Employment Protection Legislation and Informality: Theory and Evidence from India*

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Abstract

We present causal evidence on how employment protection legislation (EPL) that penalize firms for hiring contractual workers can have adverse effects in contexts characterized by high levels of informality. While they increase compliance and reduce informality on the "intensive margin" as formal sector firms reduce hiring contract workers "off-the-books", they increase informality on the "extensive margin", as firms move to operating in the informal sector instead. This lowers aggregate productivity, wages and welfare in equilibrium. Counterfactual simulations demonstrate the significance of carefully designing EPL in contexts where informality is prevalent.

JEL Classification: D22, E26, J46, O12, O17

Keywords: Contract labor, Employment Protection Legislation, Firms, Informality.

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1 Introduction

Policy discussions surrounding employment protection legislation (EPL) have gained renewed attention worldwide in the aftermath of the Covid-19 pandemic. While there exists a substantial body of literature evaluating the impact of EPL,[1] a key distinction in understanding their effects in high- and low-income countries is a sizeable presence of the informal sector in the latter (La Porta and Shleifer, 2008, 2014).[2] Furthermore, as highlighted by Ulyssea (2018), the nature of informality itself can be characterized along two distinct margins in these countries, namely: (i) the "extensive margin", where firms must decide whether or not to formalize their operations by registering, paying taxes, and complying with EPL;[3] and (ii) the "intensive margin," where formal sector firms instead opt to hire workers "off-the-books" on informal contracts to evade EPL.

Previous empirical studies examining the causal impact of EPL in developing countries have typically focused on only one of these two margins, primarily due to the challenge of measuring both in large-scale administrative data that are commonly available in these countries.[4] However, as we show in this paper, analyzing the impact of EPL on *both* these margins of informality yields additional valuable insights, particularly regarding the design of these policies and their unintended consequences, which can potentially adversely affect wages, aggregate productivity and welfare in equilibrium.

For example, in the context of our study, a large-scale EPL reform imposed penalties on formal sector firms for hiring workers on temporary, short-term contracts instead of on regular payroll. Firms often used these contractual arrangements to circumvent labor laws pertaining to minimum wages, social security and severance payments, among others. Therefore, the policy reform directly aimed to reduce the use of contract workers in the formal sector i.e., reduce informality on the intensive margin (which it was successful in achieving). However, it also made firms less inclined to formalize their businesses, leading to an overall expansion of the informal sector on the extensive margin. Consequently, this decreased wages, reduced aggregate productivity, and thus led to an overall decline in welfare. Through counterfactual simulations, we further illustrate

[1] See for example, Besley and Burgess (2004); Autor et al. (2006); Bachas et al. (2019); Bjuggren (2018); Boeri and Garibaldi (2007); Bornhäll et al. (2015); Butschek and Sauermann (2022); Cahuc and Postel-Vinay (2002); Cahuc et al. (2016, 2023); Chaurey (2015); Schivardi and Torrini (2008); Ulyssea (2018), etc.

[2] There is a strong negative correlation between real GDP per capita and the fraction of employment and output originating from the informal sector (Elgin et al., 2021; La Porta and Shleifer, 2014). While more than 80% of workers and 30-40% of output in low-income countries comes from the informal sector, it is only 30% of workers and 10% of output in high-income ones (see Figure A1).

[3] As documented in a comprehensive review by La Porta and Shleifer (2014), limited state capacity to monitor, poor quality of public institutions (such as corruption), and cumbersome regulations are the primary reasons for firms choosing to operate in the informal sector.

[4] For example, see Almeida et al. (2022); Besley and Burgess (2004); Bruhn (2013); Bruhn and McKenzie (2014) on the extensive margin; and Chaurey (2015); Samaniego de la Parra and Fernández Bujanda (2020) on the intensive margin.

how alternative EPL policies have the potential to effectively reduce informality, aligning with the policymakers' goals, while simultaneously yielding meaningful enhancements in welfare. Our study therefore not only addresses a significant gap in the literature by providing causal evidence on the impact of EPL reforms on different dimensions of informality, but also underscores the importance of distinguishing between these dimensions in the effective design of these policies.

Our empirical investigation focuses on India, a country characterized by a large informal sector that employs a majority of its workforce.[5] Historically, India has grappled with intricate labor laws and bureaucratic inefficiencies, making it challenging for formal sector firms to engage workers through proper payroll channels and adhere to EPL. Consequently in the 1990s, amidst trade liberalization, industrial reforms, and robust economic growth, these firms increasingly resorted to hiring workers "off-the-books" on temporary contracts, as a means to evade compliance with EPL (Bertrand et al., 2021; Chaurey, 2015; Chakraborty et al., 2020). It is in this context that the Government of Andhra Pradesh (a large state in India) issued a notification in 2003 that prohibited formal sector firms from hiring contract workers in their core manufacturing activities, imposing heavy penalties for non-compliance.[6] The reform was enacted through an amendment to the Contract Labour Act, 1971 (CLA), and was applied in addition to the Industrial Disputes Act, 1947 (IDA), India's key EPL for payroll workers.[7] The objective of the reform therefore, was to strengthen employment protection in the state by compelling formal sector firms to either comply with EPL or face penalties.

Our empirical analysis draws on multiple nationally representative datasets of firms and workers, allowing us to precisely measure the impact of this policy on various aspects such as firms' adjustments along the margins of informality, as well as on workers' wages, type of contract, and sector of employment, etc. We employ a standard difference-in-differences approach to compare outcomes in Andhra Pradesh (treated state) before and after the policy change (in 2003), as compared to other Indian states (control group).[8]

We first examine the direct impact of the policy reform on the intensive margin of informality using a representative establishment-level panel data of formal sector firms between 2000-2006 from the Annual Survey of Industries (ASI). We find significant re-

[5] India's informal sector accounts for over 85% of the workforce and 20% of GDP (Elgin et al., 2021). It ranks at the median of EPL enforcement across countries (Botero and Ponce, 2011).

[6] "Core activity" was defined as any activity for which the establishment was set up, or other activities essential for core activities.

[7] The IDA imposes severance pay for regular worker dismissal, requires firms to seek government permission for layoffs and retrenchments and asks for a minimum 60-day notification to the government for firm closures, all of which add considerably to their direct and indirect labor costs. Importantly, the IDA is applicable only to regular payroll workers, but not to contract workers, leading to the popular usage of contract workers to circumvent the costly dismissal laws.

