

# Payroll Taxes, Social Security and Informal Employees.

## The 2012 Tax Reform in Colombia

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### Abstract

Using simulations and empirical estimations, I evaluate how the drastic reduction in payroll taxes in 2012 reduced informality in Colombia. Simulations indicate that the reform should have reduced the informality rate of 2012 by 10%. Empirical difference-in-difference estimates point to small short-term effects and large long-term effects. Simple specifications indicate an overall effect of 2% by April 2013, 4% by December 2013 and 10% for 2014 to 2016. Within year estimates are larger and increasing in time with a maximum of 17% for December 2016. These results are consistent with previous studies while expanding the timeframe of analysis.

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# 1 Introduction

Informality is the collection of firms, workers, and activities that operate outside the legal and regulatory framework (De Soto, 1989). Informal workers are unable to obtain formal employment, which tends to offer higher wages and social security. But informality can be attractive if social security is undervalued and the government provides different subsidies to workers and their families who are below the poverty line. Firms can also be informal to avoid burdensome regulations and excessive taxes by choosing a smaller scale of production with restricted access to credit (Perry et al., 2007). From both perspectives, informality has been a persistent problem in Latin-America. Around the year 2000, an average of 48% of wage workers held informal jobs and 56% of all workers were employed in informal firms. By 2015 the corresponding figures were 40% and 51%, just a 8 and 5 percent point (pps) decrease in 15 years, respectively.<sup>1</sup>

One of the main causes for informality is high taxes (Hirschman, 1970; De Soto, 1989; Lora and Fajardo-González, 2016); in Colombia, it is high payroll taxes specifically that lead to informality (Clavijo et al., 2015; Merchán Álvarez, 2015; Fedesarrollo, 2014; Kugler and Kugler, 2009; Sánchez et al., 2009; Santa María et al., 2009). In this context, would a reduction in payroll taxes leads to lower informal employment? The Colombian tax reform of 2012 (from now on just *reform*) substantially reduced payroll taxes and provides an opportunity to answer this. I evaluate the impact of this reform on informal employees both theoretically and empirically.

I develop a labor market model that incorporates the main elements of the reform and predict the effects it had on informality. The model provides an appropriate framework in which to incorporate informality - defined as lack of social security - and evaluate how it is affected by taxes. The reform introduced structural changes in the economy that make comparative statics impossible, so simulations are required. This exercise indicates that the informality rate among private workers in 2012 should have been reduced by 7.2 pps or

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<sup>1</sup>Own calculations based on Socio-Economic Database for Latin America and the Caribbean (CEDLAS and The World Bank). Updated July 2017. In informal firm if (s)he is a worker in a small firm, a non-professional self-employed, or a zero-income worker. In informal job if (s)he is a salaried workers without the right to a pension when retired.

10.1% of the baseline informality rate, among private employees in December 2012.

Empirically, I obtain significant difference-in-difference point estimates indicating small short-term effects and large long-term effects. Before-after DID point estimates are  $-1.1$  pps for January to April 2013,  $-2.1$  pps for May-Dec 2013 and  $-5.4$  pps for January 2014 and after. Quarterly DID point estimates are  $-3$  pps for 2013Q3, about  $-4$  pps for 2014, from  $-4.9$  in Q1 to  $-6.4$  pps in Q4 for 2015, and close to  $-7$  pps for 2016. Monthly DID point estimates go from  $-5.6$  in August 2013 to  $-9.4$  pps in December 2016. When estimating the change in informality trend total policy estimates are lower: from zero in May 2013 to  $-4.6$  pps for December 2016.

Estimates also indicate most reductions in informality were felt persistently in the service sector while workers earning above the Minimum Wage (MW) had no significant change. Services enjoyed a reduction in informality since the second half of 2013, with the effect growing steadily until 2016. Agriculture and industry also had reductions but just for selected quarters of 2013 to 2016. For all workers earning above the MW, I find no significant estimates in both simple and quarterly DID.

This document is structured in seven parts, including this introduction. The following section includes a literature review divided in two parts, one on informality in labor market models and another on empirical studies on taxes and informality. The third section describes the social security system in Colombia. The fourth describes the reform. Sections five and six form the core of the study presenting the proposed labor market model and the econometric estimate results respectively. The last section concludes.

## 2 Literature review

Two concepts are related with informality: social protection and productivity. Social protection refers to workers whose jobs do not comply with part or all legal requirements, tax obligations, labor contract and/or are deprived of certain labor rights like pensions or health insurance. Productivity instead focuses on workers in low-productivity, small-scale firms or family based activities (Tornarolli et al., 2014). Economic models and empirical studies have

been designed with both of these definitions in mind.

## 2.1 Modeling informality

Informal labor markets have traditionally been modeled as dualistic models since Lewis (1954). In these models workers and firm pay taxes, contribute to social security and/or comply with the MW only in the formal market. They are characterized by higher wages in the formal market and just some workers getting access to it. The classic model by Harris and Todaro (1970) includes urban and rural sectors, where urban specializes in manufactures and rural in agriculture, wages in urban are fixed at the MW while wages in rural are free. Rauch (1991) explicitly models the formal-informal size dualism, where exogenous MWs are only enforced in large firms, and obtains formal and informal sectors endogenously. Workers are all equal and firms have different levels of managerial talent, which determines firm size as in Lucas (1978), greater talent generating larger firm size.

More recent dualistic models have introduced taxes and other improvements. Fortin et al. (1997) incorporate both corporate profit and payroll taxes in a model with heterogeneous firms resulting in an endogenous informal sector. Assuming that the marginal cost of tax and regulation evasion increases with firm size, their model is able to explain discontinuities in firms' size. They obtain three forms of dualism consistent with market segmentation: scale, wage and evasion. Galiani and Weinschelbaum (2012) also introduce payroll taxes in a model with heterogeneous firms and, as innovation, workers with preferences over formal/informal sector. They incorporate three stylized facts: (1) small firms tend to operate informally while large firms tend to operate formally; (2) unskilled workers tend to be informal while skilled ones have formal jobs; (3) workers other than the household head are less likely to operate formally than primary workers. Antón (2014) develop a dynamic, general equilibrium model with occupational choice and informality including value added, payroll and corporate income taxes.

In an innovative approach Amaral and Quintin (2006) introduce informality in a competitive market. They keep heterogeneous workers and entrepreneurs. Firms face a choice between taxes and credit: formal (informal) firms (do not) pay taxes but (do not) have

access to credit. In equilibrium, there is a demand for formal and informal workers but labor supply is the same, this is, there is only one labor market. Contrary to other models, similar workers earn the same amount in formal and informal sectors.

Models predictions on how taxes affect informality are generally uncertain so simulations are used. With informality defined as a low productivity sector and taxes not translated in higher benefits for workers or firms, Fortin et al. (1997) and Galiani and Weinschelbaum (2012) models imply that lower payroll taxes lead to lower informality. But, if informality is defined as lack of social protection, informal workers receive public subsidies and payroll taxes fund formal social benefits results are ambiguous (Antón, 2014). Lower payroll taxes make formal employees cheaper to employers which should decrease informality. But if only informal employees qualify for subsidies incentives to take formal jobs are weakened. Also, if the lower payroll taxes undermines the funding formal social benefits or if these benefits are undervalued, formal jobs are even less attractive. For this reason simulations are used to predict the effect tax changes on informality. Steiner (2014) and Antón (2014) use this approach to study the Colombian reform. Steiner (2014) finds that the reform should increase formal employment by 1.4% and Antón (2014) suggests that the reform would decrease informal rate by 1.4 to 1.5 pps.

