Who benefits from reducing the cost of formality? Quantile regression discontinuity analysis*

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April 20, 2011

Abstract

This paper studies the effects 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 policy reform and therefore, this policy has an impact only on a segment of the micro-firm population. Second, the benefits to such reform, as measured by profits and revenues, are increasing in the entrepreneur's ability. Empirically, we estimate the effect of formality on the entire conditional distribution (quantiles) of performance using the 1997 Brazilian SIMPLES program and a rich survey of formal and informal micro-firms. The econometric approach employed compares eligible and non-eligible firms, born before and after SIMPLES in a local interval about the introduction of SIMPLES. Moreover, to carry the estimations, we use an estimator that combines both quantile regression and the regression discontinuity strategies. The empirical results corroborate the positive effect of formality on micro-fims' performance and produce a clear characterization of who benefits from these programs.

Key Words: Formality; Micro-firms; Quantile regression; Regression discontinuity

JEL Classification: J23; L25

*The authors would like to express their appreciation to Scott Adams, John Heywood, William Maloney, Blaise Melly, and participants at the seminars at City University London, Queen Mary University and Universidad Autónoma de Barcelona for helpful comments and discussions. All the remaining errors are ours.

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

1 Introduction

The very high costs of complying with government regulations and institutions have often been seen as largely responsible for the presence of large informal sectors in developing countries. Formality is broadly defined as participation in societal and governmental institutions, such as paying taxes, being registered with the authorities, etc. (see Gerxhani, 2004; Maloney, 2004, for a survey). Firms' inability to become formal is thought to have deleterious effects on performance. As examples, formality offers the firm access to risk pooling mechanisms that may attract more educated paid workers and engage them in a longer relationship with the firm, which in turn makes training and capital goods acquisition more profitable; formality may be a requirement for access to formal credit markets or Government provided business development services or as Paula and Scheinkman (2007, 2010) have argued, for subcontracting relations with formal firms. Moreover, to the extent that formality increases the ability of micro-entrepreneurs to establish property rights over their investments and reduces the risk of being fined by Government inspectors, it creates incentives for operating out of fixed locations rather than in an ambulatory fashion (see de Soto, 1989). The perceived onerous cost of formality was tackled by several Latin American governments by introducing tax reductions and simplifications. Examples of such programs are the Monotributo[1] in Argentina, SARE[2] in Mexico, and the SIMPLES[3] in Brazil. Available evidence shows

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

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

[3]SIMPLES stands for "Sistema Integrado de Pagamento de Impostos e Contribuções as Microempresas e Empresas de Pequeno Porte". See Section 3 for a detailed description of the program.

that these programs had a positive effect on formality. See Kaplan, Piedra, and Seira (2006) for SARE; and Monteiro and Assunçao (2006) and Fajnzylber, Maloney, and Montes-Rojas (2011) for SIMPLES.

We contribute to the literature by answering two questions: First, which firms benefit from tax reduction and simplification schemes? Second, is there heterogeneity on the effect of formality on firm performance? These questions have very important policy implications. In a Ricardian setting, tax reductions imply a redistribution of wealth, and therefore, it is important to quantify which firms are really benefiting from these programs. In particular, if tax reductions only benefit already well-off formal firms, then the program did not accomplished the task of broadening the scope of formality. We focus on the micro-firm sector, defined as own-account workers and firms with less than five paid employees, and that constitutes the majority of firms in developing countries. Within this sector three groups can be distinguished. First, high-ability entrepreneurs with substantial growth prospects may have self-selected into formality with the old (high) tax system, as the perceived benefits of being formal offset the cost of formality. Then, this segment benefits only from the tax reduction. Second, some micro-entrepreneurs are in the informal sector as a subsistence strategy, only temporarily waiting for a formal job vacancy, as predicted in the Harris and Todaro (1970) dual labor market hypothesis (see Maloney, 1999, 2004; Mandelman and Montes-Rojas, 2009, for a discussion). These are low-ability entrepreneurs and they will not value future gains from becoming formal and, therefore, tax 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 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 this corresponds to medium-ability entrepreneurs. These are the firms that should benefit from the tax reduction programs, and change their formality status.

We begin our analysis by developing a theoretical model motivated by the work of Rauch (1991) and Paula and Scheinkman (2007, 2010), with emphasis on the effect of a reduction in taxes. This model yields two 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 impact only on a segment of the micro-firm population, defined by default as medium-ability entrepreneurs. Second, the benefits to such reform, as measured by profits and revenues, are increasing in the entrepreneur's ability.

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

To resolve the first problem, the identification strategy makes use of the SIMPLES program in Brazil, that offers an exogenous change in legislation that can be used to control for self-selection and endogeneity. It builds on previous work by Monteiro and Assunçao (2006) and Fajnzylber, Maloney, and Montes-Rojas (2011) that exploit the SIMPLES program applying a difference-in-differences approach with the age of the firm and with ineligible firms as a control group. Unfortunately, there is no experimental data or suitable panel of firms. However, those authors rely on a cross-sectional survey of micro-firms and argue that time-in-business (i.e. age) of the firm can be used to identify firms that benefit from SIMPLES and those that did not. Monteiro and Assunçao (2006) study the effect of SIMPLES on having a government issued license, which constitutes a necessary requirement for further formalization (such as pay taxes or social security), and they find an increase in formal licensing among retail firms of 13 percentage points, but no effect on eligible firms from other sectors (construction, manufacturing, transportation and other services). Moreover, using

SIMPLES eligibility as an instrumental variable for formality, they show that the latter significantly increases access to credit, and alters the amount and composition of investment towards larger and longer-term projects. Fajnzylber, Maloney, and Montes-Rojas (2011) show that SIMPLES has only a *local* effect on licensing rates for firms born just after the introduction of the program. Using a regression discontinuity design (see Hahn, Todd, and van der Klaauw, 2001; van der Klaauw, 2002, for a discussion about regression discontinuity estimators), with weights given by the age of the firm (time-in-business) and its distance to the introduction of SIMPLES, they find a significant effect on licensing, tax registration, tax payments and social security contributions. When more firms were taken into consideration, these effects' statistical significance decreases monotonically with the sample average time-distance to the introduction of SIMPLES. We build on their analyses extending it to a quantile regression discontinuity analysis.

In order to estimate the distributional effects of formality, we make use of the heterogeneity in the conditional distribution of revenue applying quantile regression (QR) techniques, which will prove an indispensable tool for the problem in question. QR methods offer the advantage of describing not only averages of possible outcomes but also their entire distribution. Thus, QR techniques provide a systematic method to analyze differences in covariates effects (see Koenker and Hallock, 2001; Koenker, 2005), a framework for robust estimation and inference, and most importantly allow exploring a range of conditional quantiles exposing conditional heterogeneity. For the present problem, the micro-firm heterogeneity given by unobserved characteristics (entrepreneurial ability) can be analyzed along the single dimensional conditional quantiles of the firm revenues. Along this dimension, high quantiles correspond to *high-ability entrepreneurs* and low quantiles to *low-ability entrepreneurs*. Chesher (2005) studies identification under discrete variation and shows that the identifying intervals can be estimated using quantile regression methods. Thus, as argued in Chesher

(2005), the identification through QR strategy may work for some quantiles (in our case *target* entrepreneurs) but not for others (in our case the low- and high-ability entrepreneurs). We face a similar situation where the SIMPLES program can be used for identification only for medium-ability entrepreneurs but not for low- and high-ability ones.