[8] Section 5.4 shows the robustness of our results to alternate specifications, samples, and definitions.

ductions in contract work, as indicated by a 42-47% decline in the number of contract workers (worker-days), and a 20% drop in the fraction of contract workers.[9] Therefore, while the policy de-jure prohibited the use of contract workers, in practice, it led to a substantial, though incomplete reduction in their usage. We also find a corresponding increase in payroll workers by 20-25%, with little change in overall firm size.[10]

To examine the extensive margin of informality, we complement our analysis with various rounds of the National Sample Survey (NSS) and the Economic Census (EC). Unlike the ASI, which samples firms only in the formal sector, the EC is a census of all firms in India, and the NSS is a nationally representative survey of workers.[11] Put together therefore, they provide a comprehensive picture of workers and firms in both the formal and informal sectors that we can use to study the extensive margin of informality. We find that after the policy reform, workers in Andhra Pradesh were 6.2% more likely to work in an informal enterprise, 15.1% more likely to work on informal contracts, 11.2% more likely to work as a casual (informal) worker, and had 6% lower wage earnings on average (relative to control states). Finally, there was a 18% increase in the the fraction of firms in Andhra Pradesh that were large (employing more than 10 workers) and chose to remain unregistered, and a 26% increase in the fraction of workers who worked in them. Our analysis confirms that the policy reform effectively decreased informality on the intensive margin (as intended), but inadvertently increased it on the extensive margin. Notably, large firms who could have perhaps formalized, opted to remain informal instead. Moreover, workers were more likely to work in the informal sector, on temporary contracts, with lower wages.

How did the policy reform impact aggregate productivity and welfare in general equilibrium? Furthermore, could an alternative policy design have mitigated these adverse effects on informality and potentially improved welfare? These critical policy-relevant questions extend beyond the scope of the reduced-form analysis discussed above. To address them, we build a theoretical framework that closely follows the approach developed by Ulyssea (2018). It integrates the extensive and intensive margins of informality

[9]Note that the policy reform only prohibited the use of contract workers in core activities. A unique feature of the ASI data is that it also reports the number of worker-days in core and non-core activities separately. We use this as a placebo check in Section 5.4 to indeed show that the decline in contract workers is driven entirely by a reduction in core activities (Table A3).

[10]Note that finding no change in the overall firm size does not necessarily imply perfect substitution between contract and payroll workers. As we document later, the policy lowered wages on average as well, thus reducing firms' cost of hiring workers more generally. Using a methodology similar to Acemoglu et al. (2004), we also estimate the elasticity of substitution of between contract and payroll workers to be 2.6 and 4 (depending on the specification).

[11]The Economic Census is a census of all non-agricultural firms in the country and provides information on the registration status of each firm. We can therefore use it to study the extensive margin of informality. However, unlike the ASI, it does not provide information on the number of payroll and contract workers within a firm, thus limiting its use to study the intensive margin of informality.

into a general equilibrium model with heterogeneous firms.

In the theoretical framework, firms are ex-ante heterogeneous in productivity, pay a fixed cost of entry to the market, and decide whether to enter the informal or formal sectors (the extensive margin of informality) or not enter at all. Conditional on formalizing, firms can endogenously choose to comply with EPL and hire workers on payroll, or evade them by hiring workers off-the-books (the intensive margin of informality). In the informal sector, firms can hire workers without complying with taxes and EPL, but face a size-dependent penalty remaining informal.[12] The relationship between firm productivity, its size, and choice to operate in the formal or informal sector is inherently intertwined. Typically, more productive, larger firms opt to operate in the formal sector, while smaller, less productive ones persist in the informal sector. The model therefore provides a parsimonious way of rationalizing the implications of the aforementioned policy reform. We show for example that such policies would reduce informality on the intensive margin (as formal firms hire lesser workers off-the-books), but conversely, increase it on the extensive margin due to the increased costs of formal sector operations, particularly for larger firms. This, in turn, reduces aggregate labor demand, real wages, and overall welfare in equilibrium.

We then quantitatively estimate the model using a Simulated Method of Moments estimator and consider the implications of two counterfactual EPL policies, both aimed at increasing compliance with EPL. First, similar to the policy in Andhra Pradesh, we consider a 10% and a 20% *penalty* on the marginal cost of hiring a contract worker by a formal sector firm. Consistent with the reduced-form, the policy reduces informality on the intensive margin and increases it on the extensive margin. This is because the *direct* effect of the policy makes it costlier for firms to operate in the formal sector. However, there is an *indirect* channel that operates through general equilibrium. Since firms are less productive in the informal sector, there is an overall decline in labor demand, which reduces real wages.[13] Lower (real) wages in equilibrium however, make it cheaper for (all) firms to hire workers, therefore offsetting some of the direct effects of the policy. Put together, aggregate productivity (TFP) decreases by 1-2% and real income, our measure of welfare, declines by 2-3%.

We then consider a second policy counterfactual that has long been advocated by Indian entrepreneurs and researchers alike: an overhaul of the complex and cumbersome

[12]This penalty captures the probability of being audited and caught, and more general constraints such as access to formal sources of finance and markets (La Porta and Shleifer, 2014).

[13]While we hold aggregate labor supply to be fixed in our model, it is possible that the policy could change it. In Table A2, we show that the policy reform in Andhra Pradesh had no impact on the probability of unemployment and/or the probability of working in agriculture. Nevertheless for completeness, we discuss the implications of our counterfactual policy simulations after allowing for endogenous labor supply changes in Section 7.3.

EPL, by simplifying the hiring and firing of regular workers.[14] In the context of our model, this translates into a lower relative marginal cost of hiring payroll workers. To make the effects comparable across the two counterfactuals, we reduce these costs such that the resulting impact on the intensive margin of informality is the same across both policies. Contrary to the previous policy however, this policy *reduces* informality on the extensive margin as well, and *increases* TFP and real income by 1% and 3-5% respectively.

In summary, our analysis yields several significant insights. Firstly, it highlights the importance of careful design and targeting of labor market policies, as policymakers endeavor to reduce informality and encourage compliance with EPL. Penalizing formal sector firms for not complying with EPL does increase their compliance, but also discourages them from formalizing entirely, thereby leading to adverse effects on aggregate productivity, real wages, and welfare. Conversely, alleviating the costs and constraints associated with hiring workers through regular payroll (such as reducing burdensome bureaucratic red tape) can substantially reduce both dimensions of informality and positively impact the overall economy.

This paper contributes to multiple strands of the literature. Firstly, while there is a substantial body of research on the employment effects of EPL reforms,[15] much of it concentrates on advanced economies where informality is not widespread. A relatively smaller literature that has highlighted the role of informality in understanding these reforms, has primarily focused on studying either its extensive margin (Almeida et al., 2022; Besley and Burgess, 2004; Ponczek and Ulyssea, 2022), or the intensive margin (Chaurey, 2015; Samaniego de la Parra and Fernández Bujanda, 2020) separately.[16] Our contribution lies in demonstrating that examining both margins of informality offers additional insights on understanding the impacts of EPL. In this regard, our paper aligns closely with Ulyssea (2018) and Cisneros-Acevedo (2022). Ulyssea (2018) develops and estimates a structural model of heterogeneous firms in Brazil to show that labor market policies and informality need not move in the same direction, and may not lead to higher TFP or welfare. We complement this analysis by providing causal empirical evidence using a large-scale EPL policy reform in India. Cisneros-Acevedo (2022) shows how the Peruvian trade reforms reduced informality on the extensive margin and increased it on the intensive margin, complementing our analysis in a different policy context.

A second strand of the literature has examined the impact of EPL on the composition

[14] See Ahsan and Pagés (2009); Besley and Burgess (2004); Chaurey (2015); Sodhi (2014) for examples.

