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CHAPTER 3

WHO BENEFITS FROM REDUCING THE COST OF FORMALITY? QUANTILE REGRESSION DISCONTINUITY ANALYSIS

Tommaso Gabrieli, Antonio F. Galvao Jr.
and Gabriel V. Montes-Rojas

ABSTRACT

This paper studies the effect of increasing formality via tax reduction and simplification schemes on micro-firm performance. We develop a simple theoretical model that yields two intuitive results. First, low- and high-ability entrepreneurs are unlikely to be affected by a tax reduction and therefore, the reduction has an impact only on a segment of the micro-firm population. Second, the benefits to such reduction, as measured by profits and revenues, are increasing in the entrepreneur's ability. Then, we estimate the effect of formality on the entire conditional distribution (quantiles) of revenues using the 1996 Brazilian SIMPLES program and a rich survey of formal and informal micro-firms. The econometric approach compares eligible and non-eligible firms, born before and after SIMPLES in a local interval about the introduction of SIMPLES. We develop an estimator that combines both quantile regression and the regression discontinuity design. The econometric results corroborate the

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1 *positive effect of formality on micro-firms' performance and produce a*
 2 *clear characterization of who benefits from these programs.*

3 **Keywords:** Formality; micro-firms; quantile regression; regression
 4 discontinuity

5 **JEL classification:** J23; L25

6
 7
 8
 9 *“Lo que pasa es que acá si vos queres abrir un negocio te matan a papeles, y después te*
 10 *controlan, y los impuestos te revientan.”* [What happens here is that when you try to open
 11 a business they kill you on paperwork (red tape), then they control you, and taxes are
 12 unbearable.] Martín Caparrós, *El Interior*, a book on interviews and anecdotes from the
 13 poor countryside in Argentina.

14 INTRODUCTION

15
 16 Formality is broadly defined as participation in societal and govern-
 17 mental institutions, such as paying taxes, being registered with the
 18 authorities, etc. (see Gerxhani, 2004; Maloney, 2004, for a survey). Firms’
 19 inability to become formal is thought to have deleterious effects on
 20 performance. As examples, formality offers the firm access to risk pooling
 21 mechanisms that may attract more educated paid workers and engage
 22 them in a longer relationship with the firm, which in turn makes training
 23 and capital goods acquisition more profitable; formality may be a
 24 requirement for access to formal credit markets or government provided
 25 business development services or as Paula and Scheinkman (2007, 2010)
 26 have argued, for subcontracting relations with formal firms. Moreover,
 27 to the extent that formality increases the ability of micro-entrepreneurs
 28 to establish property rights over their investments and reduces the risk
 29 of being fined by government inspectors, it creates incentives for
 30 operating out of fixed locations rather than in an ambulatory fashion
 31 (see de Soto, 1989).

32
 33 The high costs of complying with government regulations and institutions
 34 have often been seen as largely responsible for the presence of large informal
 35 sectors in developing countries. The perceived onerous cost of formality
 36 was tackled by several Latin American governments by introducing tax
 37 reductions and simplifications. Examples of such programs are the Mono-
 38 tributo¹ in Argentina, SARE² in Mexico, and the SIMPLES³ in Brazil.
 39 Available evidence shows that these programs had a positive effect on

1 formality. See Kaplan, Piedra, and Seira (2006) for SARE; and Monteiro and
Assunção (2006) and Fajnzylber, Maloney, and Montes-Rojas (2011) for
3 SIMPLES.

We contribute to this literature by answering three questions: First, what
5 is the effect of formality on firm performance? Second, which firms benefit
from tax reduction and simplification schemes? Third, is there hetero-
7 geneity on the effect of formality on firm performance? These questions
have very important policy implications. In a Ricardian setting, tax
9 reductions imply a redistribution of wealth, and therefore, it is important
to quantify which firms are really benefiting from these programs. In
11 particular, if tax reductions only benefit already well-off formal firms, then
the program did not accomplish the task of broadening the scope of
13 formality. We focus on the micro-firm sector, defined as own-account
workers and firms with a maximum of five paid employees, that constitutes
15 the majority of firms in developing countries.⁴ Within this sector three
groups can be distinguished. First, high-ability entrepreneurs with
17 substantial growth prospects may have self-selected into formality with
the old (high) tax system, as the perceived benefits of being formal offset
19 the cost of formality. Then, this segment benefits only from the tax
reduction. Second, some micro-entrepreneurs are in the informal sector as
21 a subsistence strategy as predicted in the Harris and Todaro (1970) dual
labor market hypothesis (see Maloney, 1999, 2004; Mandelman & Montes-
23 Rojas, 2009, for a discussion). These are low-ability entrepreneurs and they
will not value future gains from becoming formal and, therefore, tax
25 reductions will not affect them. Third, in between those segments there are
micro-firms that may become formal only when the cost of formality is low
27 enough. These micro-firms receive the gains from being formal but have to
pay taxes as a result. We call this segment the *target* group and it
29 corresponds to medium-ability entrepreneurs. These are the firms that
should benefit from the tax reduction programs and change their formality
31 status.

We begin our analysis by developing a theoretical model motivated by the
33 work of Rauch (1991) and Paula and Scheinkman (2007, 2010), with
emphasis on the effect of a reduction in taxes. This model yields two
35 intuitive results. First, low- and high-ability entrepreneurs are unlikely to be
affected by a tax reduction policy reform and therefore, the reform has an
37 impact only on a segment of the micro-firm population, defined by default
as medium-ability entrepreneurs. Second, the benefits of such reform, as
39 measured by profits and revenues, are increasing in the entrepreneur's
ability.

1 Empirically, our goal is to quantify the impact of formality on the
conditional distribution (quantiles) of micro-firm's revenues, and the size of
3 the *target* group (i.e., which firms benefit from the tax reduction). Two
problems arise in our empirical setup. First, formality is endogenous, and in
5 particular, correlated with the unobserved entrepreneurial ability. Second,
we might not be able to identify the effect of formality for all firms.

7 To solve the first problem, the identification strategy makes use of the
SIMPLES program in Brazil, that offers an exogenous change in legislation
9 that can be used to control for self-selection and endogeneity. Thus, our
paper builds on the work of Monteiro and Assunção (2006) and Fajnzylber
11 et al. (2011) by analyzing the SIMPLES program in Brazil that offers an
exogenous change in legislation that can be used to control for self-selection
13 and endogeneity. We use the same unique dataset for micro-firms, the
ECINF 1997. Moreover, following those authors we use a difference-in-
15 differences approach with the age of the firm and with ineligible firms as a
control group to identify the effect of formality on firm performance.
17 Monteiro and Assunção (2006) study the effect of SIMPLES on having a
government issued license, which constitutes a necessary requirement for
19 further formalization (such as paying taxes of social security), and they find
an increase in formal licensing among retail firms of 13 percentage points,
21 but no effect on eligible firms from other sectors (construction, manufactur-
ing, transportation, and other services). In addition, using SIMPLES as an
23 instrumental variable (IV) for formality, they show that the latter
significantly increases access to credit, and alters the amount and
25 composition of investment toward larger and longer-term projects.
Fajnzylber et al. (2011) show that SIMPLES has only a *local* effect on
27 licensing rates for firms born just after the introduction of the program.
Using a regression discontinuity design (see Hahn, Todd, & van der
29 Klaauw, 2001; van der Klaauw, 2002, for a discussion about regression
discontinuity estimators), with weights given by time-in-business and its
31 distance to the introduction of SIMPLES, they find a significant effect on
licensing, tax registration, tax payments, and social security contributions.
33 When more firms were taken into consideration, the statistical significance
of these effects decreases monotonically with the sample average time-
35 distance to the introduction of SIMPLES. We build on their analysis and
extend it to a quantile regression (QR) discontinuity analysis.

37 In order to address estimation of the distributional effects of formality, we
make use of the heterogeneity in the conditional distribution of revenue
39 applying QR techniques, which will prove an indispensable tool for the
problem in question. QR methods offer the advantage of describing not only

1 averages of possible outcomes but also their entire distribution. Thus, QR
2 techniques provide a systematic method to analyze differences in covariates
3 effects (see Koenker, 2005; Koenker & Hallock, 2001), a framework for
4 robust estimation and inference, and most importantly allow exploring a
5 range of conditional quantiles exposing conditional heterogeneity. For the
6 present problem, the micro-firm heterogeneity given by unobserved
7 characteristics (entrepreneurial ability) can be analyzed along the single
8 dimensional conditional quantiles of the firm revenues. Along this
9 dimension, high quantiles correspond to *high-ability entrepreneurs* and low
10 quantiles to *low-ability entrepreneurs*. Chesher (2005) studies identification
11 under discrete variation and shows that the identifying intervals can be
12 estimated using QR methods. Thus, as argued in Chesher (2005), the
13 identification through QR strategy may work for some quantiles (in our case
14 *target* entrepreneurs) but not for others (in our case the low- and high-
15 ability entrepreneurs). We face a similar situation where the SIMPLER
16 program can be used for identification only for medium-ability entrepre-
17 neurs but not for low- and high-ability ones.

18 Our proposed estimation strategy thus combines the regression disconti-
19 nuity approach and the QR framework. In this paper, we employ the linear
20 instrumental variables quantile regression (IVQR) estimator proposed by
21 Chernozhukov and Hansen (2006, 2008) applied to estimate a *fuzzy*
22 regression discontinuity design model. The model is semiparametric in the
23 sense that the functional form of the conditional distribution of the response
24 variable given the regressors is left unspecified. The use of IVQR in a
25 regression discontinuity design appeared in Guiteras (2008) motivated by an
26 empirical application to the returns to compulsory schooling, and Pereda-
27 Fernandez (2010) estimating the effects of class size on scholastic
28 achievement. Frolich and Melly (2008) propose a nonparametric identifica-
29 tion of the quantile treatment effects in the regression discontinuity design
30 and they propose an uniformly consistent estimator for the potential
31 outcome distributions and for the function-valued effects of the policy.
32 Frandsen (2008) introduces a procedure to nonparametrically estimate local
33 quantile treatment effects in a regression discontinuity design with binary
34 treatment.

35 The rest of the paper is organized as follows. The second section develops
36 a theoretical model. The third section describes the ECINF micro-firm
37 survey. The fourth section describes the SIMPLER program and the
38 identification strategy. The fifth section develops the QR discontinuity
39 estimator. The sixth section presents the econometric results. The seventh
section concludes.

