation by q_t

$$(1 - \tau)p_t F_K = r(1 - k - \tau z)q_t + \delta(1 - k - \tau z)q_t - \dot{q}_t(1 - k - \tau z)\frac{q_t}{q_t}$$

Factoring the term $(1 - k - \tau z)q_t$ in the second term of the equation

$$(1 - \tau)p_t F_K = (r + \delta - \frac{\dot{q}_t}{q_t})(1 - k - \tau z)q_t$$

When we divide and merge we obtain:

$$F_K = \frac{(r + \delta - \frac{\dot{q}_t}{q_t})(1 - k - \tau z)q_t}{(1 - \tau)p_t}$$

The user cost of capital is given by the marginal product of capital

$$F_K = C = \frac{q_t}{p_t} (r + \delta - \frac{\dot{q}_t}{q_t}) \frac{(1 - k - \tau z)}{(1 - \tau)}$$

Replacing q_t for P^I , p_t for P , the user cost equation used in this paper is obtained:

$$C = \frac{P^I}{P} \left(i + \delta - \frac{\Delta P^I}{P^I} \right) \frac{1 - k - \tau z}{1 - \tau}$$

Appendix II. Data description

Variable		Definitions and Sources
P	Price index	P represents the prices at which firms sell goods and services. In this paper PPI is used from the BdR database.
P^I	Price index of capital goods	P^I represents the price index for capital goods. It is the capital goods component of the PPI, from the BdR database.
i	Interest rate	The interest rate is calculated as expectations for the 1-year rate on certificates of deposit. Expectations were estimated using ARIMA models.
δ	Depreciation rate	Calculated using the perpetual inventory method. The sectoral investment data required is from the DNP and DANE databases. To use the perpetual inventory method, the historical growth of the investment series is estimated and a different depreciation rate for each type of capital is assumed (i.e., 8 percent for machinery and equipment; 10 percent for transport equipment).
k	Investment tax credits	k represents deductions for investment in fixed assets. This information is available from the tax regulation of the last 20 years.
τ	Income tax	This information is available from the tax regulation of the last 20 years.
z	Depreciation deductions	Estimated using the formula suggested by Cohen (1968).

Appendix III. Some Relevant Labor-Market Features of Fedesarrollo's Computable General Equilibrium Model

Fedesarrollo's CGEM allows us to simulate the transition of the economy from an initial to a final equilibrium, following an exogenous shock (in this case a reduction in non-wage labor costs). For that purpose, we use the 2007 Social Accounting Matrix (SAM) describing economic transactions between 59 sectors of the Colombian economy.

Production

Each sector's output is based on a production function that uses two inputs (capital K and labor L) and a basket of intermediate goods. Inputs and intermediate goods are combined by means of nested constant elasticity of substitution (CES) functions. In the first level, the amount of productive factors that are used as inputs is determined, and capital and labor—with some degree of substitution—are combined with intermediate goods to generate aggregate value (VA) by means of a CES production function.

Production of the first level nest XP is the result of the interaction of VA and an aggregate demand for goods and services, ND. Equations (1) and (2) are the optimal demand conditions for the CES production function, where PVA and PND are the Armington prices of VA and ND for the $i=1\dots n$ subsectors in the economy. VC is the variable cost of production, as determined in Equation (3).

$$ND_i = \alpha_i^{nd} \left(\frac{VC_i}{PND_i} \right)^{\sigma_i^p} XP_i \quad (1)$$

$$VA_i = \alpha_i^{va} \left(\frac{VC_i}{PVA_i} \right)^{\sigma_i^p} XP_i \quad (2)$$

$$VC_i = \left(\alpha_i^{nd} PND_i^{1-\sigma_i^p} + \alpha_i^{va} PVA_i^{1-\sigma_i^p} \right)^{1/1-\sigma_i^p} \quad (3)$$