[15] See Kugler and Pica (2008); Autor, Donohue III and Schwab (2006); Bachas, Jaef and Jensen (2019); Bjuggren (2018); Boeri and Garibaldi (2007); Bornhäll, Daunfeldt and Rudholm (2015); Butschek and Sauermann (2022); Cahuc and Postel-Vinay (2002); Cahuc, Charlot and Malherbet (2016); Cahuc, Carry, Malherbet and Martins (2023); Schivardi and Torrini (2008).

[16] There is a related literature that examines the impact of trade reforms in the context of informality. See Dix-Carneiro et al. (2021); Ponczek and Ulyssea (2022); Vera et al. (2022).

of a firm's workforce, with earlier studies primarily focusing on EPL for regular workers.[17] However, given the rapid rise of contract workers in recent years due to automation and globalization (Dix-Carneiro et al., 2021; Ponczek and Ulyssea, 2022; Bertrand et al., 2021), more recent literature has explored how EPL can affect their use (Aguirregabiria and Alonso-Borrego, 2014; Ardito et al., 2021; Baek and Park, 2018; Cahuc et al., 2023; Daruich et al., 2023; Hijzen et al., 2017). Our contribution lies in emphasizing the significance of carefully designing and targeting policies that aim to regulate flexible and part-time work arrangements in contexts where informality is prevalent.

The rest of the paper is organized as follows: Section 2 develops the theoretical model that provides a basis for interpreting the empirical results. Section 3 discusses the policy reform in India. Section 4 describes the data and we present the empirical methodology and results in Section 5. Sections 6 and 7 discuss the quantification of the model, and counterfactual policy simulations. Section 8 offers a short conclusion.

2 Theory

An economy consists of J industries and two sectors in each industry, namely the formal and informal sectors. There is a continuum of potential firms in each industry, with mass N_j, $j \in J$. Each firm is indexed by its productivity $z \sim F_j(z)$. Labor is the only input in production, and firms can hire homogeneous workers at a competitive wage w. Firms can endogenously decide whether to enter at all, and conditional on entry, whether to operate in the informal or formal sector, $s \in \{I, F\}$. We refer to this as the "extensive" margin of informality. Firm entry is static so that after entry, firms stay active forever.[18] Moreover, firms in the formal sector can hire workers either on regular payroll or on temporary contracts i.e. "off-the-books". We refer to this margin as the "intensive" margin of informality. The goods market is perfectly competitive and the formal and informal sectors are perfect substitutes in consumption.[19]

The key difference between the two sectors is that in the informal sector, a firm chooses to remain unregistered with the government. Therefore, it does not pay any taxes nor does it need to conform with EPL regulations. However, it faces a size-dependent penalty of operating in the informal sector. This penalty not only captures the cost of being large, evading taxes and getting caught, but also other constraints faced by operating

[17] See Botero et al. (2004); Cingano et al. (2010); Besley and Burgess (2004); Autor et al. (2007).

[18] As reported by Hsieh and Klenow (2009), most firms in India are born small, and never grow or die.

[19] To measure the overlap of firms manufacturing similar products or operating in the same (finely measured) industry, we use establishment-level data from the 2005 round of the Annual Survey of Industries and National Sample Survey. These data capture the distribution of firms in both the formal and informal sectors. We find that 97-98.5% of industries as measured by their 3-digit, 4-digit and 5-digit NIC classifications have both formal and informal firms.

in the informal sector such as access to formal channels of finance for example, where registration with a government agency is required.[20] On the other hand, in the formal sector, firms pay taxes, but can endogenously decide on its compliance with EPL by choosing the composition of its workers on payroll or on temporary contracts.

With this setup, we now turn to discussing the details of the model. In Section 2.1, we begin with the production decision of incumbent firms in the formal and informal sectors. In Section 2.2, we then discuss the entry decisions of a firm and define equilibrium in Section 2.3. Lastly, we discuss the implications of a policy that penalizes the hiring of contract labor by formal firms in Section 2.4. Moving forward, we drop firm and industry subscripts for notational clarity.

2.1 Incumbents

Output of a firm with productivity z is given by a decreasing returns to scale production function, $y(z) = zl^{\rho}$, where $0 < \rho < 1$, and l is the labor used in production. We now discuss a firm's production decision in the formal and informal sectors below.

Formal Sector: Two features define production in the formal sector. First, firms must pay a per-unit tax t on sales. Second, they can hire workers on both regular payroll (l_r) as well as "off-the-books" on informal contracts (l_c). Both types of workers are imperfect substitutes in production with an elasticity of substitution ν, such that $l_F = \left[l_r^{\frac{\nu-1}{\nu}} + l_c^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}}$. However, apart from the wage w, firms pay additional marginal costs b_r and b_c to hire a payroll and contract worker respectively. These costs are therefore a reduced-form way of incorporating compliance with labor laws for regular payroll workers such as incurring hiring/firing costs, as well as search costs, intermediary contract worker payments, etc., for hiring contract workers. Note that in the estimation, we will not impose any restrictions on the value of these parameters i.e., they could be greater or less than 1. The variable profit of a firm manufacturing in the formal sector is therefore:

$$\pi_F(z) = (1-t)pzl_F^{\rho} - wb_r l_r - wb_c l_c$$

Define: $w_F = \left[b_r^{1-\nu} + b_c^{1-\nu} \right]^{\frac{1}{1-\nu}} w$. The ratio of contract to regular workers and the

[20] See La Porta and Shleifer (2014), Beck and Hoseini (2014) and Nikaido, Pais and Sarma (2015).

variable profit of the firm in the formal sector can therefore be given by:

$$\frac{l_c}{l_r} = \left(\frac{b_c}{b_r}\right)^{-\nu} \tag{1}$$

$$l_F(z) = \left[\rho(1-t) \times \frac{z}{w_F/p}\right]^{\frac{1}{1-\rho}} \tag{2}$$

$$\pi_F(z) = (1-\rho)(1-t)pzl_F^{\rho}(z) \tag{3}$$

See proof in Appendix C.1. Note that although b_c/b_r captures the additional marginal costs in our model, in theory, they could also reflect (industry-specific) differences in the relative productivity of contract and regular workers. For example, let $B = b_c/b_r = A_c/A_r \times \tilde{b}_c/\tilde{b}_r$, where $A = A_c/A_r$ is the relative productivity of contract workers to payroll workers, and $\widetilde{B} = \tilde{b}_c/\tilde{b}_r$ is the true difference in the relative marginal costs of hiring contract and regular payroll workers, after taking into account the productivity differences. Our current data structure does not allow us to disentangle them, and our calibration exercise in Section 6 will identify B instead of $\tilde{B}$. However, our analysis and counterfactual policies will focus on changing the marginal costs of hiring contract (or payroll) workers, keeping the relative productivity differences (A) unchanged. Therefore, if we define $\triangle X = x_{new}/x_{baseline}$, then $\triangle B = \triangle\widetilde{B}$ (since $\triangle A = 1$).