1 TAXES AND THE INFORMAL SECTOR

3 In this section, we present a simple model that generates a segmentation
 4 characterized by salaried workers, informal and formal micro-entrepre-
 5 neurs. The model shows that an individual becomes an informal
 6 entrepreneur, rather than being a salaried worker, if her individual ability
 7 is higher than a certain threshold, and becomes a formal entrepreneur,
 8 rather than being an informal one, if her individual ability is higher than an
 9 even higher threshold. The higher is the cost of formality the higher is the
 10 threshold value of ability to become a formal entrepreneur. This simple
 11 model builds on the models of Rauch (1991) and Paula and Scheinkman
 12 (2007, 2010). The model will then be used to analyze the impact of
 13 SIMPLES on formality.

14 We consider a continuum of agents, each denoted by i and characterized
 15 by entrepreneurial ability θ_i , which is distributed according to a probability
 16 density function $g(\cdot)$. Agents choose between working for an existing firm
 17 and earning a wage of w independent of their ability,⁵ thus becoming a
 18 salaried worker, operating a firm in the informal sector or operating a firm
 19 in the formal sector. The last two options correspond to the entrepreneurial
 20 sector. An entrepreneur produces quantity y_i of an homogeneous good using
 21 capital k_i and labor l_i as inputs. In order to maintain tractability we consider
 22 a Cobb–Douglas technology $y_i = \theta_i k_i^\alpha l_i^\beta$, with $\alpha, \beta > 0$ and $\alpha + \beta < 1$.⁶

23 We normalize the price of the homogeneous good to 1. The unit costs of k
 24 and l are respectively r and w , where r and w are given. We distinguish
 25 between formal and informal entrepreneurs. A formal entrepreneur pays an
 26 *ad valorem* tax ϕ . An informal entrepreneur *cheats* the system and pays no
 27 taxes, but if detected is out of business. We assume that the probability of
 28 detection p increases with the size of the firm and that $p(k) = 0$ if $k \leq k^*$ and
 29 $p(k) = 1$ if $k > k^*$, that is, an informal entrepreneur cannot employ more
 30 than k^* but is able to evade taxes.⁷

31 The profit functions for an entrepreneur of ability θ_i who chooses to be
 32 respectively informal or formal follow:

$$\begin{aligned}
 \pi_i^I &= \max_{l_i, k_i \leq k^*} \{ \theta_i k_i^\alpha l_i^\beta - r k_i - w l_i \} \\
 \pi_i^F &= \max_{l_i, k_i} \{ (1 - \phi) \theta_i k_i^\alpha l_i^\beta - r k_i - w l_i \}
 \end{aligned}
 \tag{1}$$

33
 34
 35
 36
 37
 38
 39 The maximization of Eq. (1) gives the optimal quantity of production
 factors which are respectively used by an informal and a formal
 entrepreneur, given her ability θ_i :

$$\begin{aligned}
 1 \quad k_i^I &= \min \left\{ \theta_i^{1/(1-\alpha-\beta)} \left(\frac{\alpha}{r} \right)^{(1-\beta)/(1-\alpha-\beta)} \left(\frac{\beta}{w} \right)^{\beta/(1-\alpha-\beta)}, k^* \right\}, \\
 3 \\
 5 \quad l_i^I &= \min \left\{ \theta_i^{1/(1-\alpha-\beta)} \left(\frac{\alpha}{r} \right)^{\alpha/(1-\alpha-\beta)} \left(\frac{\beta}{w} \right)^{(1-\alpha)/(1-\alpha-\beta)}, \left(\frac{\beta \theta^i k^{*\alpha}}{w} \right)^{1/(1-\beta)} \right\}, \\
 7 \\
 7 \quad k_i^F &= ((1-\phi)\theta_i)^{1/(1-\alpha-\beta)} \left(\frac{\alpha}{r} \right)^{(1-\beta)/(1-\alpha-\beta)} \left(\frac{\beta}{w} \right)^{\beta/(1-\alpha-\beta)}, \\
 9 \\
 9 \quad l_i^F &= ((1-\phi)\theta_i)^{1/(1-\alpha-\beta)} \left(\frac{\alpha}{r} \right)^{\alpha/(1-\alpha-\beta)} \left(\frac{\beta}{w} \right)^{(1-\alpha)/(1-\alpha-\beta)} \\
 11
 \end{aligned}$$

13 When is it optimal for an entrepreneur to become formal? In choosing
 15 whether to become formal or not micro-entrepreneurs trade-off the gains of
 17 employing more than k^* with the cost of paying the tax ϕ . On one hand,
 19 formality decreases productivity as it decreases the marginal products of the
 21 factors of production and such effect shows that informality can work as a
 device to enhance flexibility and productivity. On the other hand, formality
 allows firms to grow bigger as it increases the production set. It is the extent
 of the trade-off between the two effects that determines which entrepreneurs
 find it optimal to become formal rather than remaining informal.

21 As shown by Paula and Scheinkman (2007), the convexity of the profit
 23 functions Eq. (1) in θ implies that there is a unique threshold level of ability
 25 above which entrepreneurs become formal. The following proposition
 formally establishes this result and finds an analytical expression for the
 threshold level of ability. The proof is given in the appendix.

AU 4

27 **Proposition 1.** *There exists a threshold level of ability $\bar{\theta}$ such that an*
 29 *entrepreneur i will decide to be formal if and only if her ability θ_i is greater*
than $\bar{\theta}$. $\bar{\theta}$ increases in ϕ .

31 This result is driven by the fact that productivity increases in θ_i and
 therefore agents with higher θ_i can afford to trade-off a decrease (measured by
 ϕ) in the marginal product of factors for an increase of the production set.⁸

33 Define an ability threshold $\hat{\theta}$ such the individual with ability $\hat{\theta}$ is
 35 indifferent between becoming a salaried worker or an informal entrepreneur,
 hence $w = \pi^I(\hat{\theta})$. Plugging the first-order conditions into Eq. (1) we
 find that $\hat{\theta} = (1-\alpha-\beta)^{(\alpha+\beta-1)} (r/\alpha)^\alpha (1/\beta)^\beta w^{1-\alpha}$. Therefore, we have that:

- 37 if $\theta_i \leq \hat{\theta}$, then i is a salaried worker;
- 39 if $\theta_i \in (\hat{\theta}, \bar{\theta}]$, then i is an informal entrepreneur;
- if $\theta_i > \bar{\theta}$, then i is a formal entrepreneur.

Effect of a Policy Change

If the salaried wage is fixed,⁹ the fact that $\bar{\theta}$ increases in ϕ (Proposition 1) implies the following corollary.

Corollary 1. *The greater the tax ϕ , the greater the cut-off level of ability $\bar{\theta}$ and the smaller the formal sector (and vice versa).*

It is interesting to note that those who gain the most out of a reduction in the cost of formalization from ϕ to ϕ' are the more able individuals. The following proposition shows this result, and proof is relegated to the appendix. As we will remark, this result is due to the convexity of the technology.

Proposition 2. *The greater the individual ability θ_i is the greater is the increase in the profit $\pi(\theta_i)$ and revenue $y_i(\theta_i)$ for a decrease in the tax rate from ϕ to ϕ' .*

We illustrate the results from the propositions above using diagrams. Fig. 1 illustrates the informal entrepreneurs' profit function (thick line) and

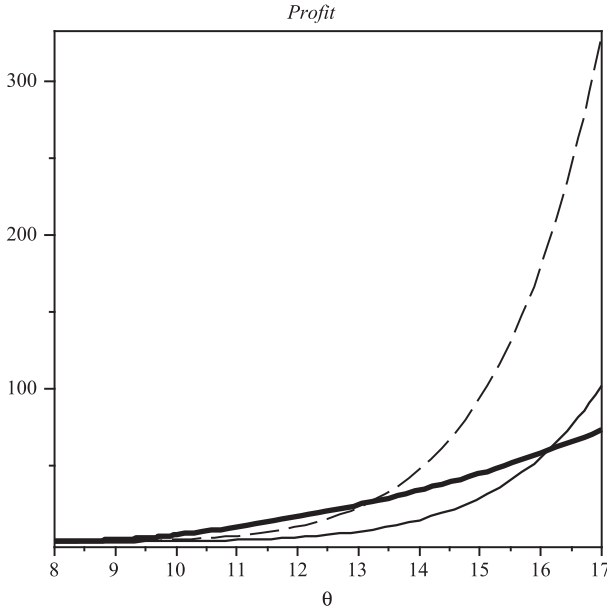


Fig. 1. Ad-Valorem Tax. Profit Functions: Informal (Thick Line), Formal (Thin Line), Formal After Decrease in Tax (Dashed Line).

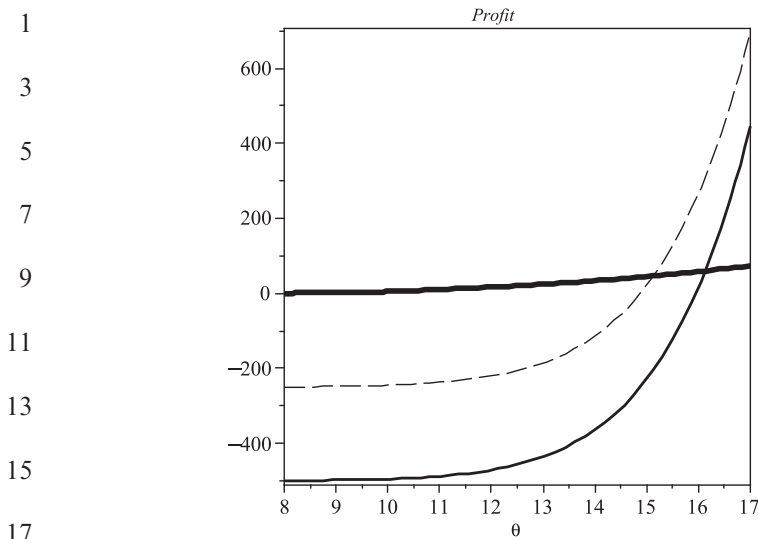


Fig. 2. Lump-Sum Tax. Profit Functions: Informal (Thick Line), Formal (Thin Line), Formal After Decrease in Tax (Dashed Line).

the formal entrepreneurs' profit and revenue function before and after a reduction in the tax (thin and dashed lines). From the figure it is possible to notice the results of Propositions 1 and 2.¹⁰ Moreover, from the figure, it is also evident that the result of Proposition 2 would not apply to a different model in which $\pi^F(\phi')$ is not always convex for $\theta > \bar{\theta}'$.¹¹

The model can be extended to the case of a lump-sum tax. In this case, the profit function of a formal entrepreneur is the following: $\pi_i^F = \max_{l_i, k_i} \{ \theta_i k_i^\alpha l_i^\beta - rk_i - wl_i - \phi \}$, where ϕ now represents a lump-sum tax. In such case all the previous conclusions still hold. Fig. 2 illustrates the profit function plot for this case of a lump-sum tax change.¹²

DATA AND DESCRIPTIVE STATISTICS

We employ the Brazilian Survey of the Urban Informal Sector (Pesquisa Economica Informal Urbana, ECINF) collected in October 1997 (11 months after the introduction of the SIMPLES) by the Brazilian Statistical Institute (IBGE, Instituto Brasileiro de Geografia e Estadística). This survey is a

1 cross-section representative of all the urban self-employed and micro-firm
2 owners with at most five paid employees, excluding domestic workers. The
3 stratified sampling design (in two stages) allows studying a population of
4 units which are rare, heterogeneous and hard to detect in standard
5 household surveys. Geographically, it covers all of the 26 Brazilian states,
6 as well as the federal district, and also each of the 10 metropolitan areas
7 (Belém, Fortaleza, Recife, Salvador, Belo Horizonte, Vitória, Rio de
8 Janeiro, São Paulo, Curitiba, and Porto Alegre) and the municipality of
9 Goiânia. In each of its two waves, ECINF interviewed roughly 50,000
10 households among which it found more than 40,000 individuals which
11 reported owning a micro-enterprise.