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

The econometric results are summarized as follows. First, for comparison reasons, we present results for both 2SLS and IVQR estimates of the conditional mean and quantiles of firm revenues. The results show positive point estimates for both 2SLS and IVQR evidencing that formality has a positive effect on revenues. However, the point estimate are rather imprecise. These high and rather imprecise estimates are similar to those in Monteiro and Assunçao (2006) and Fajnzylber, Maloney, and Montes-Rojas (2011). 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 SIMPLES had a potential effect on 40% to 50% of the micro-entrepreneur population. Third, we find evidence of heterogeneity across quantiles on the impact of license on the conditional distribution of revenues. These estimates suggest that reducing the cost of formality might significantly benefit informal firms and not necessarily the conditionally best ones. Finally, from the study of the covariates effects, there is evidence that women engage in less profitable activities, possibly due to household commitments or outright gender discrimination. Moreover, interestingly, education is non-monotonic for the conditional mean model and for low quantiles. In those cases, incomplete secondary education has the highest effect in both subsamples. However, education becomes monotonically increasing for $\tau \geq 0.5$. This determines that for firms in the low conditional quantiles, higher education is not necessarily associated with higher revenues, but it is with outstanding firms.

The rest of the paper is organized as follows. Section 2 develops a theoretical model. Section 3 describes the SIMPLES program and the identification strategy. Section 4 develops the quantile regression discontinuity estimator. Section 5 describes the ECINF micro-firm survey. Section 6 presents the econometric results. Section 7 concludes.

2 Taxes and the informal sector

In this section, we present a simple model that generates an equilibrium with segmentation characterized by salaried workers, informal and formal micro-entrepreneurs. Accordingly, in the next section, we will show empirically that SIMPLES has an impact only on a segment of the micro-firm population, for which the effect of formality on firm performance can be identified, and that can be analyzed along the single dimensional quantiles of the conditional firm revenues.

We model a economy where agents decide whether to work as salaried workers or to become (micro-)entrepreneurs, and we describe an equilibrium where only a fraction of agents become entrepreneurs and salaried workers are paid a subsistence salary. The model shows that an individual becomes an informal entrepreneur, rather than being a salaried worker, if her individual ability is higher than a certain threshold and becomes a formal entrepreneur, rather than being an informal one, if her individual ability is higher than an even higher threshold. The higher is the cost of formality the higher is the threshold value of ability to become a formal entrepreneur. This simple model builds on the models of Rauch (1991) and Paula and Scheinkman (2007, 2010).

We consider a continuum of agents, each denoted by i and characterized by entrepreneurial ability θ_i, which is distributed according to a probability density function $g(\cdot)$. Agents choose between working for an existing firm and earning a subsistence level s independent from their ability thus becoming a salaried worker, operating a firm in the informal sector or operating a firm in the formal sector. The last two options correspond to the entrepreneurial sector. An entrepreneur produces quantity y_i of an homogeneous good using capital k_i and labor l_i as inputs. In order to maintain tractability we consider a Cobb-Douglas technology $y_i = \theta_i k_i^\alpha l_i^\beta$, with $\alpha, \beta > 0$ and $\alpha + \beta < 1$.[4]

We normalize the price of the homogeneous good to 1. The unit costs of k and l are respectively r and w, where w is the equilibrium wage earned by salaried workers. We assume that the cost of capital is determined outside the described small economy. We will describe an equilibrium where each salaried worker earns a wage which is equal to the subsistence level of wealth ($w = s$). For exposition purposes, we start by describing the optimal choices of the entrepreneurs given r and w.

We distinguish between formal and informal entrepreneurs. A formal entrepreneur pays an ad valorem tax ϕ. An informal entrepreneur *cheats* the system and pays no taxes, but

[4]The results of the model would still apply with any concave production function.

if detected is out of business. We assume that the probability of detection p increases with the size of the firm and that $p(k) = 0$ if $k \leq k^*$ and $p(k) = 1$ if $k > k^*$, that is, an informal entrepreneur cannot employ more than k^* but is able to evade taxes.[5]

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

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

The maximization of (1) gives the optimal quantity of production factors which are respectively used by an informal and a formal entrepreneur, given her ability θ_i:

$$\begin{aligned} k_i^I &= \min\{\theta_i^{\frac{1}{1-\alpha-\beta}} (\frac{\alpha}{r})^{\frac{1-\beta}{1-\alpha-\beta}} (\frac{\beta}{w})^{\frac{\beta}{1-\alpha-\beta}}, k^*\}, \\ l_i^I &= \min\{\theta_i^{\frac{1}{1-\alpha-\beta}} (\frac{\alpha}{r})^{\frac{\alpha}{1-\alpha-\beta}} (\frac{\beta}{w})^{\frac{1-\alpha}{1-\alpha-\beta}}, (\frac{\beta\theta^i k^{*\alpha}}{w})^{\frac{1}{1-\beta}}\}, \end{aligned} \tag{2}$$

$$\begin{aligned} k_i^F &= ((1-\phi)\theta_i)^{\frac{1}{1-\alpha-\beta}} (\frac{\alpha}{r})^{\frac{1-\beta}{1-\alpha-\beta}} (\frac{\beta}{w})^{\frac{\beta}{1-\alpha-\beta}}, \\ l_i^F &= ((1-\phi)\theta_i)^{\frac{1}{1-\alpha-\beta}} (\frac{\alpha}{r})^{\frac{\alpha}{1-\alpha-\beta}} (\frac{\beta}{w})^{\frac{1-\alpha}{1-\alpha-\beta}}. \end{aligned} \tag{3}$$

When is it optimal for an entrepreneur to become formal? If irrespective of the tax ϕ an entrepreneur finds optimal to employ less than k^*, then she has no advantage to become formal. We can illustrate this result formally. Using the first order conditions we define θ^* as that ability such that an informal entrepreneur finds optimal to choose k^*,

$$\theta^* \equiv k^{*1-\alpha-\beta} \left(\frac{r}{\alpha}\right)^{1-\beta} \left(\frac{w}{\beta}\right)^{\beta}, \tag{4}$$

hence $k^I(\theta^*) = \theta^{*\frac{1}{1-\alpha-\beta}} (\frac{\alpha}{r})^{\frac{1-\beta}{1-\alpha-\beta}} (\frac{\beta}{w})^{\frac{\beta}{1-\alpha-\beta}}$ and $l^I(\theta^*) = \theta^{*\frac{1}{1-\alpha-\beta}} (\frac{\alpha}{r})^{\frac{\alpha}{1-\alpha-\beta}} (\frac{\beta}{w})^{\frac{1-\alpha}{1-\alpha-\beta}}$. It is immediate to verify that if $\theta_i \geq \theta^*$ then $\pi^I(\theta^*) > \pi^F(\theta^*)$. Therefore every entrepreneur with ability

[5] 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.

smaller than θ^* will find optimal to stay informal. It will be clear that this segment represents the *involuntary entrepreneurs* which we mentioned in the introduction. Entrepreneurs with ability greater than θ^* would always find optimal to employ more than k^* if this did not imply to pay the tax ϕ. In choosing whether to become formal or not such entrepreneurs trade off the gains of employing more than k^* with the cost of paying the tax ϕ. As shown by Paula and Scheinkman (2007), the convexity of the profit functions (1) in θ implies that there is a unique threshold level of ability above which entrepreneurs become formal. We can establish this result formally and find an analytical expression for the threshold level of ability.

Proposition 1 *There exists a threshold level of ability $\bar{\theta}$ such that an 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.*

Proof in the Appendix.

Labor market equilibrium

We describe a labor market equilibrium where each worker is paid the same subsistence wage rate $w = s$.[6] We define an ability threshold $\hat{\theta}$ such the individual with ability $\hat{\theta}$ is indifferent between becoming a salaried worker or an informal entrepreneur, hence $w = \pi^I(\hat{\theta})$. Plugging the first order conditions (2) into (1) we find that

$$\hat{\theta} = (1-\alpha-\beta)^{(\alpha+\beta-1)}(r/\alpha)^{\alpha}(1/\beta)^{\beta}w^{1-\alpha}. \quad (5)$$

For w to be the equilibrium wage it must be the case that, given w, labor demand equals labor supply. In order to compute the labor demand we add the demand from informal

[6] One reason for this could be that the ability is only relevant when managing a firm. The focus of this paper is not on the possible wage differences across workers.

and formal entrepreneurs. Informal entrepreneurs are either *involuntary* (if their ability is smaller than θ^*) or *voluntary* (if their ability is between θ^* and $\hat{\theta}$).