Informal Sector: Firms in the informal sector are unregistered with the government and tax authorities. Therefore, they can only hire informal contract workers, but do not have to pay taxes, or comply with EPL regulations (b_c and b_r). However, they face size-based challenges of operating in the informal sector such as the probability of being audited (and potentially penalized) by the government, limited access to formal channels of credit, etc. We approximate this distortion in the form of a convex cost function $c(l_I) = wl_I^{\theta}$, where l_I is the size of the firm, and $\theta \geq 1$.[21] The variable profit function of a firm in the informal sector is therefore given by:

$$\pi_I(z) = pzl_I^{\rho} - wl_I^{\theta}$$

Define $\widetilde{\rho} = \rho/\theta < 1$. The optimal profit of the firm is then given by:

$$l_I(z) = \left[\widetilde{\rho} \times \frac{z}{w/p}\right]^{\frac{1}{\theta-\rho}} \tag{4}$$

$$\pi_I(z) = (1-\widetilde{\rho})pzl_I^{\rho}(z) \tag{5}$$

[21] Appendix C.3 relates the convex-costs to a size-based penalty function for informal firms.

See proof in Appendix C.2.

2.2 Firm Entry

Let there be a mass of potential entrants N indexed by a pre-entry signal of productivity denoted by $x \sim F(x)$. We assume that $F(x)$ is continuous with support $(0, \infty)$, has finite moments and is independent across firms. For a sector $s \in \{I, F\}$, let E_s be the fixed cost of entry (in units of output) that a firm has to pay to enter the sector. We assume that entry costs in the formal sector are higher than the informal sector so that $E_F = E_I + E_R$, where E_R capture fixed costs associated with registering the firm with the government (for example, bureaucratic procedures and red-tape).

After entry occurs, an entrepreneur draws his/her actual productivity from a conditional cumulative distribution $G(z|x)$, which is assumed to be continuous in both z and x and is strictly decreasing in x. This implies that a high pre-entry signal x is indicative of a high post-entry draw of productivity z as well.[22] An entrepreneur with pre-entry productivity x, operating in sector s would have an expected variable profit $V_s(x)$ given by:

$$V_s(x) = \int \pi_s(z) dG(z|x) \tag{6}$$

Therefore, the entrepreneur will enter a sector s as long as $V_s(x) - pE_s \geq \max\{V_{s'}(x) - pE_{s'}, 0\}$. Given that $E_F > E_I$ and we observe positive entry into both sectors, this implies that there is a positive threshold level of productivity x_s^* in each sector s such that:

$$\begin{aligned} V_I(x_I^*) &= pE_I \\ V_F(x_F^*) - V_I(x_F^*) &= pE_R \end{aligned} \tag{7}$$

Entrepreneurs with $x < x_I^*$ will not enter at all, those with $x \in [x_I^*, x_F^*]$ will enter the informal sector, and $x > x_F^*$ will enter the formal sector.

2.3 Equilibrium and Welfare

We now specify the demand side to close the model in equilibrium. We assume a representative consumer who inelastically supplies labor $\overline{L}$ (no disutility from labor) and does not save. Consumer income therefore simply aggregates wage income, profits and taxes across the economy and is therefore given by $I = w\overline{L} + \Pi + T$, where Π denotes the total profits (net of fixed costs) of incumbent entrepreneurs and T is the total tax-revenue

[22] This entry structure is similar to Ulyssea (2018) in that it allows for an overlap of the firm-size distribution between the informal and formal sectors, a salient feature of firms in the Indian economy. An entry decision in the spirit of Melitz (2003) on the other hand, would predict perfect sorting of firms between the formal and informal sectors based on firm size, which is inconsistent with the data.

collected by the government that is redistributed back to the consumers. We assume a simple demand system where this representative consumer consumes a composite bundle C, whose price is normalized to 1, and a constant share of income κ_j is spent on consumption from industry j. Total consumption (and hence real income) is therefore a natural measure of welfare. The equilibrium in this economy is therefore characterized by a set of prices for each industry $\{p_j\}_{\forall j}$ and wages w such that:

(i) the goods market clears in each industry i.e., the total output produced in an industry j (across both the informal and formal sectors) is either demanded by consumers or paid in fixed costs by the incumbent firms.

(ii) the labor market clears so that the total labor demand across industries and sectors is equal to the size of the labor force in the economy.

(iii) the zero-profit condition in Equation 7 holds with equality in both sectors.

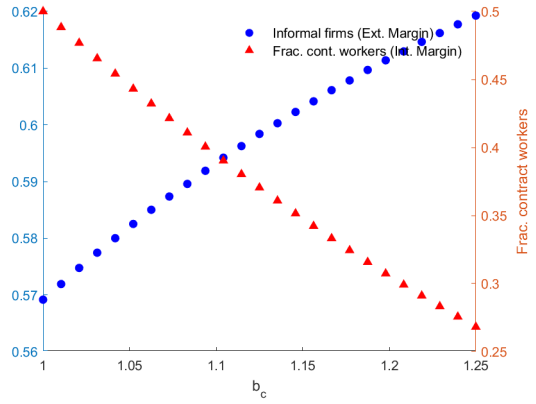
2.4 Impact of Enforcing EPL and Informality

Stricter enforcement of EPL would therefore encourage firms to hire more workers on payroll and less on temporary contracts. In this section, we consider the impact of penalizing the hiring of contract workers in the formal sector on both the intensive and extensive margins of informality. From the perspective of the model, this corresponds to an increase in b_c. To understand the mechanism, we fix some parameter values and simulate the model in equilibrium and examine its implications.

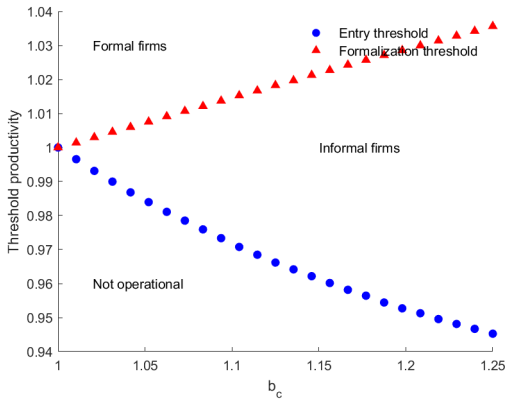
We start with a baseline scenario where $b_c = 1$ and increase b_c with each counterfactual simulation, leaving b_r unchanged. Figure 1a shows the impact of this increase on both margins of informality. As can be seen from the figure, the intensive margin of informality i.e., the fraction of workers hired on contracts in the formal sector (denoted by red triangles) declines as b_c increases. However, there is also an increase on the extensive margin of informality (denoted by blue dots) as more firms now choose to operate in the informal sector instead of formalizing. This is what we explore in Figure 1b, where we plot the productivity of the marginal firm that is indifferent between entering the informal sector or not (denoted by blue dots) and formalizing or not (denoted by red triangles). We see that as b_c increases, the productivity of the marginal firm in the formal sector (red triangles) also increases. Lastly, the size of the informal sector (area between the blue dots and red triangles) also increases as b_c increases.