## **2.2 Empirical background**

Lora and Fajardo-González (2016) study the effects of taxes on labor markets in Latin America. Carried out for 15 Latin American countries, they find that payroll taxes reduce employment when their benefits are not valued by workers; otherwise they increase labor participation. Vuletin (2008) uses data of 32 Latin American and Caribbean countries in the early 2000s, finding that high taxes as one key factor determining the size of the informal economy. Loayza (1996) uses data from Latin American countries in the early 1990s and finds that the size of the informal sector depends positively on proxies for tax burden and labor-market restrictions.

Many studies provide support to the positive relation between payroll taxes and informality in Colombia. Merchán Álvarez (2015) uses the increase in payroll taxes between

1992 and 2006 and finds a significant positive effect of payroll taxes on informality. Clavijo et al. (2015) estimate the payroll taxes that firms in Colombia faced from 1980 to 2015 and conclude that increments of 1% on payroll taxes reduced formalization by 0.4%. Mondragón-Vélez et al. (2010) shows that a 10 percent increase in payroll taxes increase informality by 8 percent. Santa María et al. (2009) analyze the effect of the 1993 social security reform, that increased payroll taxes by 14 pps, finding a significant effect on the increase of informal employment. Sánchez et al. (2009) find that the increase in payroll taxes since 1990s augmented informality by 5.3 pps.

Recent empirical studies explore the effect of the reform on informality. Kugler et al. (2017) estimates a positive effect on formality of 1 to 11.1 pps depending on the data source used and treated group considered. Bernal et al. (2017) find a significant short-term increase on firms' formal employment of about 4.3%. Fernández and Villar (2016) estimate a short-term reduction in informality of 4.1 to 6.7 pps on the treated workers depending on the specification and methodology used.

### **3 Labor market regulations**

Main Colombian labor market regulations are composed by the MW and social security. All workers earning at least a MW have to make contributions to social security while those earning under a MW are exempt from this obligation and are provided with subsidized social benefits.

#### **3.1 Minimum Wage**

The MW is the same for all workers in Colombia since 1983 and it is updated every year. A permanent commission is responsible for proposing the MW of the following year no later than December 15. If there is no consensus on the commission the president decrees the new MW. The MW has also been used as a numerary or index base for many economic variables (taxes, fines, fees for services and pensions). More critically, payroll taxes regulations indicate the amount of payroll taxes to be paid by employers according to the number of

MWs an employee earns.

The Ministry of Social Protection is in charge of the enforcement of the MW. However, there are no statistics available on the number of complaints and sanctions (or the amount of these) corresponding to non-compliance with the MW regulation (Arango et al., 2007).

The proper use of MW in empirical estimations required some additional calculations. The main frequency of the legal MW is monthly and assumes a maximum of 48 weekly hours worked. Any worker that works less than 48 weekly hours can legally earn less than the monthly MW. To incorporate this I obtain an hourly MW by dividing the monthly MW<sup>2</sup> by 4 (weeks) and then by 48 (hours). I calculate the hourly gross wage as monthly gross wage / 4 / regular weekly hours worked in main occupation. Finally I define the of number of hourly MWs by dividing the hourly gross wage in the hourly MW.

## **3.2 Social security**

The social security system is composed by four parts: pensions, health, labor risks and social services. All workers earning at least one hourly MW must contribute to social security. Employers must make health contributions for his employees. If the employer does not make the proper contributions he faces high default interests and payment for immediate health care costs required by his employees.

Self-employed workers must make their own contributions, based on their actual income, to health, pensions and occupational hazards, the latter when it applies. The same default interests to employers apply to self-employed workers that are not up-to-date with their obligations.

### **3.2.1 Pension system<sup>3</sup>**

For workers earning at least one hourly MWs, the pension system is based mainly on a mandatory contributory pillar under two schemes: one public pay-as-you-go and a private one with capitalization. In any scheme, funds must guarantee a minimum pension equal

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<sup>2</sup>Monthly MWs obtained from the Central Bank of Colombia.

<sup>3</sup>Based on Bosch et al. (2015)

to the current monthly MW. Multiple parallel alternative schemes have been designed for workers earning less than an hourly MW and/or in poverty.

The pension system has problems that undermine its value to workers. By 2013, only 37% of the elderly received a pension, low compared to the OECD average (around 90%) and 80-90% in Argentina, Brazil, Chile and Uruguay. Coverage is also low among women, workers with low and medium incomes, working in small businesses or self-employed (Bosch et al., 2015). In rural areas only 10% are covered, product of avoided contributions or insufficient earnings to contribute. People contribute in average only 15 years (instead of the 25 required), as rural workers often spend their entire life not making contributions and urban workers face periods without contributions.

The requirement that pensions cannot be lower than a monthly MW is costly. Minimum pension represents around 60% of the average wage while it represents less than 20% on average in OECD countries. Many people reach retirement age without having contributed enough to qualify for benefits at all, as only around half of the working population earns more than the monthly MW (2012 figures).

The public pay-as-you-go scheme mainly benefits high-income formal workers. More than 80% of pensions go to the highest income quintile while the two poorest quintiles receive less than 2% (Santa María et al., 2010), they are often the best educated and high-income individuals (OECD, 2013), contributions are deductible from the income tax base, the returns on pension investment are not taxable, and the benefits are largely tax exempt.

### **3.2.2 Health care**

There are two forms of affiliation to the health care system: contributory and subsidized. All workers earning at least a monthly MW must be in the contributory scheme and contribute to the health system paying to their health promotion entity their corresponding amount.<sup>4</sup> All employees, self-employed workers and retirees must be affiliated to the contributory scheme. The responsibility of the employee's affiliation is of the employer. The contribution is 12.5% of the salary, a percentage fully assumed by independent workers; employees assume

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<sup>4</sup>Health promotion entities organize and ensure the provision of health services.

4% and the employer 8.5% (zero for employees earning less than 10 monthly MWs after the reform).

With the subsidized scheme the government subsidizes the population without employment, work contract or income. Members of this scheme receive full or partial subsidies, which are financed with funds from the contributory scheme and additional public funds. Municipalities or districts manage membership using targeting mechanisms.<sup>5</sup> Users of this scheme have the right to receive the same benefits as in the contributory scheme.

The health care system also has problems that makes workers undervalue it. Despite the high coverage, 94.6% by 2015, the system suffers from quality issues with 18.3% of affiliates considering their health coverage to be bad or really bad by 2015.<sup>6</sup> Also, certain health care services tend to be denied by insurers or providers, long wait times to obtain medical appointments and/or medical care (exams and treatment) or unexpected direct costs for affiliates when in need of health care. This has derived in large legal conflicts between insurers and their affiliates, insurers and providers to be under corruption charges (Vélez, 2016) and insurers going bankrupt.<sup>7</sup>

## 4 Payroll taxes and the 2012 tax reform

Payroll taxes have increased systematically in recent decades in Colombia. Since the 1980s payroll taxes were about 42-46% for 1-2 monthly MWs and 38% for those with more than 2 monthly MWs. At the end of the 1980s payroll taxes increased even more due to higher pension contributions<sup>8</sup> and parafiscals.<sup>9</sup> In 1994 payroll taxes increased 8-9 pps product of larger contributions to health and pensions and the creation of the general system of professional risks. In 2003 and 2007 new increases were imposed on employer's contributions

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<sup>5</sup>They use Identification the Classification System of Potential Beneficiaries (*Sistema de Identificación de Potenciales Beneficiarios de Programas Sociales*, SISBEN), census listings of indigenous communities, identification of abandoned child and indigent population.