Total costs is the sum of a unit variable cost and a unit fixed cost, in turn composed of units of K and L. Firms are assumed to be symmetric (i.e., they have identical cost structures and the fixed costs are specified on a per firm basis). If N is the number of firms, the unit fixed cost FC is given by Equation (4), where KF and LF are the units of K and L needed to produce the

first unit of output. As the amount of output increases, the average fixed cost goes down. Total cost, TC, is defined by Equation (5).

$$FC_i = N_i(\sum_{kt} R_{i,kt} KF_{i,kt}^d + \sum_l W_{i,l} LF_{i,l}^d) / XP_i \quad (4)$$

$$TC_i = FC_i + VC_i \quad (5)$$

Firms may be able to establish a mark-up (π) over variable costs. The producer's price, PX, is given by Equation (6). In this case, it will be assumed that both fixed costs and the mark-up are zero; that is, perfect competition and constant returns to scale are assumed.

$$PX_i = \left(VC_i + \frac{VatdY_i}{XP_i} \right) (1 + \pi_i) \quad (6)$$

In the second level of production, aggregate demand for inputs is a sectoral demand for goods and services, indexed by an Armington good XA. Equation (7) is the demand for good k by sector j, where α is this sector's demand as a proportion of aggregate demand. In equation 8 PND is the weighted average of the price of goods and services, PA, where the weights are given by the α coefficients. The Armington price is the price of composite good XA.

$$XA_{k,j} = \alpha_{k,j} \left(\frac{PND_j}{PA_{k,j}} \right)^{\sigma_j} ND_j \quad (7)$$

$$PND_j = \left[\sum_k^n \alpha_{k,j} (PA_{k,j})^{1-\sigma_j^n} \right]^{1/1-\sigma_j^n} \quad (8)$$

In the third level of production, aggregate demand for K and L is decomposed into a demand for non-skilled labor and a demand for skilled labor and capital (KSK). In the fourth level of production, KSK is decomposed into a demand for capital and a demand for skilled labor. Each sector's demand for skilled and non-skilled labor is modeled with a CES function, with different sectoral elasticities of substitution.

As in Steiner, Forero, and Rojas (2012), aggregate demand has four components: government consumption, household consumption, intermediate consumption and investment. Households save a portion of their income in order to finance investment and they consume the remainder. Firms demand inputs produced by other sectors and the government demands goods

and services for current consumption. These components are grouped together in an Armington total consumption.

Labor Market²⁵

The labor market is divided into two segments: informal and formal, indexed in gz with each segment having different dynamics (Equation (9)). The elasticity of migration between segments is ω^m . If such elasticity is infinite, there will be perfect labor mobility. If it is finite, there will be labor market segmentation, a function of the costs of migration – costs that are, in turn, determined by relative wages.

$$gz \in \{\text{Inf, For}\} \quad (9)$$

Labor Supply

In the informal sector labor supply in period t is equal to labor supply in $t-1$, adjusted by population growth g^l minus migration (MIGR) to the formal sector (Equation (10)), likewise, in the case of formal labor supply (Equation (11)). Total labor supply is defined in Equation (12).

$$L_{l,Rur}^s = (1 + g_{l,Inf}^l) L_{l,Inf,-1}^s - MIGR_l \quad (10)$$

$$L_{l,Urb}^s = (1 + g_{l,For}^l) L_{l,For,-1}^s + MIGR_l \quad (11)$$

$$L_{l,Tot}^s = L_{l,For}^s + L_{l,Inf}^s \quad (12)$$

In order to explain the behavior of MIGR, we define the average expected wage (AWAGE), which is determined by the different net wages received by employees (NW).²⁶ The average expected wage is adjusted for the probability of being employed (and equal to 1 minus the rate of unemployment, UE) (Equation (13)). Migration is a function of the expected wage in the formal sector relative to the expected wage in the informal sector (Equation (14)). In case the elasticity of migration (ω^m) is infinite, this equation is disregarded since the labor market would be completely unified.