12 We analyze firms with a government issued license as our measure of
13 formality. Only 23.2% of all micro-firms have a license which increases to
14 31.1% for micro-firms with at least one paid employee.

15 Within the Brazilian micro-entrepreneur sector, the most frequent sectors
16 of activity are retail trade (26% of micro-firms) and personal services (20%),
17 followed by construction (15%), technical and professional services (11%)
18 and manufacturing (11%). Respectively 8% and 7% of micro-firms belong
19 to the sectors of hotels and restaurants, and transportation. Most firms are
20 very small both in terms of revenues and employment: the average and
21 median monthly revenues of Brazilian micro-firms were \$US 1,083 and \$US
22 600, respectively. We find that 87% of all Brazilian micro-firms have no paid
23 employees, and 79% have no employees or partners at all, 10% of the
24 surveyed micro-firms have one or two paid employees, and only 3% have
25 between three and five paid workers. In those firms with at least one paid
26 employee, roughly 22% of all workers are family members, almost two-
27 thirds of paid workers are non-registered (*sem carteira assinada*) and only
28 35% pay social security contributions.

29 The ECINF asks whether respondents started their firms themselves or
30 became owners at a later date. The survey then collects data on the number
31 of years and months since respondents respectively started the firm or
32 became owners-partners. We use this information to construct our time-in-
33 business variable. For firms that were not started by their current owners,
34 our time-in-business variable reflects the time since the current owner joined
35 in as a partner, which is not necessarily the actual age of the firm. This
36 problem, however, affects only 8% of firms (92% of respondents report
37 having started their own firms) and it does not appear to have a significant
38 impact on our main conclusions. Given that the IV strategy relies heavily on
39 the validity of this measure we will also consider separately the subsample of
40 micro-firms where the firm was started by the current owner.

1 THE SIMPLES PROGRAM AND IDENTIFICATION 3 STRATEGY

5 In November 1996, the Brazilian government implemented a new
7 unanticipated simplified tax system for micro-firms and small firms, the
9 SIMPLES. The new national system consolidated several federal taxes and
11 social security contributions. Basically, the SIMPLES abridged procedures
13 for the verification and payment of federal, state, and municipal taxes. At
15 the federal level, the system allowed eligible firms to combine six different
17 types of federal taxes and five different social security contributions into a
19 one single monthly payment, varying from 3% to 5% of gross revenues for
21 micro-enterprises, and from 5.4% to 7% of revenues for small firms. One
23 important aspect of the new system is that it allowed substituting a fixed
25 (and relatively low) percentage of total invoicing for the standard payroll
27 contribution, which led to a substantial reduction in labor costs and hence
29 created a strong incentive to hire new employees and/or legalize already
31 existing labor relationships. The motivation behind these reductions in
33 direct and indirect taxes was to enable small, unskilled labor-intensive firms
to compete more effectively with larger enterprises, for which high tax
burdens are more manageable due to scale economies. Moreover, while
value added taxes collected at the state and municipal levels – the Imposto
Sobre Circulação de Mercadorias e Prestação de Serviços (ICMS) and the
Imposto Sobre Serviços (ISS) – were initially not included in SIMPLES,
states and municipalities could enter into agreements with the federal
government to transfer to the latter the collection of the corresponding taxes
through an increase in the SIMPLES rates. As a result, SIMPLES permitted
an overall reduction of up to eight percentage points in the tax burden faced
by eligible firms MonteiroAssuncao06. SIMPLES, however, explicitly
excluded from program eligibility all activities that by law require the
employment of professionals in regulated occupations. Examples of
ineligible activities include the manufacturing of chemical products,
machinery and equipment, as well as education, health, accounting,
insurance and financial services, among others.¹³

35 Given the previous model, firms' output or revenues $y_i = \theta_i k_i^\alpha l_i^\beta$ can be
37 re-expressed as a function of formality (which can be thought of as an
indicator variable with 0 and 1 and labeled with d), and entrepreneurial
ability θ_i :

$$39 \quad y_i = f(d_i, \theta_i)$$

1 As the previous section showed formality affects output through the
 2 quantity of capital as formal entrepreneurs can employ a quantity $k_i > k^*$.
 3 Net of the effect of costs of formality ϕ , an entrepreneur i would employ
 4 $k_i > k^*$ if and only if $\theta_i > \theta^*$. Therefore, $f(1, \theta_i) - f(0, \theta_i) > 0$, $\theta_i > \theta^*$ (return
 5 to formality) and $\partial f(\cdot, \cdot) / \partial \theta_i = k_i^\alpha l_i^\beta > 0$ (return to ability).

6 As we have shown, there exists a cut-off value of ability, $\bar{\theta}$, and firms with
 7 ability above that threshold will select into formality. SIMPLES can be
 8 conceived of as a reduction in the cost of formalization to $\phi' < \phi$ (albeit
 9 across many margins: registration costs, labor costs, etc.) that will change
 10 the cut-off value of ability from $\bar{\theta}$ to $\bar{\theta}'$ (Corollary 1). Firms that change their
 11 formality status because of SIMPLES are those with $\theta \in (\bar{\theta}', \bar{\theta}]$. This also
 12 implies that there will be a subset of firms who will not change their
 13 formality status: some will remain formal (*best* entrepreneurs), others will
 14 remain informal (*worst* entrepreneurs).

15 The introduction of SIMPLES by unanticipated administrative decree
 16 can be seen as an exogenous policy change that significantly altered the
 17 incentives to become formal and hence is useful to solve the endogeneity
 18 problem. The theoretical model developed above predicts that only for a
 19 segment of firms we will be able to identify the effect of formality. The
 20 reason is that we will only observe an effect of SIMPLES on those firms
 21 with $\theta \in (\bar{\theta}', \bar{\theta}]$. This is the group of firms that have a large enough θ such
 22 that the SIMPLES tax reduction makes them to re-evaluate their formality
 23 status, but not so large as to make the change in ϕ irrelevant to their
 24 formality decision. This segment contains firms that will become formal
 25 only after the reduction in taxes, and therefore we can identify β_1 by using
 26 the regression discontinuity approach described above. Note that this does
 27 not mean that for firms with $\theta < \bar{\theta}'$ or $\bar{\theta} < \theta$ formality has no effect on the
 28 firm performance variable. Rather ~~that~~ we cannot identify the effect of
 29 formality for those firms.

30 Monteiro and Assunção (2006) argue that for relatively young firms (i.e.,
 31 less than two years old) when the firm was started clearly differentiates firms
 32 that benefit from SIMPLES from those that did not. Although all firms
 33 could benefit from SIMPLES, firms born after SIMPLES show a much
 34 higher propensity to have a license than those born before. Overall this
 35 suggests a dual process for formalization: first, a firm's decision to formalize
 36 is primarily taken at the time of its creation; second, the likelihood of
 37 becoming formal increases with time-in-business.¹⁴ The ECINF provides
 38 some evidence on this: only one out of four licensed business made no
 39 attempt at regularizing at the time of starting up compared to 4 out of 5
 non-licensed business. Thus, the decision of whether to operate formally or

1 informally appears to be made in most cases at the time of start-up. This
 3 could be due either to costly and/or complex registration procedures, to high
 5 tax rates, or to a limited demand among very small businesses for the
 7 government services or the expanded access to markets that are associated
 with formality at any price. While the data do not allow us to distinguish
 among these different two possible explanations, 72% of the firms that do
 attempt to register report having no difficulties in the process.

Monteiro and Assunção (2006) exploit the first process, that is, the
 differential effect on licensing caused by the introduction of SIMPLES for
 firms born before and after it. Let $AFTER$ be an indicator for whether a firm
 was created before or after the SIMPLES was implemented (such that
 $AFTER_i = 1$ if $t_i \leq \bar{t}$ and $AFTER_i = 0$ otherwise, where firms that have been
 in business for at most \bar{t} months were created after SIMPLES) and $ELIG$ an
 indicator for the eligibility status of the firm. Monteiro and Assunção (2006)
 the interaction of eligible/non-eligible and before/after indicators, that is,
 $AFTER \times ELIG$ as an IV difference-in-differences to measure the impact of
 formality on firm performance.

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Fig. 3 plots licensing rates for firms with different dates of creation (see
 section “Data and Descriptive Statistics” for a description of the database
 of micro-firms used). The first two graphs plot separately eligibles and non-
 eligibles for all firms; the last two take only the sample of entrepreneurs that
 started as owners of the firm. The figures show that there is a significant
 jump in licensing rates for eligible firms, but no change for non-eligible
 firms. Moreover, the jump is observed only for firms born about the time of
 the introduction of SIMPLES. Then, as argued in Fajnzylber et al. (2011),
 the validity of $AFTER \times ELIG$ as an IV for formality crucially depends
 on comparing firms that were born just after and before than \bar{t} , that is,
 $|t_i - \bar{t}| < \varepsilon$ for ε small enough.