<sup>6</sup>Source DANE, *Encuesta de Calidad de Vida* 2015.

<sup>7</sup><http://www.elpais.com.co/elpais/economia/noticias/asi-fue-como-quebraron-saludcoop>

<sup>8</sup>Formal workers get a mandatory discount, determined by law, from their gross wage towards their pension fund. These are administered by a single public entity, Colpensiones, or private administrators, *Administradoras de Fondos de Pensiones* (Pension Fund Managers, AFPs). Workers choose to which of these entities to send their discounted amount.

<sup>9</sup>Parafiscals are all contributions (not taxes) to fund a public social service.

to health and pensions. In May of 2013 payroll taxes reached peak levels of 59-66% for 1-2 monthly MWs and 52% for wages above 2 monthly MWs. The 2012 tax reform drastically reduced these payroll taxes for the first time (Clavijo et al., 2015).

The 1607/2012 Act, passed on December 2012, was aimed to promote formal employment. It lowered hiring costs for firms reducing employer's contributions by 13.5 pps for workers earning less than 10 monthly MWs: 5 pps destined to public institutes<sup>10</sup> and 8.5 pps to the health care system. Public institutes' contributions took effect on May 1st 2013 and health in January 1st 2014. With this, the total tax on labor in Colombia was reduced from 59% to 45.5%, a 23% reduction (Fedesarrollo, 2014).

To make up for the lost fiscal revenue, tax on firms' profits was modified. The statutory rate was reduced from 33% to 25% and a new surtax introduced.<sup>11</sup> Revenues of this profit surtax were directed to the concerned public institutes and health care system. These funds were not part of the public general budget and government provided additional funding if revenues fell short of budget needs. The statutory rate of the profit surtax was established at 9% for the period 2013-2015 (OECD, 2015), which was later increased for years 2015-2018 for large firms. The tax reform of 2016 finally eliminated the profit surtax starting in 2017.

#### 4.1 Other regulatory changes

In the period of analysis, 2008-2016, other regulatory changes might have had an impact on informality along the reform: law 1429 of 2010 (First Job Act), decree 2616 of 2013 and an increased enforcement included in the reform.

The First Job Act, introduced in 2010, reduced taxes for certain firms. Beneficiary firms had to have less than 50 workers, or assets of less than 5,000 MWs, and started to work between December 2010 and December 2014. Under this law firms enjoyed no income tax or payroll taxes for the first two years of operation. Benefits were conditional on new hires of certain types of workers: (i) less than 28 years old, (ii) heads of household in poverty,

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<sup>10</sup>The *Servicio Nacional de Aprendizaje* (National Service of Learning, SENA), a public institution focused in the development of professional education programs, and the *Instituto Colombiano de Bienestar Familiar* (Colombian Institute of Family Welfare, ICBF), a public institution in charge of the development and protection of children and families.

<sup>11</sup>The *Impuesto sobre la renta para la equidad* (Corporate Income Contributions to Equity, CREE)

(ii) victims of the armed conflict, (iii) disabled, (iv) women older than 40 years old and (v) workers earning less than 1.5 monthly MWs. Given the limited scope of beneficiary firms it is likely that this policy had a small effect on the overall informality of the economy but any significant estimate before the reform could be the product of this regulation.

The decree 2616 of 2013 created, since January 2014, a weekly contribution to social security. This applied to workers working for less than a month and earning less than a monthly MW. Previously the system only allowed monthly contributions. For example, for an employee working for a single week earning less than a monthly MW, the employer had to pay the contributions corresponding to a monthly MW. Weekly contributions apply to all workers with labor contracts working less than 30 days, independently of hours worked.<sup>12</sup> If the worker works between 1 and 7 days in a month, the minimum to contribute is one week (1/4 of a monthly MW). For 8-14 days 2 weeks (1/2 monthly MW), for 15-21 days 3 weeks (3/4 monthly MW) and for more than 21 days an entire monthly MW. This additional flexibility might have allowed this type of workers to become formal, but data limitations do not allow to identify how many weeks an employee has worked in a month.

Finally, the reform also improved the enforcement capabilities of the public entity that supervises workers' contributions to social security. This increased enforcement might explain part of the reduction in informality. Unfortunately, there is no way to disentangle this from the effect of the lower payroll taxes.

## 5 Labor market model

The reform introduced not only a reduction in payroll taxes but also a change in the funding of social benefits using a new tax on profits. To investigate the final effect of these changes on informality I propose a labor market model that internalizes them. The following is a modified version of the model proposed by Antón (2014). It's main characteristics are: a) static, b) single good sold in a perfectly competitive market, c) employees and employers are characterized by different managerial ability (Lucas, 1978), d) taxes on payroll and prof-

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<sup>12</sup>These workers still qualify for the health subsidized scheme.

its, e) imperfect enforcement of payroll tax, f) employees formal/informal status defined by employers' compliance with payroll tax, g) informal employees and employers receive Non-Contributory Social Benefits (NCSB), h) formal employees receive Contributory Social Benefits (CSB) and i) Social Benefits are not fully valued (Levy, 2008). Government behavior is not modeled, it is only assumed that collects taxes and makes social benefits transfers keeping a balanced budget.

The model has one time period with a single representative household composed by a continuum of individuals of mass one. Each individual is endowed with a managerial ability  $z$  that has a probability density function  $g(z)$  with support  $[\underline{z}, \bar{z}]$ ;  $G(\cdot)$  denotes the cumulative distribution function. Individuals can choose to be employees or employers according to their managerial ability.

## 5.1 Employers

Employers produce a single product  $y$  using labor  $l$  and managerial ability  $z$ . The product is sold in a perfectly competitive market at price  $p$ , which is used as numeraire. Technology is characterized by a Cobb-Douglas production function  $y = z^{1-\gamma} (l_I + l_F)^\gamma$ . Employers are required to pay  $\tau_l$  for each unit of labor hired but imperfect enforcement of payroll tax allows hiring formal employees, paying  $\tau_l$  and a wage  $w_F$ , or informal employees, paying only wage  $w_I$ . Employers face a probability of audit  $\theta_l$  and, if audited, they pay a fine  $\sigma_l \tau_l w_I l_I$  were  $\sigma_l > 0$  measures the severeness of the fine and  $l_I$  is the level of informal employment used by the firm. Government also raises a fraction  $\tau_\pi$  of firms' profits.<sup>13</sup> Employer's problem is

$$\pi(w_I, w_F, z, \tau_l, \tau_\pi) = \max_{l_I, l_F} (1 - \tau_\pi) \{ z^{1-\gamma} (l_I + l_F)^\gamma - (1 + \tau_l) w_F l_F - (1 + \theta_l \sigma_l \tau_l) w_I l_I \} \quad (1)$$

There will be labor tax evasion as long as  $(1 + \theta_l \sigma_l \tau_l) w_I \leq (1 + \tau_l) w_F$ . To obtain a non-degenerated distribution of informal labor across firms in equilibrium, it is assumed that  $\theta_l$  is

<sup>13</sup>I assume perfect enforcement of this tax.

not constant but an increasing function of  $l_I$  and  $z$ , this is,  $\theta_l(l_I, z)$  with  $\frac{\partial \theta_l}{\partial l_I} > 0$  and  $\frac{\partial \theta_l}{\partial z} > 0$ . From  $\pi(w_I, w_F, z, \tau_l, \tau_\pi)$  we obtain factor demands  $l_I(w_I, w_F, z, \tau_l)$  and  $l_F(w_I, w_F, z, \tau_l)$ . Notice how  $\tau_\pi$  play no direct role in firms' labor demands. For any level of  $\tau_\pi$  the level of labor employment chosen by firms does not change. Also, observe how formal and informal workers imply the same productivity for the firm and firms will hire informal workers as long as they are cheaper than formal ones.