²⁵ For more details, please consult World Bank (2005), “*Prototype Model for a Single Country: Real Computable General Equilibrium Model*”.

²⁶ NW is defined for skilled and unskilled workers, youngsters and adults, and formal and informal workers.

$$AWAGE_{i,gz} = (1 - UE_{i,gz}) \frac{\sum_{i \in gz} NW_{i,l} L_{i,l}^d}{\sum_{i \in gz} L_{i,l}^d} \quad (13)$$

$$MIGR_i = X_i^{migr} \left(\frac{AWAGE_{i,urb}}{AWAGE_{i,rur}} \right) \omega^m \quad (14)$$

Wage rigidities are introduced so as to introduce a wedge between labor supply and labor demand. Let W_{Min} be the minimum wage²⁷ and UE the rate of unemployment. Equation (15) is the orthogonality condition supporting two possible regimes:

$$(UE - UE_{min})(W - W_{Min}) = 0 \quad (15)$$

In the informal sector the equilibrium wage is above the minimum. As a result, there will be full employment. In the formal sector the equilibrium wage is below the minimum. As a result, the actual wage will equal the minimum and there will be unemployment in equilibrium (Equation 16).

$$W \geq W_{Min} \quad UE \geq UE_{Min} \quad (16)$$

Although there is perfect labor mobility across sectors, there can be sectoral wage differentials, which we assume to be fixed. Equation (17) determines the sectoral skill-specific wages as a function of the base inter-sectoral wage differentials and changes in the segment-specific wage. Gross wages (W in equation 18) is equal to net wages received by employees, NW , plus non-wage labor costs ($\tau_{i,l}^{xfl} NW$).

$$NW_{i,l} = \phi_{i,l}^l W_{i,gz}^e \quad (17)$$

$$W_{i,l} = (1 + \tau_{i,l}^{xfl}) NW_{i,l} \quad (18)$$

²⁷ For analytical purposes, the minimum wage in the informal sector is 0.

Labor Demand

Total labor demand by sector and level of skill²⁸ is composed of a fixed (LF) and a variable demand (LV), in turn a function of the terms included in Equations (19) to (21). The elasticities of substitution for skilled and un-skilled labor are σ^s and σ^u , respectively, whereas labor productivity per sector and level of skill is represented by λ^l . Wages for skilled and unskilled workers are, respectively, PSKL and PUL.

$$L_{i,l}^d = LF_{i,l}^d + LV_{i,l}^d \quad (19)$$

$$LV_{i,ul}^d = \alpha_{i,ul}^l (\lambda_{i,ul}^l)^{\sigma_i^u - 1} \left(\frac{PUL_i}{W_{i,ul}} \right)^{\sigma_i^u} UL_i \quad ul \in \{Unskilled\ labor\} \quad (20)$$

$$LV_{i,skl}^d = \alpha_{i,skl}^l (\lambda_{i,skl}^l)^{\sigma_i^s - 1} \left(\frac{PSKL_i}{W_{i,skl}} \right)^{\sigma_i^s} SKL_i \quad skl \in \{skilled\ labor\} \quad (21)$$

A Reduction in Non-wage Labor Costs

A reduction in non-wage labor costs $\tau_{i,l}^{xfl}$ reduces formal sector wages paid by employers (Equation (18)). This brings about a reduction in labor costs (W), thereby increasing formal labor demand (Equations (20) and (21)), so that take-home-pay in the formal sector goes up (Equation (17)). This mechanism is only at play in the formal sector, given that there are no non-wage labor costs in the informal sector. A higher net wage for formal sector workers brings about an increase in formal AWAGE (Equation (13)). This affects relative wages, fostering migration from the informal to the formal sector (Equation (14)). As a result, total employment goes up, unemployment goes down, and a higher proportion of workers in the formal sector increases GDP.

²⁸ The demand for skilled labor is SKL; the demand for unskilled labor is UL.