The underlying mechanism (that we will come back to again in Section 7) is more nuanced. The policy reform increases the size of the informal sector in two ways. First, it has a direct effect: the marginal formal sector firm at baseline now chooses to remain

Figure 1: Theoretical Implications of Penalizing Hiring Contract Workers



(a) Margins of Informality



(b) Productivity Thresholds

Note: The above figure examines the impact of penalizing the hiring of contract workers on the intensive and extensive margins of informality (Graph A) and on the productivity of the marginal firm, which is indifferent between entering the informal and formal sectors (Graph B). We start with a baseline scenario of $b_c = 1$, and examine the impact of gradually increasing b_c. We use the following parameter values for the simulation: $E_I = 0.25$; $E_R = 2.5$; $\tau = 0.1$; $\sigma = 0.5$; $\nu = 4.5$; $\rho = 0.74$; $\theta = 1.3$; $N = 10k$; $L = 1m$

informal as b_c increases (red triangles in Figure 1b). However, since firms are less productive in the informal sector, the resulting changes in general equilibrium–through lower labor demand and lower real wages–has a second indirect effect: low-productivity firms now choose to enter the informal sector i.e., the threshold productivity of the marginal firm choosing to enter now decreases (blue dots in Figure 1b). Therefore, although the policy reduces informality on the intensive margin, it increases informality on the extensive margin through both the direct and indirect channels.

3 Context of the EPL Reform in India

An Overview of Labor Laws in India: Before discussing the policy reform instituted by the Government of Andhra Pradesh, it is important to understand key labor laws in India, along with their implications for hiring workers on payroll or temporary contracts. The Industrial Disputes Act (1947) makes it expensive for a firm to dismiss or layoff its hired workers on payroll. For example, firms retrenching a worker must offer severance pay, seek government permission, and issue advance notification in case of closures.[23] On

[23]Section V-A of the IDA lays down regulations for establishments with 50 or more workers. For example, a retrenched worker is entitled to compensation equalling 15 days' average pay for each year of service, and for layoffs, every worker is paid fifty percent of the basic wages and a dearness allowance for each day that they are laid off (maximum of 45 days). Section V-B mandates that no worker may be

the other hand, contract (or fixed-term) workers are not protected under the IDA. These workers are not directly hired on the payroll of a firm, but are usually hired on fixed-term contracts with licensed contractors. The Contract Labour Act, 1970 (CLA) allows the use of contract workers in any firm with a minimum of twenty or more workers, but mandates that such establishments register with the government to use contract workers, and their contractors obtain a license to operate.

This naturally creates a tradeoff where since the IDA is not applicable to contract workers, firms normally hire them to circumvent the payment of formal benefits as well as associated high dismissal costs. In fact, several studies provide robust evidence for this channel by examining the rise in the usage of contract labor by firms operating in states with stringent employment protection laws.[24] Moreover, India's economic liberalization implemented through the decade of the 1990s further exacerbated the need for policy to consider the welfare of workers, and hence regulate the usage of contract workers in production (Saha, Sen and Maiti, 2013; Chakraborty, Singh and Soundararajan, 2020).

EPL Reform in Andhra Pradesh: It was in this context that the Government of Andhra Pradesh in 2003 issued a notification that prohibited firms from hiring contract workers in their "core" production activities either directly or through licensed contractors. The reform was aimed at protecting workers by encouraging firms to hire them on regular payroll (thus conforming with the IDA regulations) instead of on temporary contracts. Core activities included the primary activity for which an establishment was set up, along with other activities essential to this primary activity. All other activities (such as catering, housekeeping, transport, etc.) were classified as "non-core" activities, and the use of contract workers was permitted in them (see Appendix B for a complete list).

4 Data

Annual Survey of Industries: Our primary source of data is the panel version of the Annual Survey of Industries (ASI), administered by the Ministry of Statistics and Programme Implementation (MoSPI), Government of India. The ASI is an annual representative survey of factories registered under The Factories Act (1949), a central piece of legislation regulating manufacturing establishments in India.[25] The ASI comprises two

laid-off or retrenched in large firms (of size 100 and above) without prior permission of the government. Establishments that want to close down are also required to issue a sixty days (Section V-A) or ninety days (Section V-B) notification to the government prior to the shutting down. Both these sections of the IDA make it costly for firms to fire workers.

[24] See Chaurey (2015), Ahsan and Pagés (2009) for specific examples as well as a comprehensive overview by Basu, Chau and Soundararajan (2020).

[25] All factories employing 10 workers or more (without using electricity) or employing 20 workers or more (with or without using electricity), are required to register under the Factories Act.

parts: first, the Census Sector, which is a census of establishments employing 100 or more workers; second, the Sample Sector, consisting of establishments that are randomly sampled using a systematic circular sampling technique within each State $\times$ Industry $\times$ Sector $\times$ 4-digit NIC industry stratum.[26]

We use a panel of establishments from the ASI between 2000-2001 to 2005-2006 for this study. The reference period for ASI is the accounting year of the factory ending on the last day of the fiscal year between April to March. For instance, the data for the year 2005-2006 corresponds to all activities between 1^{st} April 2005 and 31^{st} March 2006. A unique feature of the data that is relevant for this study is that it contains detailed information on the number of contract and regular workers, their worker-days employed, and wage expenditure for both these categories of workers. Using the ASI, we study the impact of the amendment on the firms' usage of labor— contract, regular, total workers, and worker-days. Data on worker-days are further disaggregated between core and non-core activities of a firm. We use this distinction to conduct placebo tests, since the policy reform in Andhra Pradesh was only applicable to core activities. A limitation of the ASI is that it does not cover informal firms. We therefore complement our analysis with two additional datasets, namely the National Sample Survey and the Economic Census to examine the impact of the policy on the informal sector.

National Sample Surveys: We use two rounds of the Employment-Unemployment module of the National Sample Survey (NSS) for the years 1999-2000 and 2004-2005. The NSS is a repeated cross-section of a nationally representative sample of households. Among other things, this module of the NSS collects detailed data on the employment of individuals, including: (a) the characteristics of the workplace, such as, the firm size, and whether or not the workplace uses electricity; (b) nature of employment, namely, regular or casual (informal) work;[27] (c) nature of payment (whether piece-rate or flat-rate), along with the frequency of payment (daily, weekly, monthly etc.); (d) number of days worked and earnings in the past week. The NSS provides a representative picture of workers both in the formal and in the informal sectors. For each individual, we calculate wages as the ratio of total earnings divided by the number of days worked. We use the NSS to estimate the impact of the policy on the probability that a worker is employed in an un-registered firm (based on Factories Act, 1949), the probability that a worker is employed casually/informally, the probability that a worker is employed on an informal contract, and on wages. In a separate analysis, we use prior rounds of the NSS data from 1993-94

[26] Apart from the large establishments, the Census Sector also comprises of: (1) all industrial units belonging to the six less industrially developed states and Union territories viz. Manipur, Meghalaya, Nagaland, Sikkim, Tripura and Andaman & Nicobar Islands; (2) all factories filing Joint Returns.

[27] The NSS defines a casual worker as *"a person engaged in farm or non-farm enterprises (both household and non-household) and getting in return a wage according to the terms of the daily or periodic work contract."*

to conduct placebo checks on the impact of the policy. We do not include this round in our main specification because while the 1993-94 round includes details on the nature of employment and wages, it does not measure firm characteristics and the nature of payment.