## 5.2 Households

The representative household has a concave utility function  $u(C)$  where  $C$  is the total consumption of goods. Household income come from labor, if employee, and profits from firms, if employer. The non-decreasing nature of the distribution  $g(z)$  guarantees that there is a unique level of managerial ability  $z_1$  such that for  $z < z_1$  the individual chooses to be an employee and for  $z > z_1$  the individual chooses to be an employer. This means that a mass  $[\underline{z}, z_1)$  will be employees and a mass  $[z_1, \bar{z}]$  will be employers. The household also must choose the fraction  $\eta$  of formal employees. Informal employees and employers receive a NCSB transfer  $T_I$  and formal employees receive a CSB transfer  $T_F$ . The household problem is given by

$$\max_C u(C) = \max_{\eta, z_1} \left( \int_{\underline{z}}^{z_1} WN g(z) dz + \int_{z_1}^{\bar{z}} [\pi(\cdot, z) + T_I] g(z) dz \right)$$

where  $WN = \eta(w_F + T_F) + (1 - \eta)(w_I + T_I)$ . Household's first order condition for  $\eta$  is given by

$$w_F + T_F = w_I + T_I \tag{2}$$

Eq. (2) can be interpreted as indifference between formal and informal employment. At  $z_1$  individual has to be indifferent between being employee or employer then

$$\eta(w_F + T_F) + (1 - \eta)(w_I + T_I) = \pi(\cdot, z_1) + T_I$$

And combined with (2) we have the final condition for  $z_1$

$$w_I = \pi(\cdot, z_1) \quad (3)$$

On the other hand, every formal employee receives  $w_F$  and CSB transfers  $T_F$ . Following Levy (2008), formal workers value these benefits by a fraction  $\beta_F \in [0, 1]$  then  $T_F = \beta_F \tau_l w_F$  before the reform. After the reform  $\tau_\pi = \tau_\pi^0 + \tau_\pi^{TR}$  where  $\tau_\pi^{TR}$  is the part of the tax on profit used to fund CSB, then  $T_F = \beta_F \left( \tau_l w_F + \tau_\pi^{TR} \int_{z_1}^{\bar{z}} \pi(\cdot, z) g(z) dz / L_F \right)$  where  $L_F = \int_{z_1}^{\bar{z}} l_F(w_F, z, \tau_l, \tau_\pi) g(z) dz$  is the total demand for formal labor. Likewise, informal employees receive  $w_F$  and NCSB transfers by  $\tau_{NCSB}$  but value these benefits by  $\beta_I \in [0, 1]$ .<sup>14</sup> These assumptions mean that the first order condition for  $\eta$  before the reform can be written as

$$w_F + \beta_F \tau_l w_F = w_I + \beta_I \tau_{NCSB} \quad (4)$$

and after the reform as

$$w_F + \beta_F \left( \tau_l w_F + \tau_\pi^{TR} \frac{\int_{z_1}^{\bar{z}} \pi(\cdot, z) g(z) dz}{L_F} \right) = w_I + \beta_I \tau_{NCSB} \quad (5)$$

Eq. (4) mean that for any given  $\beta_F, \beta_I, \tau_l$  and  $\tau_{NCSB}$  then  $w_I$  is determined by  $w_F$  before the reform and also  $\tau_\pi$  after (Eq. (5)).

Eqs. (4) and (5) represent the fact that the reform changed the funding of CSB transfers using the new tax on profits. This means that even if  $\tau_\pi$  does not affect firms' labor demand directly, the new amount of CSB transfers could be different from before the reform and household choose a different level of  $\eta$ . This is an important departure from Ant3n (2014) who only considers the change in taxes and not the change in funding of CSB.

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<sup>14</sup>I assume these benefits do not change after the reform.

### 5.3 Equilibrium

All individuals such that  $z \in [\underline{z}, z_1)$  are employees then supply of labor in the economy is  $N = G(z_1)$ . On the other hand, individuals with  $z \in [z_1, \bar{z}]$  are employers and their individual labor demands are  $l(w_F, z, \tau_l) = l_I(w_F, z, \tau_l) + l_F(w_F, z, \tau_l)$ . The equilibrium in the labor market is given by

$$G(z_1) = \int_{z_1}^{\bar{z}} l(w_F, z, \tau_l) g(z) dz \quad (6)$$

Finally, the resource constraint yields the equilibrium in the goods market

$$C = Y(\tau_l, \tau_\pi, w_F) = \int_{z_1}^{\bar{z}} y(\cdot, z) g(z) dz \quad (7)$$

In equilibrium we obtain  $(w_F^*)$  given  $(\tau_l, \tau_\pi, T_F, T_I)$ .

### 5.4 Simulation

As the reform introduced a structural change in the model, represented by Eqs. (4) and (5), straightforward comparative statics are not possible. Lower payroll taxes increases labor demand and pushes  $z_1$  up (Eq. (6)) but increased firms' profits attracts more employees to become employers, this is, a decrease in  $z_1$ . So the final direction of  $z_1$  is uncertain. On the other hand, the increased labor demand and lower labor supply will lead to an increase in  $w_F$ , alongside  $w_I$  as indicated by Eq. (4). Finally, comparing Eqs. (4) and (5), CSB transfers can go up or down after the reform leading to an uncertain new level of  $\eta$  chosen by households. These effects in conjunction lead to an uncertain final effect on the informality rate in the economy.

To measure the effect of the reform on informality, I carry out a simulation exercise. For this, following Antón (2014), I assume a truncated Pareto distribution of the form

$$G(z) = \frac{1 - (\underline{z}/z)^S}{1 - (\underline{z}/\bar{z})^S}$$

where  $S \in (0, 1)$  is a shape parameter and  $\underline{z}$  and  $\bar{z}$  are the minimum and maximum values

Table 1: Parameters values in simulation

Parameter	Value	Source	Reform		
			Parameter	Without	With
$\gamma$	2/3	González et al. (2012)	$\tau_l$	0.603	0.468
$\beta_F$	0.48	Olivera and Cuesta (2010)	$\tau_\pi$	0.33	0.25
$\beta_I$	0.53		$\tau_\pi^{TR}$	-	0.09
$\sigma_l$	1.50	Antón (2014)			
$\underline{z}$	1				
$\bar{z}$	3.8				
$S$	0.45	Calibration			
$\tau_{NCSB}$	0.95				
$\lambda_l$	0.42				

for  $z$  respectively. I also assume that  $\theta_l(l_I, z) = \lambda_l l_I z$  where  $\lambda_l$  is a positive parameter. For calibration, some parameters' values are chosen using previous values extracted from the literature; others are set to match Colombian data by the time the reform was passed. Table 1 presents the parameters values used, their respective sources and those used in simulations without and with the reform. Calibrated parameters are set to match the informal rate of the treated group (56.2% by December 2012, model 56.2%) and the formal/informal wage rate (1.94 by December 2012, model 1.94).

Simulation indicates that the reform should reduce informality rate by  $-5.7$  pps or 10.1% (5.7/56.2) of the December 2012 informality rate. Table 2 presents a sensibility analysis. I test how informality changes if CSB valuation,  $\beta_F$ , NCSB valuation,  $\beta_I$ , and severeness of the fine,  $\sigma_l$ , are arbitrary lower or higher and in all cases the reform results in lower informality. In addition, results indicate that the lower the valuation con Social Benefits, both contributory and non-contributory, or lower severeness of the fine the higher is the effect of reform. This could be indicating that if the market conditions favor informality then the effect of a change in payroll taxes is amplified.