The regression discontinuity literature (see Hahn et al., 2001; van der
 Klaauw, 2002) argues that an unbiased estimate of the treatment impact can
 be obtained by giving heavier weights to observations arbitrarily close to a
 discontinuity. If, conditional on a set of exogenous covariates, we assume
 very similar distributions of unobservable characteristics of firms born
 immediately before and after SIMPLES implementation, the discontinuity
 that the introduction of SIMPLES introduces in the factors determining
 formality can be exploited to provide unbiased estimates of the local average
 treatment effect of the program. Using this argument, Fajnzylber et al.
 (2011) show that the regression coefficient of $AFTER \times ELIG$ is dependent
 on the weighting scheme. Following these authors we will implement a *fuzzy*
 regression discontinuity design, where on a small enough interval about the

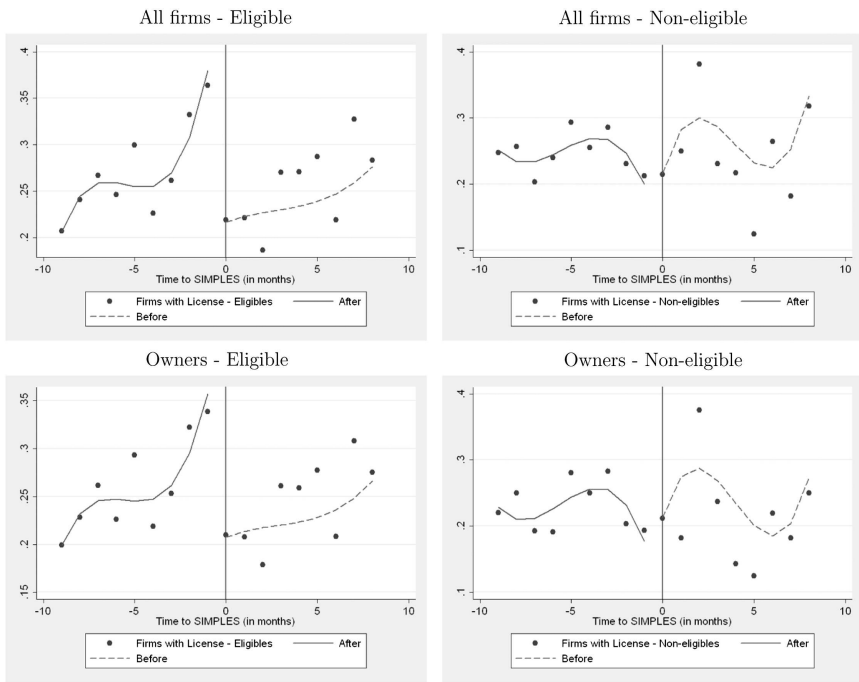


Fig. 3. Average Licensing Rates by Month of Firm Creation. Note: Average licensing rates by reported month of firm creation. Owners: Original owners of the micro-firm.

introduction of SIMPLES, identification can be achieved by comparing firms born just before and just after the SIMPLES introduction.

The validity of the estimates of the effect of formality on revenues relies on the validity of SIMPLES as an IV. In particular, if self-selection into treatment occurred this would produce biased estimates, and the direction of the bias would depend on the correlation between those that benefit from SIMPLES treatment and unobservables. The first concern is that some firms might have strategically delayed their creation after the introduction of SIMPLES, thus changing the composition of firms before and after. Monteiro and Assunção (2006) show that SIMPLES did not produce any change in the number of starting firms as compared to similar months before (i.e., SIMPLES produced no “rush” to start a firm) and it only affected formality of eligible firms. Moreover, Fajnzylber et al. (2011) compare firms

1 born before and after together with eligible and non-eligible firms on several
 2 observable characteristics (education, age, gender, location) and find that
 3 there are no statistically significant differences. While this still does not rule
 4 out differences in unobservables, these characteristics are likely to be
 5 correlated with unobservables, and therefore they provide indirect evidence
 6 for the validity of SIMPLES as an IV. Finally, Monteiro and Assunção
 7 (2006) show that the SIMPLES effect is not due to seasonal effects (they
 8 repeat their analysis one and two years later as if SIMPLES had been
 9 introduced in November 1995 and 1994, respectively, and they found no
 10 effect) which shows that there are no intrinsic differences between firms born
 11 before and after about the November cut-off in other years.

12 The second concern is that SIMPLES might have changed the
 13 composition of eligible and non-eligible firms.¹⁵ First, ~~changes in market~~ AU:6
~~conditions might produce that low skilled entrepreneurs are pushed out by~~
 14 ~~new entrants and excluded from the survey~~, (which is a retrospective survey,
 15 taken one year after SIMPLES, see section “Data and Descriptive
 16 Statistics”). Although we cannot control for potential attrition bias and
 17 sample selection, sectoral transition studies (see Fajnzylber, Maloney, &
 18 Montes-Rojas, 2006; Maloney, 1999) suggests that micro-entrepreneurs will
 19 remain within the micro-firm sector and will not become salaried workers or
 20 unemployed, hence that the micro-entrepreneurs sector will not change its
 21 overall composition. Second, firms might have strategically changed ~~the~~
 22 the industry or sector to become eligible. However, ~~given that~~ the definition of
 23 non-eligibility mostly applies to regulated and professional occupations, for
 24 an entrepreneur to change from the non-eligible to the eligible sector would
 25 require a substantial change in the goods or services offered, a possibility
 26 which seems unlikely in the short run.¹⁶

27 To summarize, our identification strategy allow us to estimate the effect of
 28 formality on firm performance for firms with $\theta \in (\bar{\theta}', \bar{\theta}]$ and born near the
 29 introduction of SIMPLES, that is, $|t_i - \bar{t}| < \varepsilon$ for ε small enough. This
 30 strategy requires the use of both QR (to model θ) and regression
 31 discontinuity designs (to amplify the effect of SIMPLES at the time of its
 32 introduction).

35

36 QUANTILE REGRESSION DISCONTINUITY

37

38 In order to find the threshold values $\bar{\theta}'$ and $\bar{\theta}$ we will consider the single
 39 dimensional conditional quantiles, indexed by $\tau \in (0, 1)$, of the firm’s
 revenues, y ,

$$1 \quad Q_y(\tau|d, x, |t_i - \bar{t}| < \varepsilon) = \beta_1(\tau)d_i + \beta_2(\tau)t_i + \beta_3(\tau)x_i \quad (2)$$

3 where i denotes the firm, d is a binary formality indicator (licensing), t
 5 denotes time-in-business and x is a set of exogenous covariates. If we assume
 7 that for all $\theta_1 \leq \theta_2$ there exists $0 < \tau_1 \leq \tau_2 < 1$, then this conditional quantile
 9 function can be used to find $\bar{\tau}'$ and $\bar{\tau}$ that match $\bar{\theta}'$ and $\bar{\theta}$, respectively. With
 11 the proposed identification we can estimate $\beta_1(\tau)$ for $0 < \bar{\tau}' < \tau < \bar{\tau} < 1$. This
 case was discussed by Chesher (2003) where he argued about “the possibility
 of identification of a structural derivative evaluated at some quantile
 probabilities but not at others”(p. 1411).

13 It should be emphasized that $\beta_1(\tau)$ measures the difference in revenues
 15 due to the effect of licensing (i.e., being formal) and that the conditioning
 17 on a small interval about the introduction of SIMPLES, that is, $|t_i - \bar{t}| < \varepsilon$,
 does not imply this effect occurred in a given interval in time. These
 differences are the result of potentially multiple simultaneous effects, such
 as hiring more labor, capital, access to credit, operating in a fixed
 location, etc.¹⁷ We only focus on the quantile heterogeneity in total
 19 revenues.

21 As argued in the previous section we use $z = (AFTER \times ELIG)$ as a valid
 instrument for d . This identification condition is discussed in Monteiro and
 Assunção (2006) and Fajnzylber et al. (2011). The IVQR estimation method
 23 may be viewed as an appropriate QR analog of the two-stage least squares
 (2SLS) that makes use of a valid exclusion restriction. More formally, and
 25 following Chernozhukov and Hansen (2006, 2008), from the availability of
 an IV, z , we consider estimators defined as:

$$27 \quad \hat{\beta}_1(\tau) = \arg \min_{\beta_1} \|\hat{\gamma}(\beta_1, \tau)\|_A \quad (3)$$

29 where $\hat{\gamma}(\beta_1, \tau)$ is obtained from

$$31 \quad \arg \min_{\beta_2, \beta_3, \gamma} \sum_{i=1}^N \omega(|t_i - \bar{t}|) \rho_\tau(y_i - \beta_1 d_i - \beta_2 t_i - \beta_3 X_i - \gamma z_i) \quad (4)$$

35 with $\omega(\cdot)$ a weighting function that is monotonically decreasing in $|t_i - \bar{t}|$,
 37 $\rho_\tau(\cdot)$ the τ -QR check function, $\|x\|_A = \sqrt{x'Ax}$ and A is a positive
 definite matrix.¹⁸ Differently to IV least squares, however, it does not have
 a first stage.

39 The asymptotic properties of the estimator are described in Chernozhu-
 kov and Hansen (2006, 2008). In particular asymptotic normality holds,

1
$$\sqrt{n}(\hat{\beta}(\tau) - \beta(\tau)) \xrightarrow{d} N(0, J(\tau)^{-1} S(\tau) J(\tau)^{-1})$$

3 where $\beta = (\beta_1, \beta_2, \beta_3)'$, $J(\tau) = E[f_{\varepsilon(\tau)}(0|d, t, x, z)(t, X, z)(d, t, x)']$ with $\varepsilon(\tau) =$
 5 $y_i - \beta_1 d_i - \beta_2 t_i - \beta_3 x_i - \gamma z_i$, $f_{\varepsilon(\tau)}(\cdot)$ the density function, and $S(\tau) =$
 $(\min(\tau, \tau') - \tau\tau')E[(d, t, x)(t, x, z)']$.

7 We refer the reader to Chernozhukov and Hansen (2005, 2006) for a more
 9 detailed discussion on the assumptions used for identification and the
 asymptotic results of the IVQR estimator. One important assumption for
 11 identification of the IVQR is rank invariance. This implies that, conditional
 on all other variables, a common unobserved factor, such as unobserved
 13 ability, determines the ranking in the outcome conditional distribution of a
 given subject across treatment states.¹⁹ In our application, a firm considers a
 15 binary formality variable, $d \in \{0, 1\}$. The potential outcome under each level
 is given by the firm’s earnings under the different licensing $\{y_d, d = 0, 1\}$. We
 17 assume that the potential revenue outcomes, conditional on $X = (x, t)$, are
 given by Eq. (2), $Q_{y_d}(U|d, x, t) = \beta_1(U)d + \beta_2(U)t + \beta_3(U)x$, where rank
 19 $U \sim U(0,1)$ indexes the unobserved heterogeneity, $U(0,1)$ denotes the
 standard Uniform distribution, and $Q_{y_d}(U|d, x, t)$ is increasing in U . Thus,
 the distribution of potential outcome y_d is characterized by the quantile
 21 functions $Q_{y_d}(U|d, x, t)$. The rank variable U is assumed to be determined by
 entrepreneurial ability and other unobserved factors that do not vary with d .
 23 Moreover, in this model, the independence condition only requires that U is
 independent of the instruments z , conditional on X . Finally, the rank
 25 variable U (entrepreneurial ability) is assumed invariant to d , which ascribes
 an important role to conditioning on covariates X . Having a rich set of
 27 covariates makes rank invariance a more plausible approximation.