Labor demand:

$$D(w) = \underbrace{(\frac{\alpha}{r})^{\frac{\alpha}{1-\alpha-\beta}}(\frac{\beta}{w})^{\frac{1-\alpha}{1-\alpha-\beta}}\int_{\hat{\theta}}^{\theta^*}\theta^{\frac{1}{1-\alpha-\beta}}dG(\theta)}_{\text{involuntary}} + \underbrace{\int_{\theta^*}^{\bar{\theta}}(\frac{\beta\theta k^{*\alpha}}{w})^{\frac{1}{1-\beta}}dG(\theta)}_{\text{voluntary informal}} + \underbrace{(\frac{\alpha}{r})^{\frac{\alpha}{1-\alpha-\beta}}(\frac{\beta}{w})^{\frac{1-\alpha}{1-\alpha-\beta}}\int_{\bar{\theta}}^{\theta^{max}}((1-\phi)\theta)^{\frac{1}{1-\alpha-\beta}}dG(\theta)}_{\text{formal}}.$$

Labor supply: $G(\hat{\theta})$, where $G(\cdot)$ is the cumulative distribution function given $g(\cdot)$.

Notice that labor demand decreases in w, while supply increases in w as $\hat{\theta}$ increases in w. A unique equilibrium exists by the unique crossing of supply and demand.[7] We are describing an equilibrium with both formal and informal entrepreneurs, hence an equilibrium where $\hat{\theta} < \theta^*$. Using (4) and (5) we find that this is the case if the equilibrium wage $w < (1-\alpha-\beta)k^*(r/\alpha)$.

We focus on such equilibrium and therefore we have that:

if $\theta_i \leq \hat{\theta}$, then i is a salaried worker,

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.

[7] See Rauch (1991) for a formal proof.

Effect of a policy change

If the salaried wage is fixed, 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).*

We describe a situation where the change in wage is negligible, or a situation where there is excess labor supply both before and after the change in the tax. In both those situations the corollary is valid.[8]

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. 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'.*

Proof in the Appendix.

Figures 1 illustrates the informal entrepreneurs' profit function (thick line) and the formal entrepreneurs' profit and revenue function before and after a reduction in the tax (thin and dash lines). From the figures it is possible to notice the results of propositions 1 and 2. [9] From the figure, it is also evident that the result of proposition 2 would not apply to a

[8] 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 equilibrium wage. One reason is that the change in the equilibrium wage may be of second order importance. Another reason is that if, given s, there is excess labor supply both before and after the change in the tax, then workers will still be payed the subsistence wage.

[9] We use $\alpha = 0.2, \beta = 0.7, r = 3, w = 5$. Then, it can be computed that $k^* = 0.3123 * 10^{-9}$ and $\theta^* = 10$. The figures show the informal entrepreneurs' profit (thick line) and those of formal entrepreneurs given $\phi = 0.2$ (thin line) and given $\phi' = 0.1$ (dash line). It can be computed that the threshold value of ability is $\bar{\theta} = 16.1$ for $\phi = 0.2$ and decreases to $\bar{\theta} = 13.2$ for $\phi' = 0.1$.

different model in which $\pi^F(\phi')$ is not always convex for $\theta > \bar{\theta}'$.[10]

The model can also be extended to the case of lump-sum tax, namely a case where 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. Figure 2 illustrates the profit function plot for such case of lump-sum tax change. [11]

3 The SIMPLES program and identification strategy

In November 1996, the Brazilian Government implemented a new unanticipated simplified tax system for micro and small firms, the SIMPLES. The new national system consolidated several federal taxes and social security contributions. Basically, the SIMPLES abridged procedures for the verification and payment of federal, state and municipal taxes. At the Federal level, the system allowed eligible firms to combine six different types of federal taxes and five different social security contributions into a one single monthly payment, varying from 3% to 5% of gross revenues for micro-enterprises, and from 5.4% to 7% of revenues for small firms. As a result, SIMPLES permitted an overall reduction of up to 8% in the tax burden faced by eligible firms (Monteiro and Assunçao, 2006). 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.

[10] 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.

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

The motivation behind the these reductions in direct and indirect taxes achieved through SIMPLES 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. 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 education, health, accounting, insurance and financial services, among others.

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

$$y_i = f(d_i, \theta_i).$$

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

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

Consider now a cross-sectional linear regression model for a firm revenue variable y,

$$y_i = \beta_1 d_i + \beta_2 t_i + \beta_3 x_i + \theta_i, \tag{6}$$

where i denotes the firm, d is a binary formality indicator, t denotes time-in-business, x is a set of exogenous covariates and θ is a firm-specific unobserved component. The main issue in measuring the effect of formality literature is that d_i is correlated with θ_i, therefore OLS estimates of β_1 will be biased.

The introduction of SIMPLES by unanticipated administrative decree can be seen as an exogenous policy change that significantly altered the incentives to become formal and hence is useful in avoiding the possible biases arising from self-selection. The theoretical model developed above predicts that only for a segment of firms we will be able to measure the effect of formality. The reason is that we will only observe a significant effect of SIMPLES on those firms with $\theta \in (\bar{\theta}', \bar{\theta}]$. This is the group of firms that have a large enough θ such that the SIMPLES tax reduction makes them to re-evaluate their formality status, but not so large as to make the change in ϕ irrelevant to their formality decision. This segment contains firms that will become formal only after the reduction in taxes, and therefore we can identify β_1 by using the regression discontinuity approach described above. Note that this does not mean that for firms with $\theta < \bar{\theta}'$ or $\bar{\theta} < \theta$ formality has no effect on the firm performance variable. In other words, we can only identify the effect of formality for those firms that did change their status due to SIMPLES.

Monteiro and Assunçao (2006) argue that for relatively young firms (less than 2 years old) time-in-business clearly differentiates firms that benefit from SIMPLES from those that did not. Although all firms could benefit from SIMPLES, firms born after SIMPLES show a much higher propensity to have a license than those born before. Those authors show that this is not due to seasonal effects[12] and it only affects eligible firms. Additional evidence on

[12] Monteiro and Assunçao (2006) repeat their analysis one and two years later as if SIMPLES had been introduced in November 1995 and 1994, respectively, and they found no effect. Moreover, they show that

the validity of this argument is given by Fajnzylber, Maloney, and Montes-Rojas (2011) that compare born-before and born-after firms on several observable characteristics (education, age, gender, location) and find that there are no statistically significant differences.[13] Overall this suggests a dual process for formalization: first, firms decision to formalize is primarily taken at the time of its creation; second, the likelihood of becoming formal increases with time-in-business.[14] These authors exploit the first process, that is, the differential effect on licensing caused by the introduction of SIMPLES for firms born before and after it and for relatively young firms where the first process outperforms the second. The fact that this program potentially affected all firms but there is a clear break in the propensity to have a license determine that this is a so-called *fuzzy* quasi-experimental design that we fully adopt in this paper.

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. They use the interaction of eligible/non-eligible and before/after indicators (i.e. $AFTER \times ELIG$) as an instrumental variable (IV) difference-in-differences to measure the impact of formality on investment and credit access, with the first stage regression being as follows:

$$d_i = \alpha_1 AFTER_i + \alpha_2 ELIG_i + \alpha_3 (AFTER_i \times ELIG_i) + \alpha_4 x_i + e_i, \tag{7}$$

Figure 3 plots licensing rates for firms with different time-in-business. The latter is measured as the time distance in months to the introduction of the SIMPLES in November

SIMPLES did not produce any change in the number of starting firms as compared to similar months years before (i.e. SIMPLES produced no "rush" to start a firm).

[13]They argue that there is no evidence poiting out that firms delayed strategically their starting time.