Economic Census: We use two waves of the Economic Census of India (EC) for the years 1998 and 2005. The EC is an enumeration of all non-farm establishments in India and contains information on the firm's location and industry, along with whether the firm is registered and conforms with various government regulations (like the Factories Act, Shop & Establishment Act, the Cooperative Society/Labour Act, etc.). The EC also reports data on the total number of workers, but not data separately on contract and regular workers. We aggregate these data to the district-year level, and examine the impact of the policy reform on the "extensive margin" of informality i.e., the share of unregistered firms, and the share of workers in unregistered firms. There are two additional rounds of the Economic Census in 1990 and 2013 that we do not use for this study because they do not collect information on the registration status of firms, which is important for our analysis.

Summary Statistics: We present summary statistics for key outcome variables of interest before the policy reform (i.e., between 2000-2002) in Table 1. Columns (1)-(3) report the mean and standard deviation in Andhra Pradesh (Treatment state), while Columns (4)-(6) report them for all other states in India (Control states). From Panel A, around 15-20% of workers in a formal firm work on temporary contracts. Using worker-level data from the NSS (Panel B), 75-80% of the workers work in informal (unregistered) firms, and around 40% work on informal contracts i.e., those contracts where payments are made on a piece-rate basis, or at a daily/weekly frequency. Lastly, from the Census of firms (Panel C), we see that over 90% of firms in India are informal (or unregistered) and these firms employ around 70% of the labor force in a district.

5 Empirical Methodology and Results

We analyse the impact of the policy reform in a difference-in-differences (DID) setup, by comparing outcomes before and after the policy change (2003) in the treated state (Andhra Pradesh) as compared to alternate control states. In our preferred specification, we compare firm-level outcomes in Andhra Pradesh (Treatment group) to all other Indian states (Control group). However, we show that our results are robust to using alternate definitions and samples in Section 5.4. Our identification strategy relies on the

Table 1: Summary Statistics

	Andhra Pradesh (Treatment State)			All Other States (Control States)		
	N	Mean	SD	N	Mean	SD
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Firm-level outcomes from the Annual Survey of Industries						
Contract Workers	5759	39.03	96.31	77665	22.91	66.49
Regular Workers	5759	117.66	219.41	77665	113.90	207.60
Total Workers	5759	174.61	310.54	77665	140.91	247.71
Contract Worker-days ('000)	5759	11.29	28.62	77665	6.59	19.76
Regular Worker-days ('000)	5759	33.39	64.01	77665	32.57	60.52
Frac. Contract Workers	5759	0.22	0.34	77665	0.15	0.30
Frac. Contract Worker-days	5759	0.23	0.34	77665	0.15	0.30
Panel B: Worker-level outcomes from National Sample Survey						
Prob. of Working in Informal Firm	7616	0.78	0.41	93871	0.76	0.42
Prob. of Working as a Casual Worker	7616	0.16	0.37	93871	0.17	0.37
Prob. of Working on Informal Contract	3839	0.38	0.48	47663	0.42	0.49
Daily Wage (Nominal INR)	3768	112.18	115.50	46284	135.85	130.31
Panel C: Outcomes from the Economic Census of India						
Frac. Unreg. Large Firms	23	0.66	0.19	510	0.70	0.26
Frac. Unreg. Small Firms	23	0.94	0.04	510	0.95	0.08
Frac. Unreg. Firms	23	0.93	0.05	510	0.94	0.09
Frac. Workers in Unreg. Large Firms	23	0.59	0.21	510	0.64	0.30
Frac. Workers in Unreg. Small Firms	23	0.84	0.07	510	0.88	0.14
Frac. Workers in Unreg. Firms	23	0.68	0.18	510	0.73	0.24

Notes: Each row reports mean and standard deviation for a variable. Columns (1)-(3) report the values for Andhra Pradesh (Treated State), while Columns (4)-(6) report the values for all other states (Control Group) in pre-treatment period. Panel A uses establishment-level data from the Annual Survey of Industries prior to the policy (2000-2002). Panel B reports data from the Employment-Unemployment Schedule of the National Sample Survey in 1999-2000. In Panel B, a firm is defined to be informal if it is not registered under the Factories Act, 1948. A contract is defined to be informal when wages are paid in cash/kind on a piece-rate basis, or paid in a non-piece rate basis but on a daily or weekly frequency. Panel C reports outcomes from the 1998 round of the Economic Census of India aggregated to the district level. Frac. unregistered firms of type T (small, large, total) are the number of unregistered T firms as a fraction of total T firms. Frac. workers in unregistered T firms are the number of workers in unregistered T firms as a fraction of total T firm workers.

assumption that the treatment and control groups have similar trends before the policy reform, which we provide evidence for in Figure 2 and discuss in more detail below. Finally, to the best of our knowledge, there was no other labor market policy that was implemented in Andhra Pradesh in 2003 that affected its firms differentially as compared to other states, which increases confidence in our identification strategy.

5.1 Impact on Workers in Formal Firms (Intensive Margin of Informality)

We first examine the impact of the policy on the intensive margin of informality i.e., the use of contract workers in formal sector firms. We do this in two ways. First, we use the ASI data to test whether the treatment and control groups had parallel trends prior to the policy, as well as examine the impact of the policy over time. Second, we then pool the pre- and post-policy years together to examine the impact of the policy on a wider set of firm and worker outcomes using the ASI and NSS datasets. We begin estimating the following event-study regression for a firm i in industry j, state s and year t:

$$Y_{i(js)t} = \kappa_i + \theta_s t + \delta_{jt} + \sum_{t=2000}^{2006} \beta_t Treat_s + \varepsilon_{it} \tag{8}$$

where Y_{it} is our outcome of interest. We consider six outcome variables, namely: (a) log contract workers; (b) log contract worker-days; (c) fraction of contract workers (d) fraction of contract worker-days; (e) log regular workers; (f) log regular worker-days.[28] We consider, 2002-2003, one year before the policy was implemented, to be our reference year. $Treat_s$ is an indicator variable that takes the value 1 if a firm is in Andhra Pradesh and 0 otherwise. We also add firm fixed effects (κ_i) that control for any time-invariant observed and unobserved heterogeneity at the firm level.[29,30] Although the DID method controls for time invariant unobservable firm characteristics, one may be concerned that the timing of passing the Act in Andhra Pradesh could be correlated with time-varying differences across industries and states. In fact, Indian states with similar patterns of labor regulation and reforms do have similar long-term trends as well (Besley and Burgess, 2004; Karak and Basu, 2020; Bhattacharjea, 2006). We therefore include a 3-digit industry-year fixed effects (δ_{jt}) as well as state-specific time trends ($\theta_s t$) in all our regression specifications. However, Borusyak and Jaravel (2018) show that an event-study specification with firm and year fixed effects along with state-specific time trends is under-identified.

[28]The amendment only affected hiring of contract labor in core activities of the firm (as discussed in Section 3). The ASI data does not disaggregate the number of workers by core and non-core activities, but data on worker-days is available for both categories separately. In Section 5.4, we take advantage of this to separately analyze the impact of the policy on contract and regular worker-days in both core and non-core activities. We show that all the effect is driven by adjustments in core activities.

[29]Note that the inclusion of firm fixed effects implies that the regression results can be interpreted only on the intensive margin of the policy change, i.e. the effect of the policy change on incumbent firms.