## 6 Econometric estimates

I use the household survey microdata from the *Gran Encuesta Integrada de Hogares* (Major Integrated Household Survey, GEIH). This survey has been in place since 2006, including a

Table 2: Sensitivity analysis, change inf. / inf. Dec 2012

Benchmark	
-10.1%	
CSB valuation	
$\beta_F = 0.35$	$\beta_F = 0.60$
-11.2%	-8.5%
NCSB valuation	
$\beta_I = 0.35$	$\beta_I = 0.60$
-13.9%	-9.1%
Severeness of the fine	
$\sigma_l = 1$	$\sigma_l = 2$
-12.4%	-7.25%

section on informality since 2007. The survey is currently specialized on the measurement of the labor market structure and households' income. It has an annual size of approximately 240,000 households (800,000 observations), the major one at national level. It covers 24 capital cities and their metropolitan areas (DANE, 2013). For my analysis I use all microdata from 2008 to 2016.<sup>15</sup>

As the reform reduced payroll taxes attached to social services I use a social security definition of informality. I classify as informal (i) employee not making health or pension contributions, in subsidized health scheme or earning under 1 hourly MW,<sup>16</sup> or (ii) self-employed not contributing to a pension fund, without health coverage or in subsidized health scheme. Formal if: (i) employee making pension contributions, in contributory health scheme and earning above 1 hourly MW or (ii) self-employed making pension contributions and in contributory health scheme.

I separate workers into treated and control groups. The reform excluded specific groups from the reduction in payroll taxes: (i) all workers earning 10 monthly MW or more, (ii) all non-profit firms, (iii) any natural person employer of one employee and (iv) government

<sup>15</sup>Survey questionnaires for 2006 and 2007 suffered many changes that render the data for these years not comparable with 2008 to 2015.

<sup>16</sup>Two adjustments were needed when using MWs. First, when using the MW of each year from January to December a high peak of informality was present in January. This is the product of slow adjustment of labor contracts to the new monthly MW. To avoid this the monthly MW of each year is used from February to January of next year. For example, the monthly MW of 2013 is valid from February 2013 until January 2014, the monthly MW of 2014 is valid from February 2014 until January 2015 and so on.

Second, measurement error was detected on hourly wages close to the minimum in year 2016 resulting in a sudden peak in informality rates. To adjust for this a 99% of the MW was used as cutoff. This has almost no effect in informality rates for other years.

workers. Employers could not deduct the payroll taxes derived from employees earning more than 10 monthly MWs for the new profit surtax, implying a different tax burden for employers. For this reason, employees earning more than 10 monthly MWs are discarded from the analysis. Employers and government workers are also excluded. Employers act more as firms and government workers belong to a non-optimizing employer.

The remaining workers that are part of the analysis are private employees, domestic, laborer or farmhand<sup>17</sup> and self-employed. I classify private, domestic and laborer or farmhand as treated and self-employed as control. Self-employed have a different tax legal framework than employees not subject to payroll taxes. Self-employed might still be affected by the reform, formalizing due to the better enforcement of becoming formal employees, but it is the best control group at hand as data limitations do not allow to identify alternative groups that were excluded from the reform.

## 6.1 Informality before and after the reform

Figure 1 presents monthly informality rates from 2008 to 2016. We can observe how 2013 is a transition year where just part of the reform was implemented. On figure 1a we see how the informality rate for the treated group had a sudden decrease in January 2014, when all parts of the reform were in place. At the same time, we observe almost no change for the control group. But a seasonal component is clear on the informality rate for the treated group, with permanent decrease at mid and peaks at end of each year. To control for this, figure 1b presents seasonal adjusted averages which makes the change in informality after the reform clearer. Small decreases are present after the law was passed and after the 1st tax waiver, but the largest drop is still present since January 2014. Again, we see almost no change for the control group.

Informality trends require some care. On figure 1b we see that trends of treated and control groups are not parallel, violating a critical assumption for the difference-in-difference (DID) approach. In addition, the decreasing trend for the treated group is more pronounced

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<sup>17</sup>As any natural person employer with one employee was excluded from the reform and survey data does not allow to observe if the employer is a natural person, only domestic and laborer in firms with more than one employee are included in the analysis.

after the final tax waiver. This could be indicating that there was a change in both level and trends of informality. I implement multiple econometric strategies to consider this series behavior.

## 6.2 Regression models and estimates

I estimate different DID specifications to capture changes in informality levels and trends. The simplest one is

$$P(I_{it}) = \alpha_0 + \alpha_1 \textit{treated} + \alpha_2 \textit{treated} * \textit{Jan13} + \alpha_3 \textit{treated} * \textit{May13} + \alpha_4 \textit{treated} * \textit{Jan14} + \boldsymbol{\alpha} \mathbf{X}_{it} + \varepsilon_{it} \quad (8)$$

Where  $P(I_{it})$  indicates the probability that a worker  $i$  has an informal job at time  $t$ ,  $\textit{treated}$  a dummy of treatment group,  $\textit{Jan13}$  a dummy equal to one if January to April 2013,  $\textit{May13}$  a dummy equal to one if May to December 2013,  $\textit{Jan14}$  a dummy equal to one if January 2014 or later,  $\mathbf{X}_{it}$  includes all controls and  $\varepsilon_{it}$  is the random error term. In this specification  $\alpha_2$  measures the effect of the reform passing,  $\alpha_3$  the effect of the first tax waiver and  $\alpha_4$  the effect of the last tax waiver.

The second specification uses year-quarter interactions

$$P(I_{it}) = \beta_0 + \beta_1 \textit{treated} + \beta_2 \textit{treated} * \mathbf{yq}_{08-12} + \beta_3 \textit{treated} * \mathbf{yq}_{13-16} + \beta_4 \mathbf{yq}_{08-16} + \boldsymbol{\beta} \mathbf{X}_{it} + \varepsilon_{it} \quad (9)$$