[14]See the analysis for micro-firms in Mexico and other evidence for Latin American countries in Fajnzylber, Maloney, and Montes-Rojas (2009).

1996 (eg. 0 corresponds to October 1996, -1 to November 1996, 1 to September 1996). The first two graphs plot separately eligibles and non-eligibles for all firms; the last two takes 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, the validity of $AFTER \times ELIG$ as an IV for d crucially depends on taking firms that were born just after and before than $\bar{t}$, i.e. $|t_i - \bar{t}| < \epsilon$ for ϵ small enough.

The regression discontinuity literature (see Hahn, Todd, and van der Klaauw, 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, Maloney, and Montes-Rojas (2011) show that the regression coefficient of $AFTER \times ELIG$ is dependent on the weighting scheme. The econometric results in Section 6 (see figures 4 and 5) show that only on a small interval SIMPLES had an effect on licensing rates. Following these authors we will implement a *fuzzy* regression discontinuity design, where on a small enough interval about the introduction of SIMPLES, identification can be achieved by comparing firms born just before and just after the SIMPLES introduction.

To summarize, our identification strategy allow us to estimate β_1 for firms with $\theta \in (\bar{\theta}', \bar{\theta}]$ and born near the introduction of SIMPLES, i.e. $|t_i - \bar{t}| < \epsilon$ for ϵ small enough. This strategy requires the use of both quantile regression (to model θ) and regression discontinuity designs (to amplify the effect of SIMPLES at the time of its introduction).

4 Quantile regression discontinuity

In this section we describe the estimator that we use to identify the effect of formality on firm performance, the approach is based on the instrumental variables quantile regression. Quantile regression will be an essential tool for identification of the *target group*, to analyze the heterogeneity among the firms, and estimate the effect of formality on firm performance. The estimation strategy follows Chernozhukov and Hansen (2006, 2008) and we will describe briefly the instrumental variable (IV) strategy to estimate the quantile regression model.

Frolich and Melly (2008) propose a different approach to identify and estimate treatment effects on the distribution of the outcome variable in the regression discontinuity design. They propose a nonparametric identification of the quantile treatment effects and show uniformly consistent of the estimator for the potential outcome distributions and for the function-valued effects of the policy. Frandsen (2008) introduces a procedure to nonparametrically estimate local quantile treatment effects in a regression discontinuity design with binary treatment. However, we follow the literature on analyzing the effects of formality on firm decision, and opt to use a semi-parametric estimator, that is the linear IV quantile regression proposed by Chernozhukov and Hansen (2006) to estimate a fuzzy regression discontinuity design model. One clear advantage of the used estimator is the ability to control for exogenous covariates that influence the firm revenues.[15] This estimator is similar to Guiteras (2008) and Pereda-Fernandez (2010). The use of IVQR in regression discontinuity design has appeared in Guiteras (2008) motivated by an empirical application to the returns to compulsory schooling, and Pereda-Fernandez (2010) estimating the effects of class size on scholastic achievement.

In order to find the threshold values $\bar{\theta}'$ and $\bar{\theta}$ we will consider the single dimensional

[15] There is an emerging literature on quantile regression treatment effects. We refer the reader to Firpo (2007) and the references therein.

conditional quantiles, indexed by $\tau \in (0,1)$, of the firm's revenues, y, in model (6),

$$Q_y(\tau|d, x, |t_i - \bar{t}| < \epsilon) = \beta_1(\tau)d_i + \beta_2(\tau)t_i + \beta_3(\tau)x_i. \tag{8}$$

If we assume that for all $\theta_1 \leq \theta_2$ there exists $0 < \tau_1 \leq \tau_2 < 1$, then this conditional quantile function can be used to find $\bar{\tau}'$ and $\bar{\tau}$ that match $\bar{\theta}'$ and $\bar{\theta}$, respectively. With the proposed identification we can estimate $\beta_1(\tau)$ for $0 < \bar{\tau}' < \tau \leq \bar{\tau} < 1$. 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).

From (7) we can use $z = (AFTER \times ELIG)$ as a valid instruments for d. This identification condition is discussed in Monteiro and Assunçao (2006) and Fajnzylber, Maloney, and Montes-Rojas (2011). The instrumental variables quantile regression (IVQR) estimator method may be viewed as an appropriate quantile regression analog of the two stage least squares (2SLS) that makes use of a valid exclusion restriction. More formally, and following Chernozhukov and Hansen (2006, 2008), from the availability of an IV, z, we consider estimators defined as:

$$\hat{\beta}_1(\tau) = argmin_{\beta_1} \|\hat{\gamma}(\beta_1, \tau)\|_A, \tag{9}$$

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

$$argmin_{\beta_2,\beta_3,\gamma} \sum_{i=1}^{N} \omega(|t_i - \bar{t}|)\rho_\tau\left(y_i - \beta_1 d_i - \beta_2 t_i - \beta_3 X_i - \gamma z_i\right), \tag{10}$$

with $\omega(\cdot)$ a weighting function that is monotonically decreasing in $|t_i - \bar{t}|$, $\rho_\tau(\cdot)$ the τ-quantile regression check function, $\|x\|_A = \sqrt{x'Ax}$ and A is a positive definite matrix.[16] Contrary to least-squares, it does not require two stages.

The asymptotic properties of the estimator are described in Chernozhukov and Hansen

[16] 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.

(2006, 2008). In particular asymptotic normality holds,

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

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

We refer the reader to Chernozhukov and Hansen (2005, 2006) for a more detailed discussion on the assumptions used for identification and the asymptotic results of the IVQR estimator. However, one important assumption for identification of the IVQR is rank invariance. This implies that, conditional on all other variables, a common unobserved factor, such as unobserved ability, determines the ranking in the outcome conditional distribution of a given subject across treatment states. Chernozhukov and Hansen (2005) also 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. In words, rank similarity implicitly make the assumption that one selects the treatment without knowing the exact potential outcomes; i.e., one may know its own ability and even the distribution of slippages, but does not know the exact slippages. This assumption is consistent with many empirical situations where the exact latent outcomes are not known beforehand.

5 Data and descriptive statistics

We employ the Brazilian Survey of the Urban Informal Sector (Pesquisa Economia 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 cross-section representative of all the urban self-employed and micro-firm owners with at most five paid employees, excluding domestic workers. The stratified sampling design (in two stages) allows studying a population of units which are rare, heterogeneous and hard to detect in standard household surveys. Geographically, it covers all of the 26 Brazilian states, as well as the Federal District, and also each of the 10 Metropolitan Areas (Belém, Fortaleza, Recife, Salvador, Belo Horizonte, Vitória, Rio de Janeiro, São Paulo, Curitiba and Porto Alegre) and the municipality of Goiânia. In each of its two waves, ECINF interviewed roughly 50,000 households among which it found more than 40,000 individuals which reported owning a micro-enterprise.

Within the Brazilian micro-entrepreneur sector, the most frequent sectors of activity are retail trade (26% of micro-firms) and personal services (20%), followed by construction (15%), technical and professional services (11%) and manufacturing (11%). Respectively 8% and 7% of micro-firms belong to the sectors of hotels and restaurants, and transportation. Most firms are very small both in terms of revenues and employment: the average and median monthly revenues of Brazilian micro-firms were $US 1,083 and $US 600, respectively. We find that 87% of all Brazilian micro-firms have no paid employees, and 79% have no employees or partners at all, 10% of the surveyed micro-firms have one or two paid employees, and only 3% have between 3 and 5 paid workers. In those firms with at least one paid employee, roughly 22% of all workers are family members, almost two thirds of paid workers are non-registered sem carteira assinada and only 35% pay social security contributions.