[30]Our set up follows the canonical format of the differences-in-differences design using two time periods (before and after the policy reform), and two groups. Therefore, we can directly estimate the average treatment effect for the treated (ATT) by comparing the average change in outcomes experienced by the treated group to the average change in outcomes experienced by the comparison group. Employing recent methods in the differences-in-differences estimation literature (Goodman-Bacon, 2018; De Chaisemartin and d'Haultfoeuille, 2020; Callaway and Sant'Anna, 2020) is not warranted here because they are concerned with issues arising due to multiple groups and multiple periods.

They recommend omitting one additional year in the estimation (1999-2000 in our case), and reporting the p-value of a F-test that jointly tests that the estimated $\widehat{\beta}_t$ before the policy (pre-period) are zero.[31] We cluster standard errors at the state-year level to allow for correlations across firms within a state-year.

The results are reported in Figure 2, and the corresponding regression coefficients are reported in Table A1 in the Appendix. The results indicate that there were no significant differences in the usage of contract or regular workers between firms in Andhra Pradesh and other states before the policy was implemented. Both, the estimated magnitudes are small and they are statistically insignificant at conventional levels. Following Borusyak and Jaravel (2018), for each outcome variable in Figure 2, the corresponding p-value of a F-test that jointly tests for the pre-policy $\widehat{\beta}_t$ to be equal to 0 are: 0.90 and 0.84 for log contract workers and worker-days (Figures 2(a), (b)); 0.20 and 0.21 for the fraction contract workers and worker-days (Figures 2(c), (d)), and 0.93 and 0.52 for log regular workers and worker-days (Figures 2(e), (f)). Turning to the impact of the policy reform, we find large and persistent declines in the usage of contract workers (worker-days) and in contrast, a corresponding increase in the hiring of regular workers (worker-days), indicating a substantial reduction in the "intensive-margin" of informality.

For the subsequent analysis, we pool the time periods before and after the policy and estimate the following regression for a firm i, in industry j, state s, and year t:

$$Y_{i(js)t} = \beta Treat_s \times Post_t + \kappa_i + \theta_s t + \delta_{jt} + \gamma X_{it} + \varepsilon_{it} \tag{9}$$

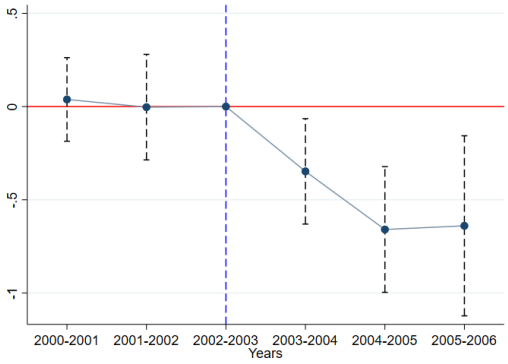
where Y_{it} are various firm-level variables of interest. $Post_t$ is an indicator variable that takes the value 1 for years after 2003 and 0 otherwise. β is our coefficient of interest and captures the differential impact of the policy reform on a firm in the treatment group relative to the control group, before and after the policy reform. In addition to the fixed effects discussed in Equation 8, we control for age and square of age of the firm.

Table 2 presents the results. Panel A reports the impact of the policy on contract workers (Columns 1-2) and worker-days (Columns 3-4). From Columns (1) and (3), we see that firms in Andhra Pradesh reduced the number of contract workers and worker-days by around 35-38 log-points (42-47%). From Columns (2) and (4), contract workers (and worker-days) as a fraction of total workers (worker-days) declined by around 3.1 p.p. (or 20% of the pre-period mean in control states).

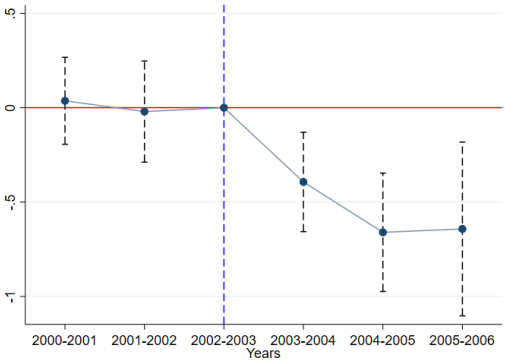
Panel B of Table 2 then examines the impact of the policy on hiring regular workers and firm size. As reported in Columns (1) and (3) of the table, firms increased the hiring of regular workers and worker-days by 19-22 log-points (around 20-25%). Furthermore,

[31] The results are not sensitive to which pre-policy year is omitted from the regression and the F-test (by construction) is invariant to which pre-policy year is omitted.

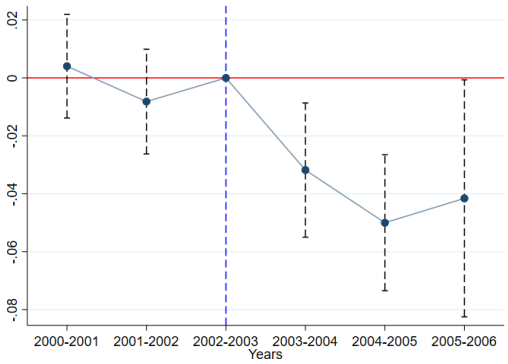
Figure 2: Impact of the Policy on the Use of Contract and Regular Workers



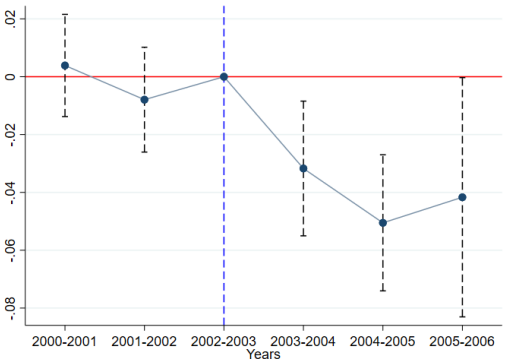
(a) Log Contract Workers



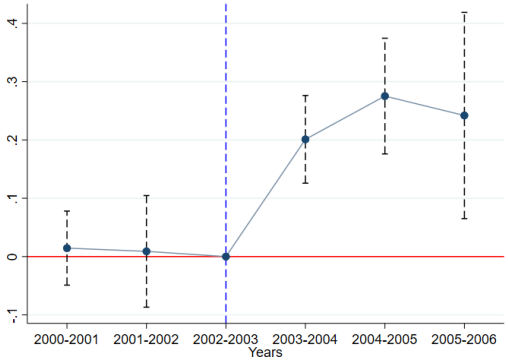
(b) Log Contract Worker-Days



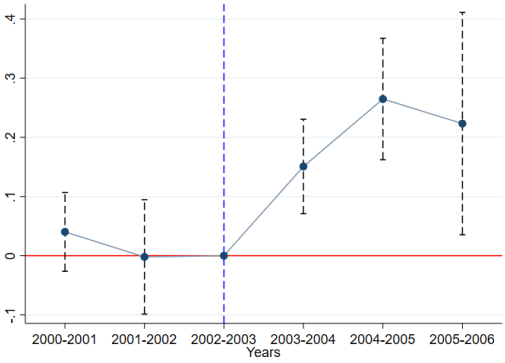
(c) Frac. Contract Workers



(d) Frac. Contract Worker-Days



(e) Log Regular Workers



(f) Log Regular Worker-Days

Notes: The above graphs plot the regression coefficients from a difference-in-differences specification discussed in Equation 8 using data from the Annual Survey of Industries. The regressions corresponding to these figures are presented in Table A1. 95% confidence intervals, clustered at the state-year level are indicated in the bars around the point estimate. The coefficient for 2002-2003, the year before the reform, has been normalized to zero. The outcome variables are winsorized at the 1% levels at the top and the bottom of the distribution. Following Borusyak and Jaravel (2018), the p-value of a F-test that jointly tests for the pre-policy $\widehat{\beta}_t$ to be equal to 0 are: 0.90, 0.84, 0.20, 0.21, 0.93, and 0.52 for each outcome variable in Figure 2(a)-(f) respectively.