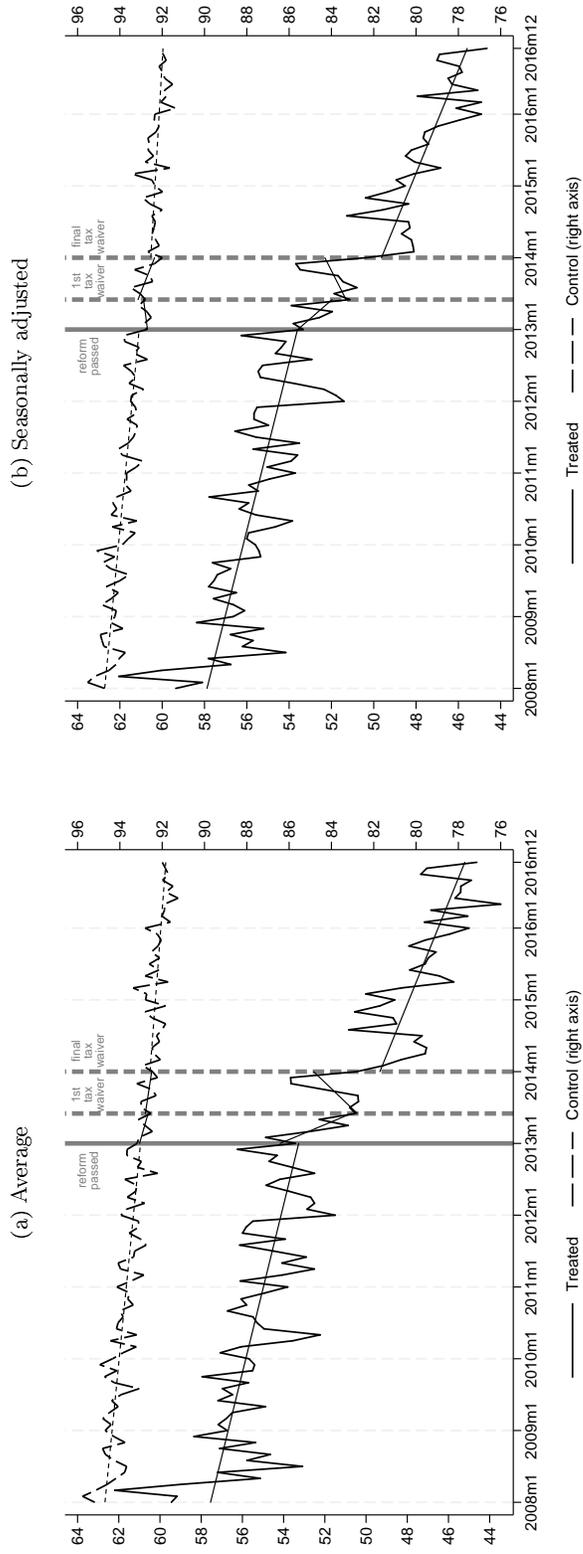
Where  $\mathbf{yq}_{08-16}$  is a vector of year-quarter dummies for 2008 to 2016,  $\mathbf{yq}_{08-12}$  is a vector of year-quarter dummies for 2008 to 2012,  $\mathbf{yq}_{13-16}$  is a vector of year-quarter dummies for 2013 to 2016. Here  $\beta_3$  is the vector of treatment effects of interest while  $\beta_2$  act as in-time placebo test, this is, for these we should find to significant estimates.<sup>18</sup> In this specification I use 2012Q4 as baseline.

The third specification uses year-month interactions

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<sup>18</sup>Placebo estimates results shown in econometric annex.

Figure 1: Monthly informality rate, % of wage workers



Source: Author calculations based on household survey data. Notes: Employees as treated, self-employed as control. Informality definition in main text. Straight lines indicate linear OLS fits. Seasonally adjusted product of regressing informality dummy in month dummies and adding average informality to residuals. Workage if age 12 or more in urban areas, age 10 or more for rural areas.

$$\begin{aligned}
P(I_{it}) &= \gamma_0 + \gamma_1 \mathit{treated} + \gamma_2 \mathit{treated} * \mathbf{ym}_{08-12} + \\
&\quad \gamma_3 \mathit{treated} * \mathbf{ym}_{13-16} + \gamma_4 \mathbf{ym}_{08-16} + \gamma \mathbf{X}_{it} + \varepsilon_{it}
\end{aligned} \tag{10}$$

Where  $\mathbf{ym}_{08-16}$  is a vector of year-month dummies for 2008 to 2016,  $\mathbf{ym}_{08-12}$  is a vector of year-month dummies for 2008 to 2012,  $\mathbf{ym}_{13-16}$  is a vector of year-month dummies for 2013 to 2016. Here  $\gamma_3$  is the vector of treatment effects of interest while  $\gamma_2$  act as in-time placebo test. In this specification I use the December 2012 as baseline.

Specifications (8), (9) and (10) impose no time structure. Parameter estimates on  $\mathit{treated} * \mathit{time}$  measure the change in the time series level, including the part due to a change in informality trend. To restrict to a linear trend and separate changes in levels and trend I use an additional specification

$$\begin{aligned}
P(I_{it}) &= \delta_0 + \delta_1 (t - c) + \delta_2 \mathit{after} + \delta_3 \mathit{treated} + \\
&\quad \delta_4 (t - c) * \mathit{treated} + \delta_5 \mathit{after} * \mathit{treated} + \\
&\quad \delta_6 (t - c) * \mathit{after} * \mathit{treated} + \\
&\quad \delta_7 \mathbf{X}_{it} + \delta_8 \mathbf{X}_{it} * \mathit{treated} + \varepsilon_{it}
\end{aligned} \tag{11}$$

Where  $t$  is the year-month time variable,  $c$  the time baseline (December 2012) and  $\mathit{after}$  a dummy equal to one if January 2013 or after. Here  $\delta_5$  captures the change in informality level while and  $\delta_6$  the change in trend. The total estimated effect of the reform equals  $\delta_5 + \delta_6 t$ , with  $t$  for January 2013 or after.

For all specifications I take the same estimation approach. I adjust for seasonality using the seasonality adjusted residuals, as shown in figure 1b, as dependent variable. To avoid the problems of using non-linear estimators in a diff-in-diff context (Greene, 2010; Blundell and Dias, 2009; Ai and Norton, 2003), I assume a Linear Probability Model (LPM) with estimates obtained using Ordinary Least Squares (OLS) with robust standard errors clustered by industry. LPM allows the diff-in-diff estimates to be readily interpretable and it is much faster given the large sample size of 2,302,575 observations.<sup>19</sup> Controls by age,

<sup>19</sup>LPM limitations like predicted probabilities outside (0,1) interval or heteroskedasticity are not of much

Table 3: Simple DID estimates

Group	[2008-2012]	Jan-Apr 2013	May-Dec 2013	[2014-2015]	DID1	DID2	DID3
Control	93.8	92.9	92.7	92.2	-0.9	-1.1	-1.6
Treated	55.4	53.0	51.7	47.3	-2.4	-3.7	-8.1
Difference	-38.4	-39.9	-41.0	-44.9	-1.5	-2.5	-6.5

Source: Author calculations based on household survey data. Notes: Employees as treated, self-employed as control. Informality definition in main text.

gender, education and department are included in all regressions.<sup>20</sup> I use main sectors and workers above 1 hourly MW for differential impact analysis.

Simple DID estimates show an increasing reduction in informality rate after the reform (Table 3). The DID estimate for the approval of the reform (DID1) is  $-1.5$ , indicating a larger reduction of 1.5 pps for treated workers than controls between January and April 2013. The estimated reduction for the first tax waiver (DID2) is bigger at 2.5 pps and for after the second tax waiver we obtain an even larger reduction of 6.5 pps.

Before-after DID estimates go in line with the simple estimates (Table 4). In column (1) I obtain similar point estimates to those obtained in the simple calculation. Using controls, column (2), point estimate for January to April 2013 becomes marginally significant at 1.1 pps, for May-Dec 2013 point estimate is highly significant at 2.1 pps as well as for January 2014 and after where point estimate is 5.4 pps.

The reform impact was unequally distributed among sectors in the short term and almost evenly in the long term. For January to May 2013 only industry had a significant estimate of a  $-1.7$  pps, on May to December 2013 both industry and services have significant estimates of  $-2.6$  and  $-1.7$  respectively. For January 2014 and later point estimates are significant for all three sectors at about  $-5$  pps.

Interestingly, I obtain no significant estimates for workers earning above 1 hourly MW. This could be indicating that these workers on the control group were indirectly affected by the reform. Possible mechanisms could include a shift from informal self-employment to

concern in a diff-in-diff context. I am not interested in predicted probabilities and heteroskedasticity is easily adjusted for.

<sup>20</sup>Sector and firm size are highly correlated with informality but using them as controls raises concerns of endogeneity. For example, a firm could change their size and its composition of informal workers after the decrease in payroll taxes.