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

Different measures of formality for this sample were studied in Fajnzylber, Maloney, and Montes-Rojas (2011). Our interest lies on firms with a government issued license as our measure of formality. Only 23.2% of all micro-firms have a license which increases to 31.1% for micro-firms with at least one paid employee. One of the main challenges in estimating the impact of formality on firm performance is the possibility that both may be correlated with the entrepreneurs' unobserved managerial ability. In particular, those micro-firm owners that start their business because they have been unable to find other jobs or because their families have been hit by negative external shocks are arguably less likely to have access to good business opportunities that would allow them to stay in business and succeed. Arguably, they are also less likely to incur the costs associated with formalization. Some evidence appears in the ECINF, which shows that individuals that became entrepreneurs to escape from unemployment are found less frequently among the owners of firms with operating licenses (21%) than among those without licenses (32%). Similarly, among licensed formal enterprise owners there are fewer who report having started up to complement their family's income (12% of licensed firms and 21% of non-licensed), and it is more common to find entrepreneurs that mention independence as the main reason to start their business (28% vs. 17%). On the other hand, a higher fraction of licensed enterprises have plans to expand (45 vs. 37% among non-licensed firms) and a lower number intend to abandon their business to search for salaried jobs (6% among licensed firms compared to 13% for non-licensed ones).

While 70% of all micro-firms and 85% of those firms that did not have a license at the time of the survey only 1 out of 4 licensed business owners made no attempt at regularizing at the time of starting up. In contrast, while 78.5% of non-licensed entrepreneurs businesses did at least not try to regularize their firm when they began operating. Thus, the decision of whether to operate formally or informally appears to be made in most cases at the time of startup. To the extent that the decision to operate informally is based on a rational cost-benefit analysis, this suggests that for most firms the former exceed the latter. This could be due either to costly and/or complex registration procedures, to high tax rates, or to a limited demand among very small businesses for the 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.

6 Econometric results

First, we follow Fajnzylber, Maloney, and Montes-Rojas (2011) and estimate the first-stage effect of SIMPLES on licensing rates by estimating eq. (7) by weighted least-squares methods. Note that the first-stage has no parallel in the QR analysis and it is only done to evaluate the statistical significance of the instrument. As additional control variables we use the $AFTER$, $ELIG$, gender (dummy for female), age and education of the entrepreneur (the latter as categorical dummies, base category: no formal education), number of members in the household, a set of dummy variables for the reasons to become an entrepreneur, time in business (interacted with $AFTER$ and as a square polynomial), and dummy variables by industry and state. We use a weighting scheme based on $\omega(w|t_i - \bar{t}|) = f(0, w|t_i - \bar{t}|)$, where $f(0, \sigma)$ is the normal density of a standard Gaussian random variable with mean 0 and standard deviation σ. Figures 4 and 5 compute the coefficient estimate of $AFTER \times ELIG$ for $w \in \{0.5, 1, 1.5, ..., 5\}$ (using the same set of controls described in the last paragraph). The figures show that the effect of SIMPLES is localized at the time of its introduction, and that this effect is monotonically decreasing in w. Fajnzylber, Maloney, and Montes-Rojas

(2011) show that a value of $w = 1$ is optimal in the sense that it has the largest significant impact.

The main analysis for our purposes is the estimation of eq. (8), that is, the conditional quantiles of the model in eq. (6). We use log of total montlhy revenues as our dependent or outcome variable in order to avoid the endogeneity of capital and labor (i.e. both are correlated with ability), and to avoid measurement errors in the cost of capital and imputation of the owner's salary, which are potentially large in micro-firms surveys. Therefore, the return to formality is the ultimate effect on revenues arising from hiring both more labor and capital. However, this may also include changes in the composition of clients as in Paula and Scheinkman (2007). In order to implement this we follow the strategy described in Section 3 where $AFTER \times ELIG$ is used as an instrument for d, having a license. We increase the power of the instrument by interacting it with gender and age of the entrepreneur and use a weighting scheme based on $\omega(|t_i - \bar{t}|)$, i.e. $w = 1$.

Tables 1 and 2 present the 2SLS and IVQR estimates of the conditional mean and quantiles (selected quantiles) of firm revenues for the selected weighting scheme described above for all and for those entrepreneurs that started as owners, respectively. Figures 6 and 7 summarizes the effect of licensing on firm revenues. The 2SLS point estimate is 3.40 (std.err. 1.04) for all firms and 3.23 (std.err. 0.97) for the owners only subsample. However, given the wide 95% confidence intervals the point estimate is rather imprecise but shows that formality has a positive effect on revenues. 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 to those in Monteiro and Assunçao (2006) and Fajnzylber, Maloney, and Montes-Rojas (2011).

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

Note however that the point estimates being non statistically significant does not imply that the instruments are not working and that the effect of licensing cannot be identified. In fact, this cannot be a priori be distinguished from it being statistically equal to zero. The lack of a first stage does not allow us to use the OLS techniques for evaluating the IV performance. Therefore, we propose a new procedure based on the Chernozhukov and Hansen (2006, 2008) estimator. If the identification strategy using the IV works well, then $\hat{\gamma}(\beta_1, \tau)$, based on eq. (9), 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. Figures 8 and 9 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.

To examine the heterogeneity associated with the IVQR estimates we perform diagnosis tests using Kolmogorov-Smirnov tests.[17] First, we test the hypothesis of a zero constant

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

coefficient for the IVQR estimates across 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 Wald statistic for each particular quantile and take the maximum over the corresponding quantiles. The results for the test statistics are 27.83 and 21.74 for the all micro-firms and owners samples, respectively. These 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 significance, and 7.63 at 10% level of significance). Thus, there exists strong evidence to reject the hypothesis of zero or negative impact of licensing on log revenues.

Secondly, we test the hypothesis of a constant given effect of SIMPLES on 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 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 IVQR contains the point estimate of 2SLS, for various intermediate quantiles, the evidence suggests that the effect of SIMPLES on revenues is heterogeneous. However, in the second sample the wide confidence intervals made the 2SLS estimate to remain inside the bands and we cannot reject the null hypothesis.

Finally, we apply the latter test, $H_0 : \beta_1(\tau) = \bar{\beta}$, only over the selected 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 owners).[18] In this case, the results for the test statistics are 11.08 and 7.57 for all micro-firm and owners samples respectively, such that we reject the 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. In fact, we observe that the effect is actually decreasing on τ for this range. This result contradicts

[18] In general the index used for Kolmogorov-Smirnov tests in QR is symmetric of the form $[\epsilon, 1-\epsilon]$. However, in some situations it is desirable to restrict the interval of estimation to 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.

that in Proposition 2 and could be due to the non-convexities described in McKenzie and Woodruff (2006), where the return to capital is higher for low-capital firms. Overall, this suggests that, over the range of identified quantiles, the formality treatment has a bigger impact on low quantiles than in high quantiles.

The study of the covariate effects is of independent interest too. The negative coefficient of Female reflects the fact that women engage in less profitable activities, possibly due to household commitments or outright gender discrimination. There is no clear pattern across quantiles, which determines that gender effect applies uniformly to all types of firms. Interestingly, education is non-monotonic for the conditional mean model and for low quantiles. In those cases, incomplete secondary education has the highest effect in both subsamples. However, education becomes monotonically increasing for $\tau \geq 0.5$. This determines that for firms in the low conditional quantiles, higher education is not necessarily associated with higher revenues, but it is with outstanding firms. Finally, the reasons to become entrepreneur show interesting variability across quantiles. reasons such as “Accumulated experience”, “Be independent”, “Make a good deal” and “Profitable business” which may be associated with entrepreneurs with high ability are larger for high quantiles, while reasons for involuntary entrepreneurs (such as “To help family income”) are larger for the low quantiles.

7 Conclusion

This paper proposes to use a quantile regression discontinuity estimator to identify the effect of formality on firm performance. It achieves several goals. First, it is shown that identification of the parameters of interest works for some quantiles for not others. The set where identification works defines the group of firms benefited by SIMPLES. Second, it applies the quantile regression discontinuity design using the instrumental variables framework. We implement a weighting strategy (used in the least-squares literature) that amplifies the observations about the time of the introduction of SIMPLES. Third, it provides empirical evidence that tax reduction and simplification schemes have a significant impact on the micro-firm sector.