29

ECONOMETRIC RESULTS

31

Our main goal is the estimation of Eq. (2), that is, the conditional quantiles
 33 of the logarithm of total revenues. In order to implement this we follow the
 strategy described in section “The SIMPLES Program and Identification
 35 Strategy,” where *AFTER* \times *ELIG* is used as an IV for having a license.²⁰ We
 increase the power of the instrument by interacting it with gender and age of
 37 the entrepreneur. Moreover, we use the same weighting scheme as in
 Fajnzylber et al. (2011) with $\omega(|t_i - \bar{t}|) = f(0, |t_i - \bar{t}|)$, where $f(0, \sigma)$ is the
 39 normal density of a standard Gaussian random variable with mean 0 and
 standard deviation σ .

1 Our measure of firm performance y is the logarithm of total monthly
2 revenues. Unfortunately, we cannot apply the same analysis to profits,
3 because this would need additional instruments for both capital and labor,
4 which are endogenous and affected by SIMPLES. Moreover, there may be
5 measurement errors in the cost of capital and imputation of the owner's
6 salary. These are potentially large in micro-firms surveys. Therefore, the
7 return to formality is the ultimate effect on revenues arising from several
8 channels: hiring both more labor and capital, higher productivity, more
9 business opportunities, access to credit, etc. This effect may also include
10 changes in the composition of clients as in Paula and Scheinkman (2007)
11 model. As additional control variables x we use the *AFTER*, *ELIG*, gender
(dummy for female), age and education of the entrepreneur (the latter as
12 categorical dummies, base category: no formal education), number of
13 members in the household, a set of dummy variables for the reasons to
14 become an entrepreneur, time-in-business (interacted with *AFTER* and as a
15 square polynomial), and dummy variables by industry and state.

16 Tables 1 and 2 present the 2SLS and IVQR estimates of the conditional
17 mean and quantiles (selected quantiles) of firm revenues for the selected
18 weighting scheme described above for all and for those entrepreneurs that
19 started as owners, respectively. Figs. 4 and 5 summarizes the effect of
20 licensing on firm revenues.
21

22 The figures show that the effect of licensing is not statistically significant
23 for $\tau < 0.10$ and $\tau > 0.60$ ($\tau > 0.50$ for the sample of original owners). This
24 suggest that, in terms of the characterization proposed in this paper, $\bar{\theta}' =$
25 0.10 and that therefore, 10% of the sample corresponds to the entrepreneurs
26 that did not benefit from SIMPLES because they opted out of formality
27 even after the tax reduction. Moreover, $\bar{\theta} = 0.50(0.60)$, and then the upper
28 50% (40%) of the sample were already considering that the cost of formality
29 was not very high. For these segments, we cannot identify the effect of
30 formality through the introduction of SIMPLES. Taking the complement of
31 those groups, we define the *target* population given by $0.10 \leq \tau \leq 0.50$ or
32 $0.10 \leq \tau \leq 0.60$ depending on the sample. Note that for this group the effect is
33 roughly similar to the 2SLS estimate.

34 Note, however, that the point estimates being non-statistically significant
35 does not imply that the instruments are not working and that the effect of
36 licensing cannot be identified. In fact, this cannot be a priori be
37 distinguished from it being statistically equal to zero. The lack of a first
38 stage does not allow us to use the OLS techniques for evaluating the IV
39 performance. Therefore, we propose a new procedure based on the
Chernozhukov and Hansen (2006, 2008) estimator. If the identification

Table 1. Quantile Regression Discontinuity Analysis – All Micro-Firms.

	IV Least-Squares Regression	IV Quantile Regression				
		$\tau = 0.1$	$\tau = 0.25$	$\tau = 0.5$	$\tau = 0.75$	$\tau = 0.9$
License	3.40*** (1.04)	2.03* (1.09)	3.48*** (0.66)	1.90*** (0.49)	4.92 (6.93)	2.60 (4.15)
Female	-0.546*** (0.075)	-0.676*** (0.162)	-0.292 (0.200)	-0.587*** (0.100)	-0.474*** (0.111)	-0.538*** (0.120)
Age	0.0039** (0.020)	-0.0021 (0.0059)	0.021 (0.006)	0.016*** (0.004)	0.018 (0.015)	0.030** (0.14)
<i>Education categories (base: no formal education)</i>						
Primary <i>inc_a</i>	0.334*** (0.090)	0.195 (0.253)	0.425 (0.296)	0.672*** (0.136)	0.988** (0.414)	1.24*** (0.16)
Primary <i>comp_a</i>	0.411*** (0.119)	0.135 (0.388)	0.555* (0.329)	0.918* (0.49)	1.19** (0.47)	1.52*** (0.37)
Secondary <i>inc_a</i>	0.735*** (0.111)	0.562** (0.313)	1.15*** (0.36)	1.16*** (0.16)	1.37*** (0.46)	1.66*** (0.21)
Secondary <i>comp_a</i>	0.591*** (0.196)	0.632** (0.306)	0.633* (0.351)	1.21*** (0.17)	1.39** (0.58)	1.90*** (0.23)
College <i>inc_a</i>	0.573* (0.301)	0.717 (0.492)	0.764* (0.455)	1.41*** (0.47)	1.75*** (0.57)	2.08*** (0.50)
<i>Reasons to become entrepreneur (base: did not find a job)</i>						
Profitable business	0.402* (0.287)	0.968** (0.441)	-0.103 (0.614)	0.513 (0.441)	1.136** (0.454)	1.64** (0.65)
Flexible hours	0.227* (0.132)	-0.022 (0.338)	0.397 (0.496)	0.127 (0.184)	0.369 (0.386)	0.476 (0.445)
Be independent	0.127 (0.165)	0.350 (0.286)	0.048 (0.268)	0.409*** (0.118)	0.390** (0.165)	0.472 (0.322)
Family tradition	-0.230 (0.302)	-0.526 (1.225)	0.030 (0.354)	0.494** (0.214)	0.334 (0.427)	0.689 (1.304)
To help family income	-0.204*** (0.060)	-0.469** (0.211)	-0.152 (0.203)	-0.171* (0.110)	-0.023 (0.120)	-0.029 (0.156)
Accumulated experience	0.330** (0.151)	0.530** (0.230)	0.447** (0.244)	0.422*** (0.158)	0.407 (0.519)	0.909 (0.912)
Make good deal	0.090 (0.136)	-0.070 (0.470)	0.061** (0.301)	0.409*** (0.153)	0.558*** (0.211)	0.395 (0.405)
As a secondary job	0.558*** (0.178)	1.013*** (0.413)	0.886** (0.495)	0.380 (0.338)	0.968** (0.431)	0.768** (0.353)

Note: 6,741 observations. Standard errors in parenthesis. Instrumental variables: *AFTER* × *ELIG* interacted with gender and age of the entrepreneur. See text for additional details.
 *Significant at the 10% level; **Significant at the 5% level; ***Significant at the 1% level.

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Table 2. Quantile Regression Discontinuity Analysis – Owners.

	IV Least-Squares Regression	IV Quantile Regression				
		$\tau = 0.1$	$\tau = 0.25$	$\tau = 0.5$	$\tau = 0.75$	$\tau = 0.9$
License	3.23*** (0.97)	4.97*** (1.61)	3.37*** (0.73)	1.87** (0.82)	5.00 (7.53)	2.98 (2.65)
Female	-0.549*** (0.077)	-0.034 (0.382)	-0.317* (0.176)	-0.577*** (0.095)	-0.482*** (0.112)	-0.421*** (0.135)
Age	0.0043** (0.019)	0.015 (0.012)	0.021*** (0.006)	0.015*** (0.004)	0.019 (0.017)	0.027** (0.11)
<i>Education categories (base: no formal education)</i>						
Primary <i>inc_a</i>	0.294*** (0.095)	-0.364 (0.686)	0.291 (0.258)	0.606*** (0.164)	0.968* (0.459)	1.17*** (0.20)
Primary <i>comp_a</i>	0.391*** (0.121)	-0.058 (0.772)	0.480 (0.293)	0.863*** (0.157)	1.17 (0.51)	1.37*** (0.32)
Secondary <i>inc_a</i>	0.718*** (0.111)	0.307 (0.883)	1.05 (0.30)	1.09*** (0.17)	1.42*** (0.52)	1.66*** (0.24)
Secondary <i>comp_a</i>	0.553*** (0.201)	-0.014 (1.054)	0.570 (0.320)	1.14*** (0.18)	1.36** (0.64)	1.74*** (0.24)
College <i>inc_a</i>	0.647** (0.278)	0.487 (1.013)	0.728 (0.512)	1.52*** (0.45)	1.88*** (0.66)	2.04*** (0.37)
<i>Reasons to become entrepreneur (base: did not find a job)</i>						
Profitable business	0.222 (0.300)	-0.201 (0.961)	-0.106 (0.747)	0.685 (0.690)	0.863 (0.742)	1.71*** (0.36)
Flexible hours	0.387*** (0.140)	0.853 (0.690)	0.325 (0.400)	0.177 (0.208)	0.369 (0.366)	0.770 (0.478)
Be independent	0.182 (0.146)	-0.257 (0.433)	0.089 (0.258)	0.445*** (0.120)	0.384** (0.158)	0.367* (0.226)
Family tradition	0.172 (0.262)	-0.618 (1.257)	0.189 (0.342)	0.688*** (0.255)	0.486 (0.387)	1.00** (0.496)
To help family income	-0.224*** (0.058)	-0.104 (0.301)	-0.208 (0.205)	-0.210** (0.113)	-0.062 (0.132)	-0.063 (0.174)
Accumulated experience	0.323** (0.148)	-0.017 (0.675)	0.393* (0.246)	0.426** (0.197)	0.395 (0.555)	0.944* (0.592)
Make good deal	0.084 (0.132)	-0.452 (0.437)	0.050 (0.298)	0.448** (0.193)	0.526*** (0.203)	0.370* (0.193)
As a secondary job	0.657*** (0.194)	1.58*** (0.64)	1.03*** (0.337)	0.478 (0.311)	1.00** (0.411)	0.569** (0.228)

Note: 6,300 observations. Standard errors in parenthesis. Instrumental variables: *AFTER* × *ELIG* interacted with gender and age of the entrepreneur. See text for additional details.
*Significant at the 10% level; **Significant at the 5% level; ***Significant at the 1% level.