Table 4: Before-after DID estimates

Variable	All employees		Sector			1 MW or more
	(1)	(2)	(3)	(4)	(5)	(6)
treated*Jan-Apr13	-0.016** (0.007)	-0.011* (0.006)	-0.019 (0.021)	-0.017** (0.008)	-0.003 (0.007)	0.001 (0.008)
treated*May-Dec13	-0.025*** (0.008)	-0.021*** (0.006)	-0.011 (0.016)	-0.026*** (0.009)	-0.017** (0.007)	0.006 (0.010)
treated*2014-2016	-0.065*** (0.011)	-0.054*** (0.008)	-0.053** (0.018)	-0.047*** (0.006)	-0.048*** (0.011)	0.009 (0.009)
Controls	No	Yes	Yes	Yes	Yes	Yes
Observations	2302575	2302195	200492	503452	1597404	1103476

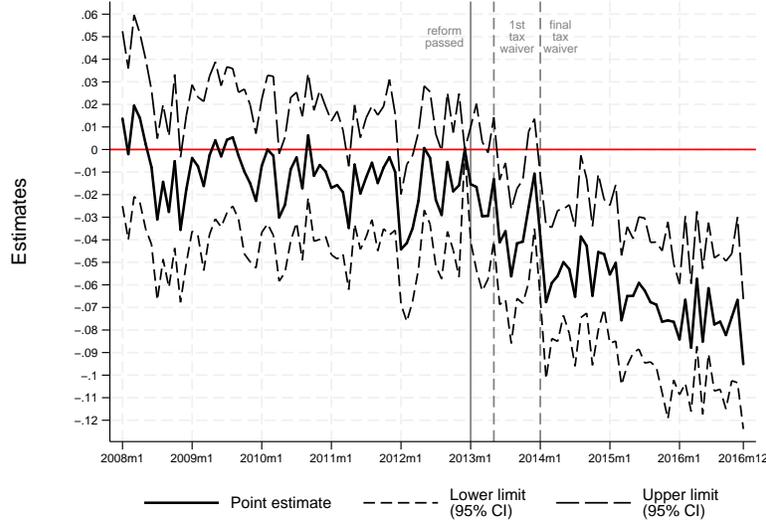
Source: Author calculations based on household survey microdata. Notes: Results from OLS regressions with robust standard errors clustered by industry. Residuals of OLS regression of informality on month dummies as dependent variable. Standard errors in parentheses. Number of observations in brackets. \*  $p < 0.1$  \*\*  $p < 0.05$  \*\*\*  $p < 0.01$ . Employees as treated, self-employed as control. Informality definition in main text. Controls include age, gender, education and department.

formal employee or informal to formal but still self-employed due to increased enforcement.

With the exception of workers above 1 hourly MW, treated\*year-quarter points estimates indicate significant and increasing intra-year effects for all groups of employees (Table 5). No significant estimate is present for 2013Q1 for any group of workers. Marginally significant estimates of  $-1.9$  to  $-1.6$  is obtained for 2013Q2 for all workers but not by sector. By 2013Q3 estimates become significant at about  $-3$  pps for all workers and  $-3.6$  pps in services. For 2013Q4 I obtain a marginally significant point estimate of  $-1.4$  pps for all workers,  $-1.9$  pps in agriculture and  $-1.8$  in services.

Point estimates on all quarter interactions from 2014 to 2016 are significant and large for all workers, with and without controls. For 2014 point estimates are about  $-4$  pps, similarly for services. On agriculture and industry I obtain significant point estimates only for 2014Q1 and 2014Q4 at about  $-3.5$  pps. For 2015 point estimates for all workers with controls are increased from  $-4.9$  pps in Q1 to  $-6.4$  pps in Q4, point estimates are even bigger in services:  $-6$  to  $-6.8$  pps respectively. In agriculture I obtain marginally significant point estimates of  $-4.9$  and  $-6.8$  for Q2 and Q3 respectively and a significant at 5% point estimate of  $-7.1$  pps for Q4. For industry I obtain a significant point estimate for Q4 at  $-4$  pps. For 2016 point estimates for all workers with controls are slightly larger and close to  $-7$  pps. Point estimates in services are also large at  $-7.5$  pps in Q1 and  $-7.2$  pps in Q4. I also

Figure 2: Diff-in-diff treated\*year-month estimates



Source: Author calculations based on household survey microdata. Notes: Results from OLS regressions with robust standard errors clustered by industry. Residuals of OLS regression of informality on month dummies as dependent variable. Employees as treated, self-employed as control. Informality definition in main text. Controls include age, gender, education and department.

obtain significant point estimates for agriculture and industry but only for Q2 to Q3. For agriculture (industry) I obtain  $-6.5$  ( $-4.9$ ) pps for Q2,  $-10.8$  ( $-5.3$ ) pps for Q3 and ,  $-5.5$  pps ( $-4.2$ ) for Q4.

The increasing size of point estimates after the tax reform are even more pronounced on treated\*year-month interactions (Figure 2). We see that confidence intervals for point estimates before January 2013 include zero in almost all months thus passing the in-time placebo test. For January to May 2013 we see that confidence intervals also include zero. From June to October 2013 all point estimates do not include zero and go up to  $-5.6$  pps for August. Starting January 2014 confidence intervals for any point estimate do not include zero. Point estimates for 2014 go from  $-3.8$  to  $-6.7$ . Point estimates for 2015 indicate further reductions with  $-5.5$  in January  $-7.6$  pps in December. Even larger are the reductions estimates for 2016 with  $-8.4$  in January to  $-9.4$  pps in December.

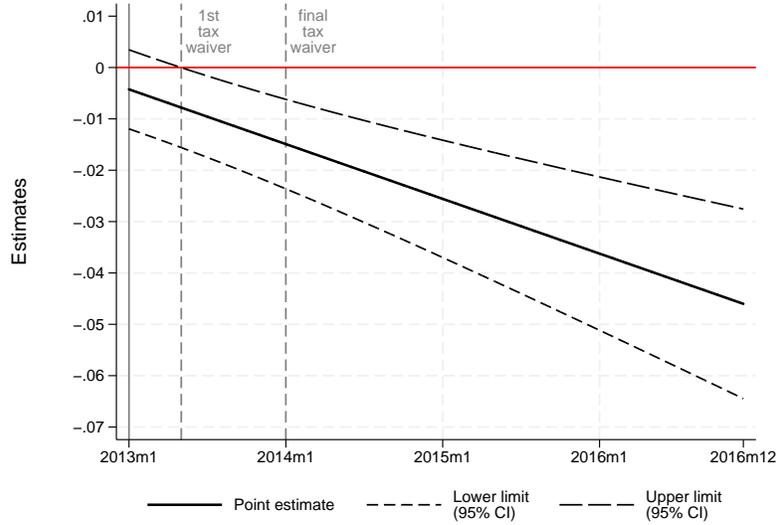
Estimation of the change in level and trend in informality also indicates significant but smaller impact (Figure 3). Using the estimates from specification (11) the figure presents