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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 (1) we obtain that

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

and

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

An entrepreneur with ability $\theta_i > \theta^*$ who decides to be informal will choose capital k^* and labor $l^I(k^*, \theta^i) = (\frac{\beta\theta^i k^{*\alpha}}{w})^{\frac{1}{1-\beta}}$. 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 $\pi^I(\theta_i) = (1+\gamma_i)^{\frac{1}{1-\beta}}(1-\alpha/(1+\gamma_i)^{\frac{1}{1-\beta}} - \beta)\theta^{*\frac{1}{1-\alpha-\beta}}(\frac{\alpha}{r})^{\frac{\alpha}{1-\alpha-\beta}}(\frac{\beta}{w})^{\frac{\beta}{1-\alpha-\beta}}$.

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

$$\frac{(1+\gamma_i)^{\frac{\alpha}{(1+\beta)(1-\alpha-\beta)}}}{1-\alpha/(1+\gamma_i)^{\frac{1}{1-\beta}}-\beta} \tag{11}$$

of the inequality above increases in γ_i as the derivative of (11) $d(\cdot)/d\gamma_i = \left(\frac{\alpha(1-x)}{(1-\alpha-\beta)}x^{\frac{\alpha}{(1-\beta)(1-\alpha-\beta)}-1}\right)/D^2$, where $D \equiv$ denominator of (11), $x \equiv (1+\gamma)^{-\frac{1}{1-\beta}}$ 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*

Proof of proposition 2

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

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

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

and

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

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

Figures and tables

Figure 1: Ad-valorem tax. Profit functions: informal (thick line), formal (thin line), formal after decrease in tax (dash line)

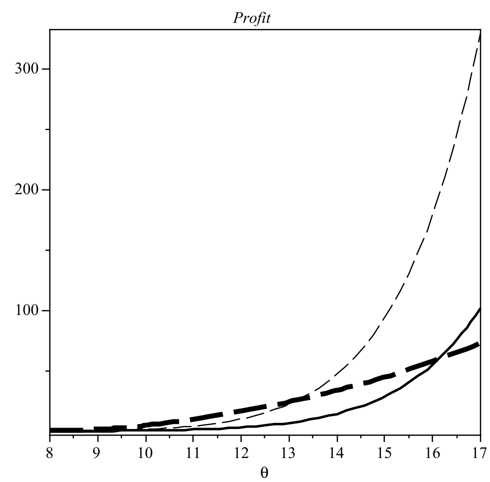


Figure 2: Lump-sum tax. Profit functions: informal (thick line), formal (thin line), formal after decrease in tax (dash line)

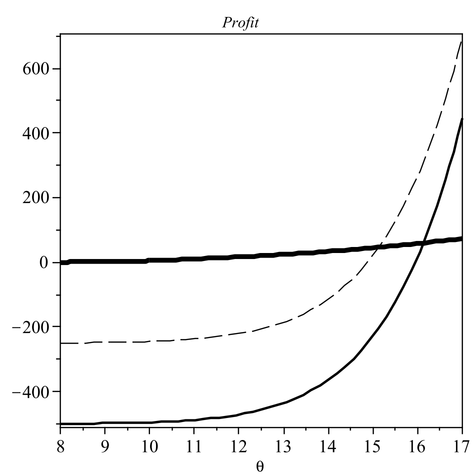
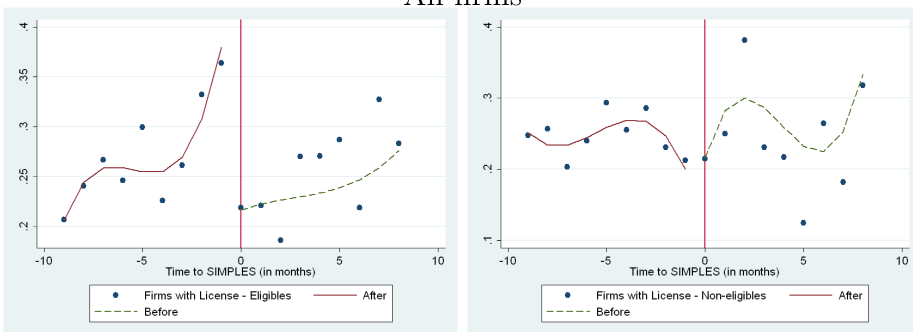