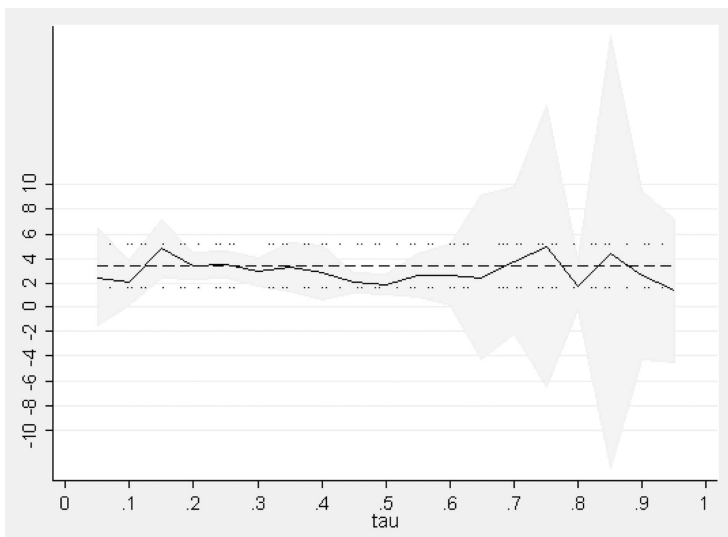
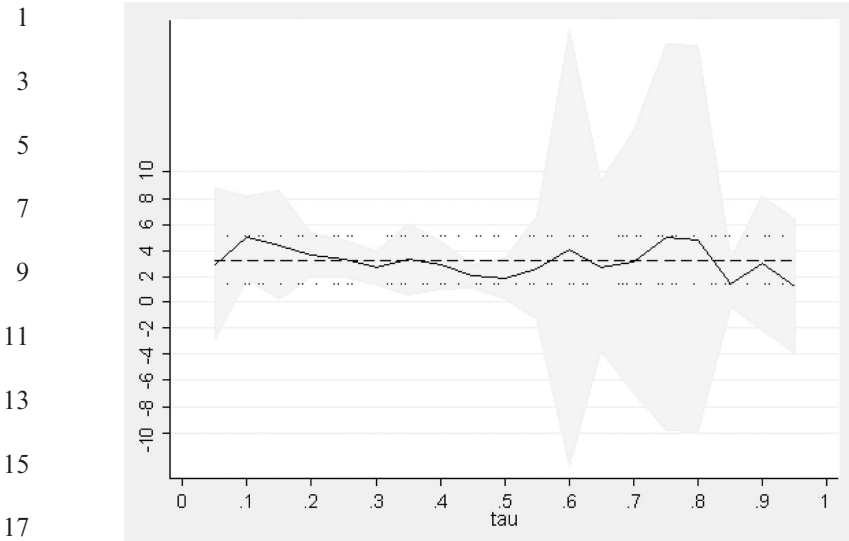


Fig. 4. Quantile Regression, All Micro-Firms. *Note:* Plot for 2SLS and IVQR estimates with their corresponding 95% confidence intervals. y -axis contains the coefficient estimates and x -axis the quantiles. The dashed horizontal line is the 2SLS estimate, and the dotted lines the corresponding confidence interval. the solid line is the IVQR estimate, and the shadow its corresponding confidence interval.

strategy using the IV works well, then $\hat{\gamma}(\beta_1, \tau)$, based on Eq. (3), should have a clear global minimum. If, however, the IV is not appropriate, it should not have a clear minimum. We thus plot several graphs of $(\hat{\gamma}(\tau), \beta_1)$ for different quantiles τ and analyze them. Figs. 6 and 7 report these for both samples and $\tau \in \{0.10, 0.25, 0.50, 0.75, 0.90\}$. From the graphs it can be noted that only for $\tau \in \{0.25, 0.50\}$ the function is convex almost everywhere with a clear minimum, but it is less so for the remaining quantiles. This implies that the lack of significance in $\hat{\beta}_1$ is associated with an IV that does not satisfy the Chernozhukov and Hansen (2006, 2008) identification criterion.

The 2SLS point estimate is 3.40 (SE 1.04) for all firms and 3.23 (SE 0.97) for the owners subsample. Note that the subsample of firms whose current entrepreneur was the original owner has higher standard errors. These high and rather imprecise estimates are similar in magnitude to those in Monteiro and Assunção (2006) and Fajnzylber et al. (2011). Moreover, although not

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19 *Fig. 5. Quantile Regression, Started Firm as Owner. Note:* Plot for 2SLS and IVQR
 21 estimates with their corresponding 95% confidence intervals. *y*-axis contains the
 coefficient estimates and *x*-axis the quantiles. The dashed horizontal line is the 2SLS
 estimate, and the dotted lines the corresponding confidence interval. The solid line is
 the IVQR estimate, and the shadow its corresponding confidence interval.

25 reported, similar point estimates are obtained in levels if we compute the
 corresponding percentage increment. As a result the large log estimates
 27 appear because of the fact that firms have in fact low levels of revenues.
 Overall, they clearly point out that formality (licensing) has a positive effect
 29 on firms' revenues. In fact, these high positive effects are observed for all
 quantiles, although as mentioned above the effect is statistically significant
 31 only for the *target* population.

To examine the heterogeneity associated with the IVQR estimates we
 33 perform diagnosis tests using Kolmogorov–Smirnov tests.²¹ First, we test
 the hypothesis of a zero constant coefficient for the IVQR estimates across
 35 quantiles, that is, we test the hypothesis that $H_0 : \beta_1(\tau) = 0$. In order to
 implement the test, we estimate the model for $\tau \in [0.1, 0.9]$, compute the
 37 Wald statistic for each particular quantile and take the maximum over the
 corresponding quantiles. The results for the test statistics are 27.83 and
 39 21.74 for the all micro-firms and owners samples, respectively. These

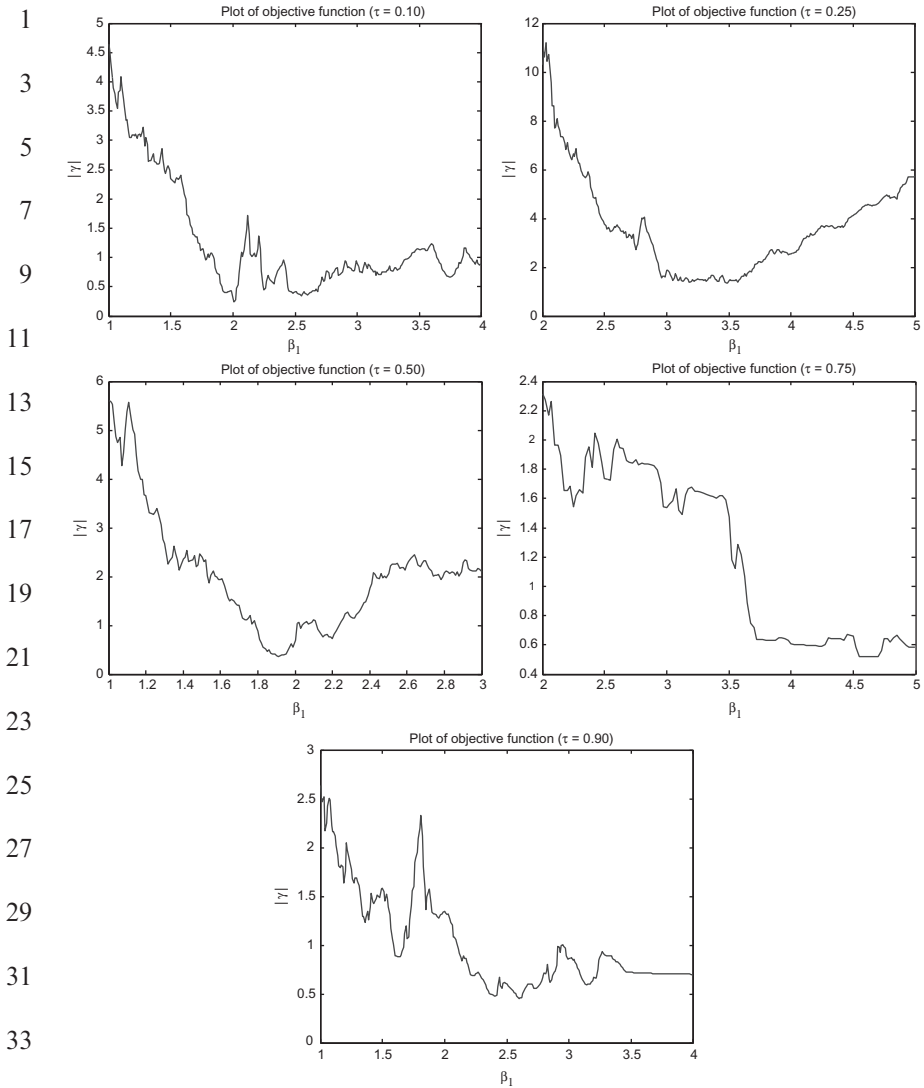


Fig. 6. Validity of the IV. Note: Plot of the function $\|\hat{\gamma}\|$ – all micro-firms. y -axis contains the estimates of $\|\hat{\gamma}\|$ and x -axis β_1 . Selected quantiles $\tau = \{0.10, 0.25, 0.50, 0.75, 0.90\}$.