Table 5: DID treated\*year-quarter estimates

	All employees		Sector			1 MW or more
	(1)	(2)	Agriculture	Industry	Services	
Baseline: 2012Q4			(3)	(4)	(5)	(6)
treated*2013Q1	-0.008 (0.010)	-0.009 (0.010)	-0.001 (0.023)	-0.002 (0.018)	-0.012 (0.012)	-0.005 (0.011)
treated*2013Q2	-0.019* (0.011)	-0.016* (0.010)	-0.024 (0.040)	-0.009 (0.014)	-0.013 (0.011)	-0.002 (0.014)
treated*2013Q3	-0.030*** (0.010)	-0.033*** (0.009)	-0.007 (0.025)	-0.036 (0.022)	-0.036*** (0.012)	-0.013 (0.012)
treated*2013Q4	-0.012 (0.008)	-0.014* (0.007)	-0.019** (0.008)	0.009 (0.012)	-0.018* (0.010)	0.000 (0.013)
treated*2014Q1	-0.048*** (0.008)	-0.044*** (0.008)	-0.036* (0.020)	-0.034** (0.015)	-0.046*** (0.010)	-0.010 (0.012)
treated*2014Q2	-0.054*** (0.012)	-0.041*** (0.010)	-0.051 (0.034)	-0.027 (0.019)	-0.037*** (0.012)	0.005 (0.012)
treated*2014Q3	-0.039*** (0.011)	-0.037*** (0.010)	-0.031 (0.020)	-0.018 (0.020)	-0.044*** (0.014)	0.008 (0.013)
treated*2014Q4	-0.045*** (0.010)	-0.041*** (0.008)	-0.034*** (0.009)	-0.032** (0.016)	-0.037*** (0.011)	-0.003 (0.014)
treated*2015Q1	-0.056*** (0.011)	-0.049*** (0.010)	-0.007 (0.028)	-0.031 (0.022)	-0.060*** (0.014)	-0.006 (0.014)
treated*2015Q2	-0.059*** (0.011)	-0.051*** (0.010)	-0.049* (0.026)	-0.017 (0.019)	-0.058*** (0.013)	0.011 (0.012)
treated*2015Q3	-0.063*** (0.011)	-0.055*** (0.011)	-0.068* (0.034)	-0.021 (0.015)	-0.060*** (0.015)	-0.004 (0.011)
treated*2015Q4	-0.068*** (0.011)	-0.064*** (0.009)	-0.071** (0.030)	-0.040** (0.017)	-0.068*** (0.012)	-0.003 (0.013)
treated*2016Q1	-0.080*** (0.011)	-0.068*** (0.010)	-0.043 (0.025)	-0.040 (0.027)	-0.075*** (0.013)	-0.010 (0.013)
treated*2016Q2	-0.066*** (0.011)	-0.056*** (0.010)	-0.065** (0.024)	-0.049** (0.020)	-0.051*** (0.013)	0.012 (0.013)
treated*2016Q3	-0.073*** (0.013)	-0.067*** (0.012)	-0.108** (0.040)	-0.053*** (0.016)	-0.059*** (0.015)	-0.005 (0.013)
treated*2016Q4	-0.071*** (0.011)	-0.067*** (0.010)	-0.055*** (0.016)	-0.042* (0.021)	-0.072*** (0.012)	0.003 (0.012)
Controls	No	Yes	Yes	Yes	Yes	Yes
Observations	2303160	2302780	200502	503597	1597833	1103717

Source: Author calculations based on household survey microdata. Notes: Results from OLS regressions with robust standard errors clustered by industry. Residuals of OLS regression of informality on month dummies as dependent variable. Standard errors in parentheses. Number of observations in brackets. \* p<0.1 \*\* p<0.05 \*\*\* p<0.01. Employees as treated, self-employed as control. Informality definition in main text. Controls include age, gender, education and department. All regressions include treated\*year-quarter interactions previous to 2013.

Figure 3: Treated\*after + treated\*after\*year-month estimates



Source: Author calculations based on household survey microdata. Notes: Results from OLS regressions with robust standard errors clustered by industry. Residuals of OLS regression of informality on month dummies as dependent variable. Employees as treated, self-employed as control. Informality definition in main text. Controls include age, gender, education and department.

the total estimated effect  $\hat{\delta}_5 + \hat{\delta}_6 t$ . We see that, as before, for January to April 2013 estimates are not significant as confidence intervals include zero. From May to December 2013 the total effect estimate go from almost zero to  $-1.4$  pps. By December 2014 the estimated total effect goes up to  $-2.5$  pps,  $-3.5$  for December 2015 and a maximum of  $-4.6$  pps for December 2016.

## 7 Conclusions

Current studies provide mixed guidance to policy makers on the effects of payroll taxes on informality. Predictions from economic theory depend on how informality is defined, workers' preference for informal employment, and the specific economic model chosen (Antón, 2014; Galiani and Weinschelbaum, 2012). Empirical evidence points to a positive relation between payroll taxes and informality (Merchán Álvarez, 2015; Clavijo et al., 2015; Mondragón-Vélez et al., 2010; Santa María et al., 2009; Sánchez et al., 2009). The large reduction of payroll taxes in Colombia in 2012 provides a great opportunity to evaluate this both theoretical

and empirically.

My labor market model incorporates the reduction in payroll taxes and the structural change in funding of social benefits introduced by the reform. The simulation exercise based on the model predicts a reduction of 7.2 pps in the informality rate. The sensitivity analysis indicates that this reduction is still present and even larger at alternative values of the parameters.

Econometric estimates indicate significant effects from the reform. DID estimates are marginally significant after the first tax waiver in May 2013 and increasingly larger after the second one in January 2014. The services sector had the largest and persistent reductions in informality. Agriculture and industry also enjoyed significant reductions, but those reductions were not apparent in all quarters between 2014 and 2016. For workers above 1 hourly MW I obtain no significant estimates, indicating that workers in the control group were indirectly affected by the reform.

The informality rate of December 2012 for the treated group was 56.2. Then, the simulation indicates a reduction of 10.1 percent of the baseline rate (5.7/56.2). Simple DID before-after indicates the reform passing had a small effect of 2%, the first tax waiver a slightly bigger one of 3.7%, and the largest effect of 9.6% coming after the second tax waiver. Quarterly and monthly DID estimates also reflect this same pattern; for example, I estimate reductions of informality of 5.3% in 2013Q3, 7.1% in 2014Q4, and 11.4% in 2016Q4. Using monthly data, I estimate reductions of 10% for August 2013 and up to 16.7% for December 2016. When restricting informality to have a linear trend I obtain smaller but more stable point estimates from almost zero in May 2013 to 8.2% in December 2016.

These results are consistent with those in Fernández and Villar (2016) but very different from Kugler et al. (2017). I successfully replicate Fernández and Villar (2016), with similar point estimates, sample sizes, controls and econometric methodology. Treated and control groups are similar, with 80% of workers identified on the same groups in this study and in Fernández and Villar (2016). Differences in estimations are due to the longer time period and estimation methodology in this study. Kugler et al. (2017) estimates were not possible to replicate. Despite attempts to emulate same formality measures and treated and control

groups, the large differences in sample sizes between the original study and those in the replication render comparison of point estimates not appropriate.

For policy implications it is important to highlight that the estimates' connection with payroll taxes is indirect and replications might not lead to the same results. Multiple regulatory changes took place at the same time as the reduction in payroll taxes: increased flexibility to make contributions to social security, a change in social benefits funding, and increased enforcement. It is possible that some or all these factors explain part of the reduction in informality. Also, this study is limited to employees, those most directly affected by changes in payroll taxes but also a small fraction of workers in developing countries. If reduction of payroll taxes reduces informality only among these types of workers, informality reduction in the country could be small. Accordingly, replications in other contexts should be done with care.

Further exploration of these results is needed. Empirically, I would like to study how results differ with alternative definitions of informality and/or groups of workers. Another pending exercise is to calibrate the labor model to the empirical results, making it possible to simulate other policies.

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