Figure 3: First stage, all micro-firms

All firms



Started as owners

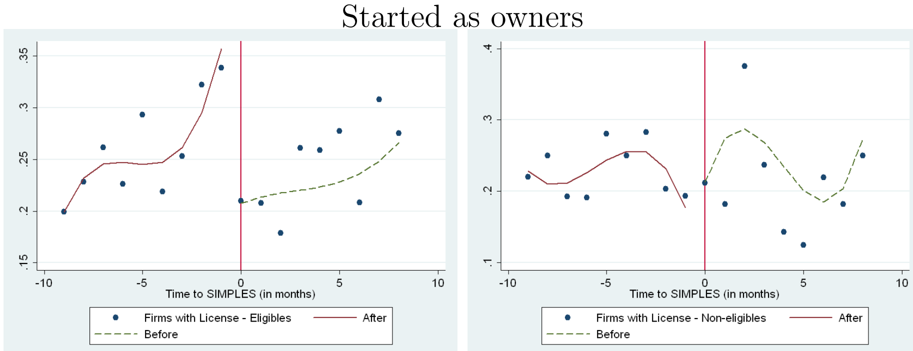


Figure 4: First stage, all micro-firms

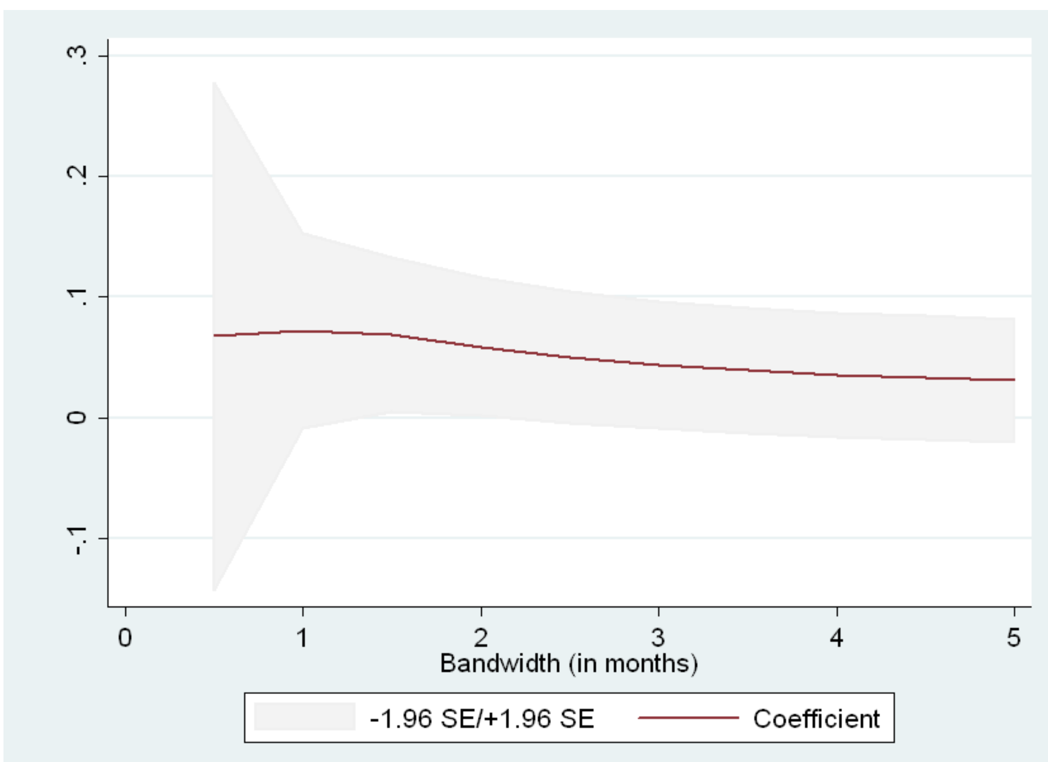


Figure 5: First stage, started firm as owner

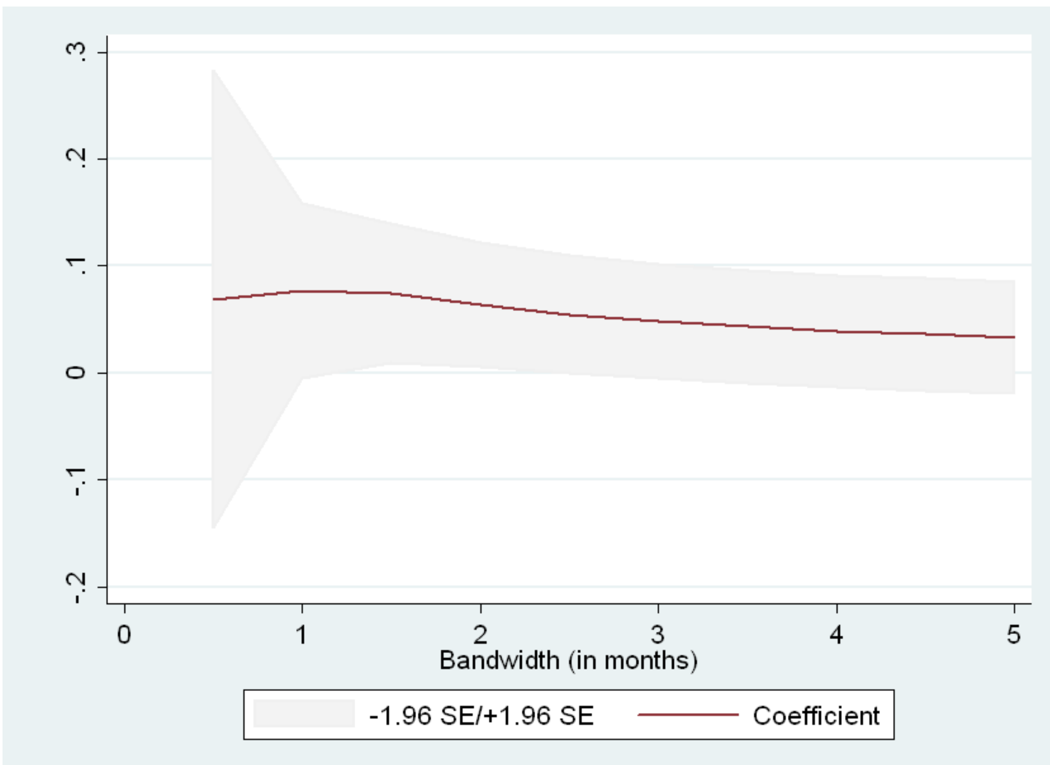


Figure 6: Quantile regression, all micro-firms

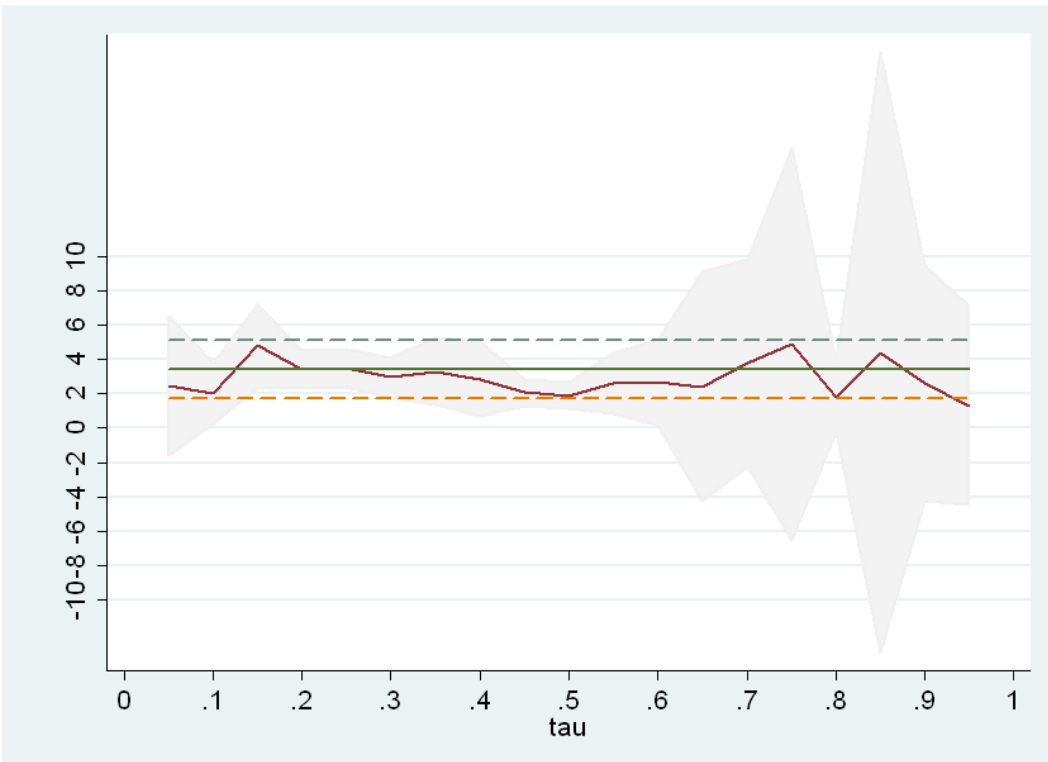


Figure 7: Quantile regression, started firm as owner

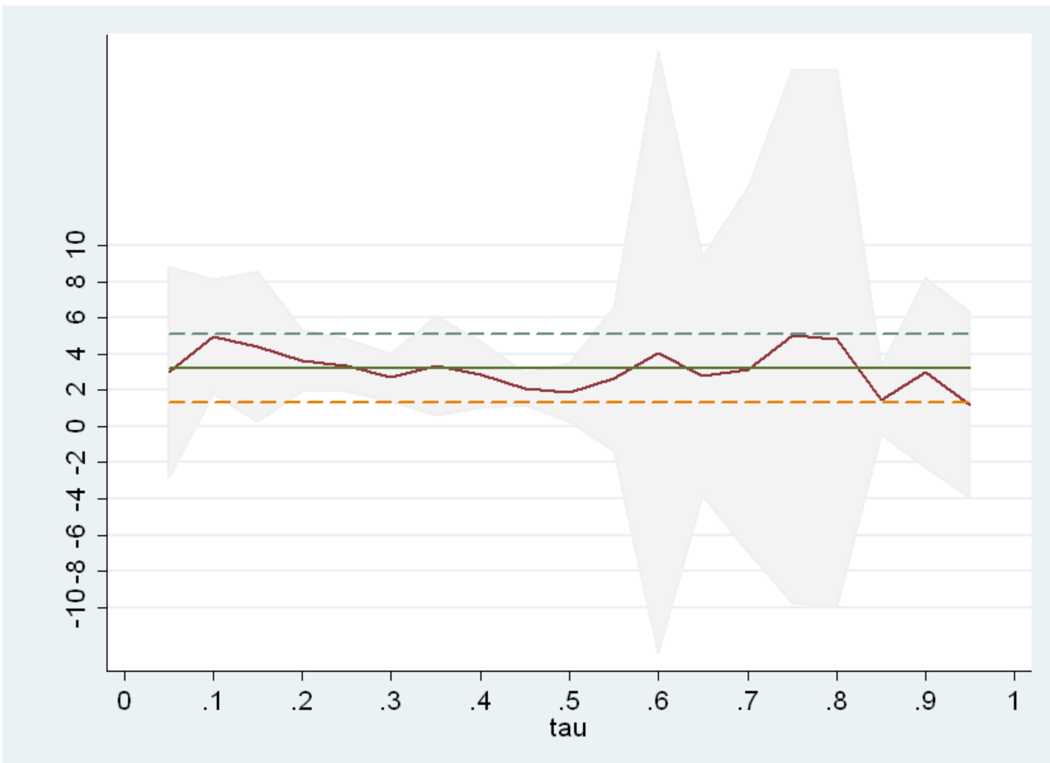


Figure 8: Objective function $\|\hat{\gamma}\|$, all micro-firms

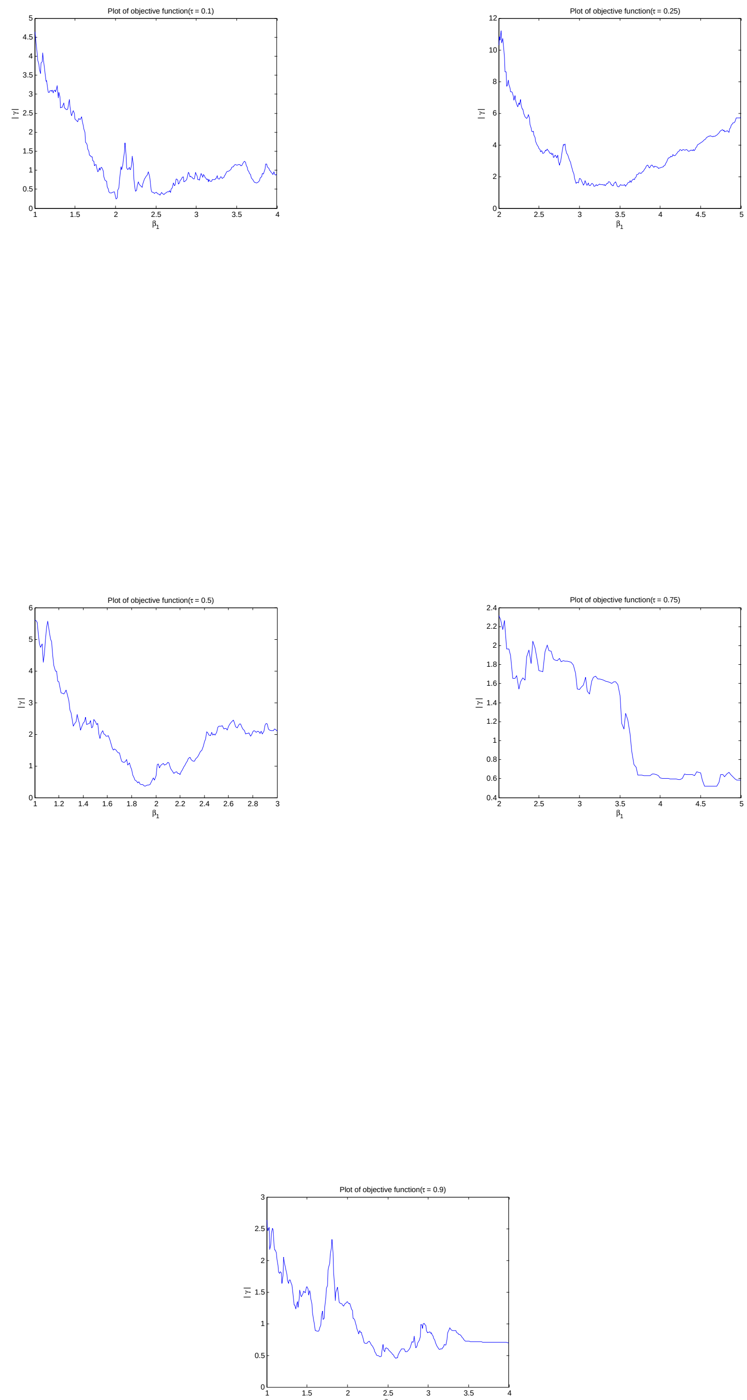


Figure 9: Objective function $\|\hat{\gamma}\|$, owners