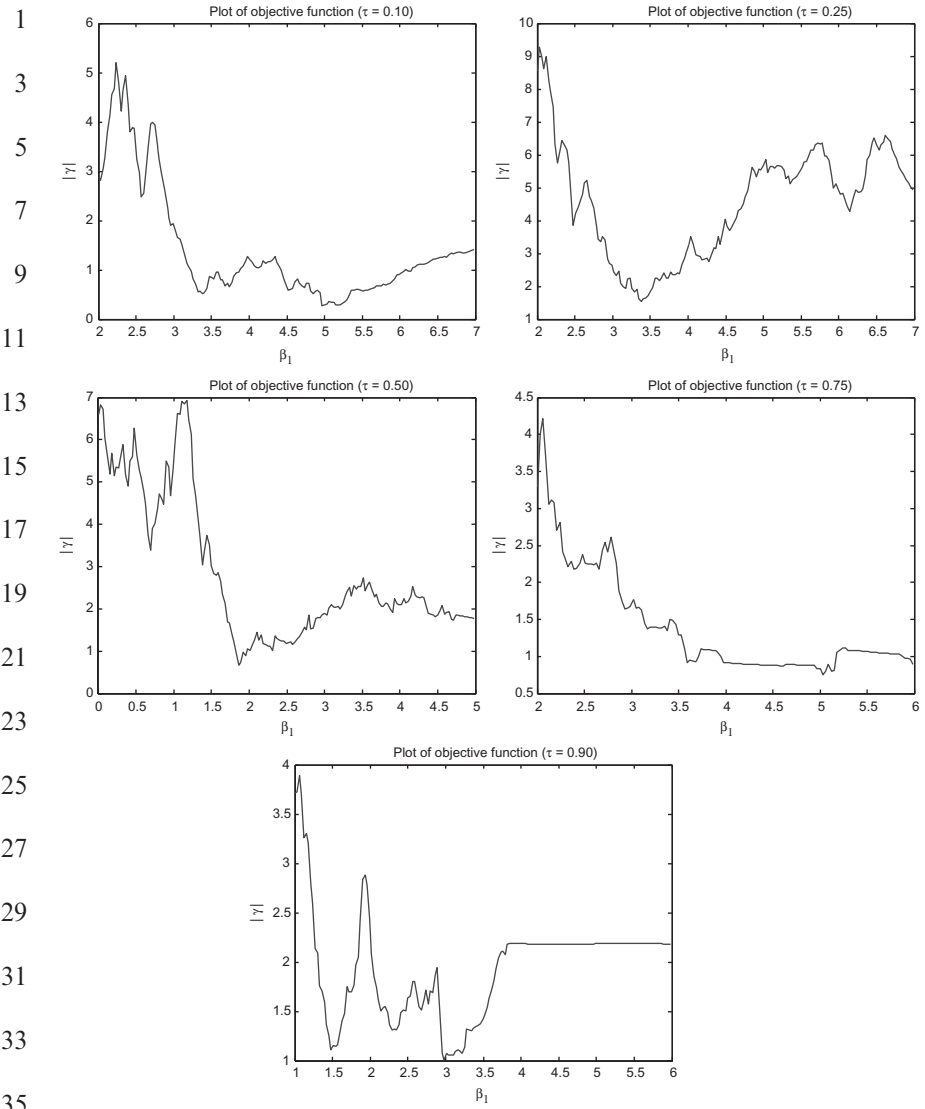


Fig. 7. Validity of the IV. Note: Plot of the function $\|\hat{\gamma}\|$ – owners. y-axis contains the estimates of $\|\hat{\gamma}\|$ and x-axis β_1 . Selected quantiles $\tau = \{0.10, 0.25, 0.50, 0.75, 0.90\}$.

1 results strongly reject the null hypothesis at the 1% level of significance
(the critical values are: 12.69 at 1% level of significance, 9.31 at 5% level of
3 significance, and 7.63 at 10% level of significance). Thus, there exists
strong evidence to reject the hypothesis of zero or negative impact of
5 licensing on log revenues.

Second, we test the hypothesis of a constant given effect of SIMPLES on
7 revenues, that is, $H_0 : \beta_1(\tau) = \bar{\beta}$, where we set $\bar{\beta}$ as the 2SLS estimate. The
results for the tests statistics are 9.43 and 6.53 for all micro-firm and
9 owners samples respectively, such that we reject the null at 5% level of
significance for the first case. Thus, although the confidence interval of the
11 IVQR contains the point estimate of 2SLS, for various intermediate
quantiles, the evidence suggests that the effect of SIMPLES on revenues is
13 heterogeneous. However, in the second sample the wide confidence
intervals made the 2SLS estimate to remain inside the bands and we
15 cannot reject the null hypothesis.

Finally, we apply the latter test, $H_0 : \beta_1(\tau) = \bar{\beta}$, only over the selected
17 quantiles where we have evidence of identification of the parameters of
interest, that is, for $\tau \in [0.10, 0.60]$ ($\tau \in [0.10, 0.50]$ for the sample of original
19 owners).²² In this case, the results for the test statistics are 11.08 and 7.57 for
all micro-firms and owners subsamples, respectively, such that we reject the
21 null at 5% level of significance for the first case, and at 10% for the second
case. This shows that there is heterogeneity within the target group segment.
23 In fact, we observe that the effect is actually decreasing on τ for this range.
This result contradicts that in Proposition 2 and could be due to the non-
25 convexities described in McKenzie and Woodruff (2006), where the return
to capital is higher for low-capital firms. Overall, this suggests that, over the
27 range of identified quantiles, the formality treatment has a bigger impact on
low quantiles than in high quantiles.

29 The study of the covariate effects is of independent interest too. The
negative coefficient of female reflects the fact that women engage in less
31 profitable activities, possibly due to household commitments or outright
gender discrimination.²³ There is no clear pattern across quantiles, which
33 determines that the gender effect applies uniformly to all types of firms.
Education is non-monotonic for the conditional mean model and for low
35 quantiles. In those cases, incomplete secondary education has the highest
effect in both subsamples. However, education becomes monotonically
37 increasing for $\tau \geq 0.5$. This determines that for firms in the low conditional
quantiles, higher education is not necessarily associated with higher
39 revenues, but it is with outstanding firms. Finally, the reasons to become
entrepreneur show interesting variability across quantiles. Reasons such as

1 “Accumulated experience”, “Be independent”, “Make a good deal” and
3 “Profitable business” which may be associated with entrepreneurs with high
5 ability are larger for high quantiles, while reasons for low-ability
entrepreneurs (such as “To help family income”) are larger for the low
quantiles.

We also implement the method of Frolich and Melly (2008) and Frandsen
(2008) for comparison reasons. This estimator differs in several aspects to
the one proposed here. First, it corresponds to a standard regression
discontinuity design and is not designed to be used in a difference-in-
differences fashion. In our setup we implement this estimator by comparing
only treated (born after SIMPLES) and non-treated (born before
SIMPLES) considering a discontinuity in age of the firm. Second, as a
nonparametric estimator, it poses difficulties with a large set of covariates.
Thus, we implement the estimator without covariates and then, following
Frolich and Melly (2008), we use an alternative parametric specification
using the propensity score ($\text{Prob}[t_i \geq \bar{t}|d, x, |t_i - \bar{t}| < \varepsilon]$) as a unique
conditioning variable. Third, standard errors are available only for the
case without covariates, and therefore only point estimates are provided for
the case with covariates. Finally, the choice of bandwidth is always an
important concern in nonparametric and semiparametric estimation, and
estimates may have large variation depending on the bandwidth. We
therefore use three different choices of bandwidth.

We estimate the model using the subsample of all micro-firms.²⁴ The
results for both estimators, with and without covariates, are presented in
Table 3. Regarding the case with no covariates, there are only a few
quantiles where the point estimates are statistically different from zero. The
point estimates for the bandwidths two and three are somehow similar to the
IVQR estimates, while those for a bandwidth of four are negative and are
not statistically different from zero, evidencing the sensitivity to the
bandwidth choice. When covariates are used through the propensity score,
the point estimates are reduced to 1.1 on average. These point estimates
provide additional evidence on formality having a positive effect on
revenues. As mentioned above, the lack of a measure of dispersion precludes
us to provide any inference on these estimates. Thus, we are not able to
statistically analyze the question posed in the paper regarding which firms
benefit from the reduction in formality costs. However, given the large
standard errors for the IV estimates presented in Tables 1 and 2, in most
cases, these nonparametric estimates are included in the 95% confidence
intervals of the estimates discussed above.

1 **Table 3.** Nonparametric Analysis Without and With Covariates – All
 2 Micro-Firms.

3	Quantiles	Without Covariates			With Covariates		
5		Band = 2	Band = 3	Band = 4	Band = 2	Band = 3	Band = 4
7	$\tau = 0.1$	5.586 (5.92)	3.832 (3.74)	-3.011 (2.30)	1.194 -	1.281 -	1.281 -
9	$\tau = 0.2$	4.500 (7.16)	3.832 (3.70)	-2.606 (2.99)	1.099 -	1.099 -	1.099 -
11	$\tau = 0.3$	4.605 (6.17)	3.817 (5.16)	-2.548 (1.50)	1.066 -	0.971 -	1.012 -
13	$\tau = 0.4$	4.700 (11.94)	4.209 (3.83)	-2.534* (1.36)	1.130 -	1.003 -	1.099 -
15	$\tau = 0.5$	4.423* (2.30)	4.081 (3.89)	-2.485** (1.24)	1.110 -	1.110 -	1.099 -
17	$\tau = 0.6$	4.423* (2.40)	4.159 (4.27)	-2.659 (2.05)	1.099 -	1.012 -	1.107 -
19	$\tau = 0.7$	4.423* (2.49)	4.338 (4.65)	-3.079 (2.69)	1.163 -	1.163 -	1.163 -
21	$\tau = 0.8$	4.423* (2.59)	4.232 (3.48)	-3.344* (1.77)	1.139 -	1.139 -	1.281 -
	$\tau = 0.9$	4.605 (9.23)	4.232 (3.47)	-2.784 (1.78)	1.124 -	1.046 -	1.225 -

Note: 6,741 observations. Band = Bandwidth. Standard errors in parenthesis.

*Significant at the asymptotic 10% level; **Significant at the asymptotic 5% level;

***Significant at the asymptotic 1% level.

CONCLUSION AND POLICY IMPLICATIONS

The econometric results are summarized as follows. First, the results show positive point estimates evidencing that formality has a positive effect on revenues. Overall this confirms the effect of formality on firm performance is positive and suggests that formality gains are potentially large. From a policy perspective this implies that improving institutions to increase participation benefits the micro-firm sector. Reducing the cost of formality allows firms to approach the steady state size dictated by their intrinsic entrepreneurial ability.

Second, the answer to the question “which firms benefit from the tax reduction and simplification?” is given by the estimates from the empirical exercise showing that the *target* population corresponds to τ quantiles in $0.10 \leq \tau \leq 0.50$ or $0.10 \leq \tau \leq 0.60$ depending on the sample. This means that

1 SIMPLES had a potential effect on 40–50% of the micro-entrepreneur
 3 population, mostly concentrated on low-ability firms. Note that this
 5 corresponds to benefits in terms of changing formality status (i.e., becoming
 7 formal) not on the overall effect of SIMPLES, because SIMPLES also had
 9 benefits for those already formal that would face lower taxes. The
 11 theoretical model also shows that the larger is the tax reduction, the larger
 13 will be the segment of firms that will change their formality status.