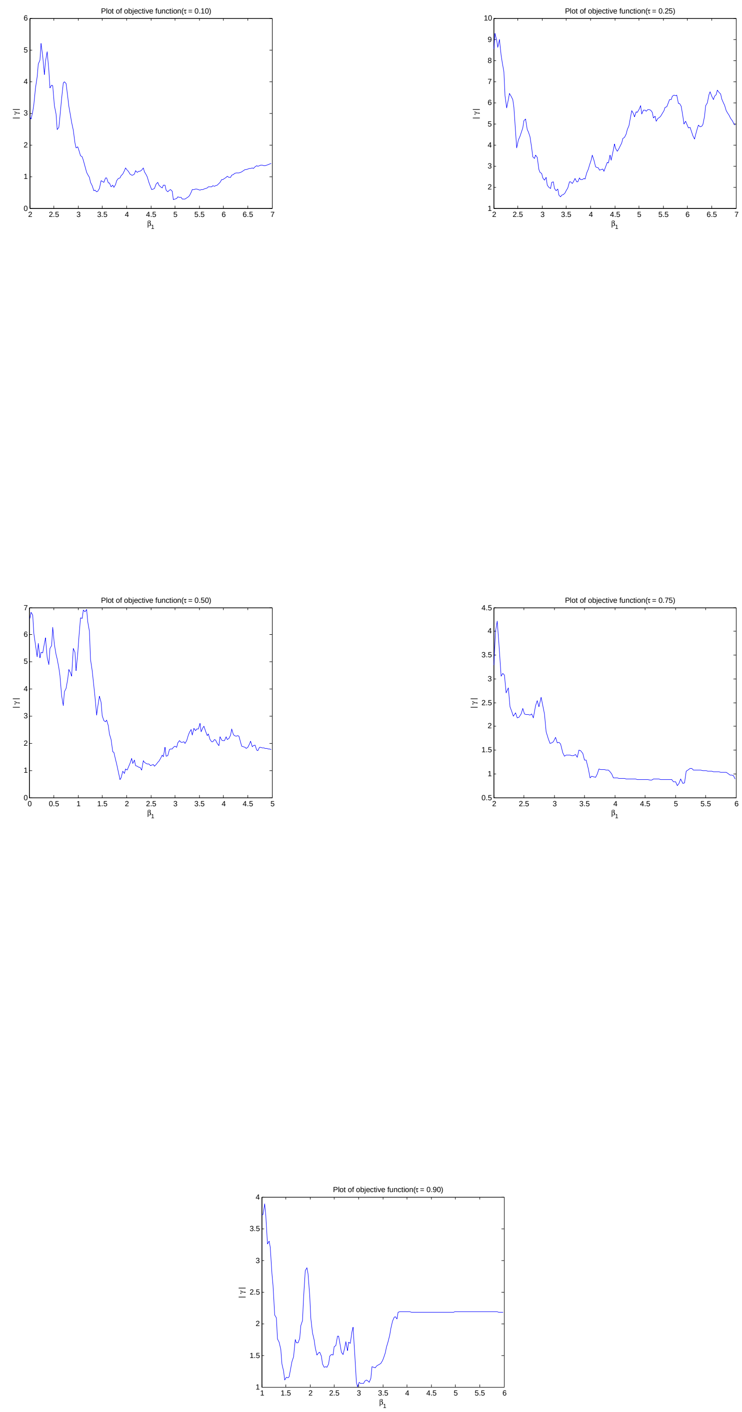


Table 1: Quantile Regression Discontinuity Analysis - All micro-firms

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

Notes: 6741 observations. Standard errors in parenthesis. Instrumental variables: $AFTER \times ELIG$ interacted with gender and age of the entrepreneur. See text for additional details.

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

Notes: 6300 observations. Standard errors in parenthesis. Instrumental variables: $AFTER \times ELIG$ interacted with gender and age of the entrepreneur. See text for additional details.