15 Third, for the *target* group where the effect of formality can be
 17 identified, we find evidence of heterogeneity across quantiles on the impact
 19 of license on the conditional distribution of revenues. These estimates
 21 suggest that reducing the cost of formality might significantly benefit low-
 23 ability firms more. However, these effects can only be studied for the
 25 quantiles where the effect of formality can be identified, and therefore, we
 27 cannot offer a complete analysis of the heterogeneity in the effect of
 29 formality on revenues.

17 NOTES

19 1. Régimen Simplificado para Pequeños Contribuyentes, see González (2006).

21 2. SARE stands for “Sistema de Apertura Rápida de Empresas.” It was
 23 implemented in selected municipalities and consolidated in single local offices all
 25 the federal, state, and municipal procedures needed to register a firm, reducing the
 27 total duration of the process to at most 48 hours.

29 3. SIMPLES stands for “Sistema Integrado de Pagamento de Impostos e
 31 Contribuições as Microempresas e Empresas de Pequeno Porte.” See section “The
 33 SIMPLES Program and Identification Strategy” for a detailed description of the
 35 program.

37 4. This is the definition adopted in Fajnzylber et al. (2009, 2011).

39 5. Ability is thus only relevant when managing a firm. Modeling the salaried
 sector exceeds the scope of this paper.

6. The results of the model would still apply with any concave production
 function.

7. The functional form of the probability of detection could be more general:
 Paula and Scheinkman (2007) show that as long as p is an increasing function of k
 there is still a threshold level of ability such that entrepreneurs go from informal to
 formal and therefore the same conclusions hold.

8. As in Rauch (1991) and Paula and Scheinkman (2007, 2010) the weakly
 monotonic relationship between exogenous ability and optimal level of formality is
 implied by the standard assumption of convex technology. Non-convex profit
 functions could imply more than one crossing point; hence, a non-monotonic
 relationship over a certain range of ability, but the relationship would still be
 monotonic for high levels of ability if formality constraints the production set.

1 Moreover, it could be an interesting avenue for future research to analyze the possibility that ability is not exogenous but is affected by the formality/informality decision, for instance by learning dynamics.

3 9. As the tax rate ϕ changes, the equilibrium wage may in principle change. Ceteris paribus, a decrease in the tax fosters a larger formal sector, but this effect increases in turn the demand for labor. We abstract from the possibility of a change in the salaried wage.

7 10. We use $\alpha=0.2$, $\beta=0.7$, $r=3$, $w=5$. Then, it can be computed that $k^*=3.123$ and $\theta^*=10$. Fig. 1 shows the informal entrepreneurs' profit (thick line) and those of formal entrepreneurs given $\phi=0.2$ (thin line) and given $\phi'=0.1$ (dashed line). It can be computed that the threshold value of ability is $\theta=16.1$ for $\phi=0.2$ and decreases to $\bar{\theta}=13.2$ for $\phi'=0.1$.

11 11. These would be the case with the non-convexities described in McKenzie and Woodruff (2006), where the return to capital is higher for low-capital firms.

13 12. Given values $\alpha=0.2$, $\beta=0.7$, $r=3$, $w=5$, it can be computed that $k^*=3.123$ and $\theta^*=10$. Fig. 2 shows a plot of the informal entrepreneurs' profit (thick line) and those of formal entrepreneurs given $\phi=500$ (thin line) and given $\phi'=250$ (dashed line). It can be computed that the threshold value of ability is $\theta=16$ for $\phi=500$ and decreases to $\bar{\theta}=14.5$ for $\phi'=250$.

17 13. This corresponds to the indicator variable *ELIG* below.

14. See the analysis for micro-firms in Mexico and other evidence for Latin American countries in Fajnzylber et al. (2009).

19 15. We thank Tiziano Razzolini and an anonymous referee for pointing this out.

16. A formal analysis of the choice non-eligible vs. eligible sector and of the general equilibrium effects of a reduction in the cost of formality (see Note 9) goes beyond the scope of the present paper.

23 17. We thank an anonymous referee for pointing this out.

18. As discussed in Chernozhukov and Hansen (2006), the exact form of A is irrelevant when the model is exactly identified, but it is desirable to set A equal to the asymptotic variance-covariance matrix of $\hat{\gamma}(\alpha(\tau), \tau)$ otherwise.

19. Chernozhukov and Hansen (2005) show that it is possible to achieve identification with IVQR using a weaker assumption called rank similarity. Rank similarity relaxes exact rank invariance by allowing unsystematic deviations, "slippages" in one's rank away from some common level.

20. The implied first-stage regression is $License_i = \alpha_1 AFTER_i + \alpha_2 ELIG_i + \alpha_3 (AFTER_i \times ELIG_i) + \alpha_4 x_i + e_i$.

21. Kolmogorov-Smirnov test in QR are discussed in Chernozhukov and Hansen (2006) and Koenker (2005).

22. In general the index used for Kolmogorov-Smirnov tests in QR is symmetric of the form $[\varepsilon, 1-\varepsilon]$. However, in some situations it is desirable to restrict the interval of estimation to a subinterval, as $[\tau_0, \tau_1] \in (0, 1)$. As Koenker (2005) discusses, this can be easily accommodated by using a renormalized statistic.

23. However, as argued by an anonymous referee, it is also the case that women engage in less risky activities, and it is not necessarily the case that more risk is optimal.

24. Similar results are obtained for the owners-only subsample. Results are available from the authors upon request.

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APPENDIX

Proof of Proposition 1

An entrepreneur with ability $\theta_i \leq \theta^*$ always finds optimal to be informal. An entrepreneur with ability $\theta_i > \theta^*$ finds optimal to become formal if and only if $\pi_i^F \geq \pi_i^I$. Plugging the first-order conditions into Eq. (1) we obtain that

$$\pi^I(\theta^*) = (1 - \alpha - \beta)\theta^{*(1/(1-\alpha-\beta))} \left(\frac{\alpha}{r}\right)^{\alpha/(1-\alpha-\beta)} \left(\frac{\beta}{w}\right)^{\beta/(1-\alpha-\beta)}$$

and

$$\pi^F(\theta_i) = (1 - \alpha - \beta)((1 - \phi)\theta_i)^{1/(1-\alpha-\beta)} \left(\frac{\alpha}{r}\right)^{\alpha/(1-\alpha-\beta)} \left(\frac{\beta}{w}\right)^{\beta/(1-\alpha-\beta)}$$

An entrepreneur with ability $\theta_i > \theta^*$ who decides to be informal will choose capital k^* and labor $l^I(k^*, \theta^i) = (\beta\theta^i k^{*\alpha}/w)^{1/(1-\beta)}$. Defining $\gamma_i \equiv \theta_i/\theta^* - 1$ we can re-express $\theta_i = (1 + \gamma_i)\theta^*$ and $l^I(k^*, \theta^i) = (1 + \gamma_i)l^*$. Plugging k^* and $l^I(k^*, \theta_i)$ into the expression for the profit of a formal entrepreneur we obtain that $\pi^I(\theta_i) = (1 + \gamma_i)^{1/(1-\beta)}(1 - \alpha/(1 + \gamma_i)^{1/(1-\beta)} - \beta)\theta^{*(1/(1-\alpha-\beta))}(\alpha/r)^{\alpha/(1-\alpha-\beta)}(\beta/w)^{\beta/(1-\alpha-\beta)}$.

Therefore, we obtain that $\pi^I(\theta_i) > \pi^F(\theta_i)$ if and only if $((1 + \gamma_i)^{\alpha/((1+\beta)(1-\alpha-\beta))}) / (1 - (\alpha/((1 + \gamma_i)^{1/(1-\beta)} - \beta)) < 1/((1 - \alpha - \beta)(1 - \phi)^{1/(1-\alpha-\beta)})$. The left-hand side

$$\frac{(1 + \gamma_i)^{\alpha/(1+\beta)(1-\alpha-\beta)}}{1 - \alpha/(1 + \gamma_i)^{1/(1-\beta)} - \beta} \quad (5)$$

of the inequality above increases in γ_i as the derivative of Eq. (5) $d(\cdot)/d\gamma_i = (\alpha(1 - x)/(1 - \alpha - \beta))x^{(\alpha/(1-\beta)(1-\alpha-\beta)-1)}/D^2$, where $D \equiv$ denominator of Eq. (5), $x \equiv (1 + \gamma)^{-1/(1-\beta)}$ and $0 < x < 1$.

Define $\bar{\gamma}$ such that the condition above is satisfied with equality. This condition identifies a threshold level of ability $\bar{\theta} = (1 + \bar{\gamma})\theta^*$ such that an entrepreneur i decides to become formal if and only if $\theta_i > \bar{\theta}$.

Notice that the right-hand side of the inequality increases in ϕ therefore $\bar{\gamma}$ and $\bar{\theta}$ increase in ϕ . QED

1 *Proof of Proposition 2*

3 The second cross-derivative $d^2\pi^F(\cdot)/d\theta d\phi$ is negative. Therefore, the
 4 difference $(\pi^F(\phi') - \pi^F(\phi))$, where $\phi' < \phi$, increases in θ . This proves the
 5 proposition for formal entrepreneurs. $\pi^F(\phi')$ increases in θ at a faster rate
 6 than $\pi^F(\phi)$ as $d^2\pi^F(\cdot)/(d\theta)^2$ is decreasing in ϕ . The result of Proposition 1
 7 (single crossing between π^F and π^I) implies that $\pi^F(\phi)$ increases at a faster
 8 rate than π^I for $\theta < \bar{\theta}$. Therefore, it must be the case that $\pi^F(\phi')$ increases at a
 9 faster rate than π^I for $\theta \in [\bar{\theta}', \bar{\theta}]$, where $\bar{\theta}'$ is the new cut-off level of ability
 10 given ϕ' . Therefore, this proves the proposition also for those entrepreneurs
 11 that change their status from informal to formal as a result of the policy
 12 change.

13 Plugging the first-order conditions into the expression for output/
 14 revenue $y_i = \theta_i k_i^\alpha l_i^\beta$ we obtain that

15
$$y^I(\theta^*) = \theta^{*(1/(1-\alpha-\beta))} \left(\frac{\alpha}{r}\right)^{\alpha/(1-\alpha-\beta)} \left(\frac{\beta}{w}\right)^{\beta/(1-\alpha-\beta)}$$


16 and

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$$y^F(\theta_i) = ((1 - \phi)\theta_i)^{1/(1-\alpha-\beta)} \left(\frac{\alpha}{r}\right)^{\alpha/(1-\alpha-\beta)} \left(\frac{\beta}{w}\right)^{\beta/(1-\alpha-\beta)}$$

18 represent respectively revenues for informal and formal entrepreneurs. It is
 19 immediate to notice that the revenue functions behave exactly as the profit
 20 functions. QED.

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