Table 2: Impact of the Policy on Contract, Payroll and Total Workers in Formal Sector Firms

	Workers		Worker-Days	
	(1)	(2)	(3)	(4)
Panel A: Impact of the policy on usage of contract workers				
Dep Var:	Log Contract	Frac. Contract	Log Contract	Frac. Contract
Post X Treat	-0.349***	-0.031***	-0.382***	-0.032***
	(0.070)	(0.006)	(0.071)	(0.006)
R^2	0.796	0.811	0.795	0.811
Panel B: Impact of the policy on hiring payroll workers and firm-size				
Dep Var:	Log Regular	Log Total	Log Regular	Log Total
Post X Treat	0.221***	0.061	0.188***	0.032
	(0.042)	(0.050)	(0.044)	(0.053)
R^2	0.852	0.939	0.857	0.935
N	161550	161550	161550	161550
Factory FE	Yes	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes	Yes
State-Trend	Yes	Yes	Yes	Yes

Notes: The above table reports the impact of the policy reform on Workers in Columns (1) and (2) and Worker-Days in Columns (3) and (4). Panel A reports the impact of the policy on the usage of contract workers, while Panel B reports the impact on the usage of regular payroll workers and total workers. Frac. Contract is the number of contract workers (or worker-days) as a fraction of total workers (worker-days) in a firm. Post is defined as 1 for years after 2003, and 0 before that. Treat is defined as 1 for Andhra Pradesh, and 0 for other states. Source of the data is the Annual Survey of Industries between 2000-2007. The outcome variables are winsorized from the bottom at 1% and from the top at 99%. Robust standard errors clustered at the state-year level in parentheses. *** -statistical significance at 1%; **- statistical significance at 5%; *- statistical significance at 10%.

firm-size as measured by the total workers and worker-days (Columns (2) and (4)) may have increased slightly by around 3-6%, though this increase is not statistically significant at conventional levels. Taken together, these results show that as intended, the policy reform did result in a substantial reduction of informality on the intensive margin.

5.2 Impact on Likelihood of Operating in the Informal Sector (Extensive Margin of Informality)

As discussed earlier, the ASI covers firms in the formal sector, and hence is only well suited to examine firm responses on the intensive margin of informality, that is, the substitution between contract and regular/payroll workers within formal firms. Using

data from the National Sample Surveys (NSS) and the Economic Census (EC), we now study changes along the extensive margin of informality, i.e., whether firms operate in the informal sector all together, or are registered in the formal sector.

Analysis using the National Sample Surveys

To begin, we use the 1999-00 and 2004-05 rounds of the National Sample Survey (NSS) to examine the impact of the reform on the probability that a worker works either in an informal firm, employed casually, or employed on an informal contract. Unlike the ASI, the NSS is a representative survey of individuals (as opposed to firms) and collects data on some firm characteristics as well as the type of payment contracts received by workers. This allows us measure worker transitions in informal or formal firms as well as on informal or payroll contracts (as described below). Given the nature of the reform, we restrict the sample to those in the working age (between ages 14 to 65), and those employed in the non-agricultural sector.[32] Similar to Equation 9, we estimate the following regression for a worker i in industry j, state s and year t:

$$Y_{i(js)t} = \beta Treat_s \times Post_t + \gamma X_{it} + \theta_s + \delta_{jt} + \varepsilon_{it} \tag{10}$$

where Y_{it} are the four key outcome variables of interest: (a) the probability that a worker works in an informal firm; (b) the probability that the worker is employed casually; (c) the probability that a worker works on an informal contract; and (d) (log) daily wages. We describe the construction of each variable in detail below. We include state fixed effects (θ_s), and three-digit-level industry-year fixed effects (δ_{jt}). The wage regression also additionally includes occupation-year and state-occupation fixed effects to account for all wage differences across occupations. Moreover, since socio-demographic characteristics of the work can influence their employment choices and wages, we also control for a range of worker characteristics (X_{it}) such as age, age-squared, gender, education, technical education, caste group and marital status. We use the NSS sample weights for the estimation and cluster standard errors at the state-year level.

The results are reported in Table 3. We begin by reporting the impact of the policy on the probability that a worker works in an informal enterprise (Column 1). The outcome variable takes the value 1 if a worker is employed in an informal enterprise as defined under the Factories Act (1948), and 0 otherwise.[33] As reported in Column 1, workers in

[32] In Section 5.4, we show that the reform had no impact on the probability that a worker was unemployed, or the probability of working in agriculture and discuss its implications.

[33] According to the Factories Act, 1948, an enterprise is deemed to be registered/formal if it employs 10 or more workers with the usage of electricity, and if it employs 20 or more workers even without the usage of electricity. The NSS asks workers to report (a range of) the size of firm they work in, which directly maps into the requirements of the Act and thus allows us to precisely determine whether the firm is formal

Table 3: Impact of the Policy on Wages and the Probability of Working in the Informal Sector

	Probability of Working			
	In an Informal Firm	As a Casual worker	On an Informal Contract	Log Daily Wage
	(1)	(2)	(3)	(4)
Post × Treat	0.0311***	0.0179***	0.0575***	-0.0581***
	(0.00951)	(0.00604)	(0.0101)	(0.0144)
N	219,187	219,187	77,147	74,131
R^2	0.337	0.449	0.429	0.666
State-FE	Yes	Yes	Yes	Yes
Industry-Year FE	Yes	Yes	Yes	Yes

Notes: Data are sourced from the 1999-2000, and 2004-2005 rounds of the NSS. Post and Treat are indicator variables that take the value 1 for the year 2004-2005, and for Andhra Pradesh respectively, and 0 otherwise. Columns 1-3 are also indicator variables that take the value 1 if: a worker works in an informal enterprise (Column 1); is employed as a casual worker (Column 2); works on an informal contract i.e., paid in cash/kind on a piece-rate basis, or paid in a non-piece rate basis but at a daily or weekly frequency (Column 3). Log daily wages (Column 4) are reported in INR. The regression in Column 4 additionally controls for occupation-year, and state-occupation fixed effects to account for wage differences across occupations. Robust standard errors clustered at the state-year level are reported in parentheses; *** -statistical significance at 1%; **- statistical significance at 5%; *-statistical significance at 10%.

Andhra Pradesh (relative to the rest of the country) were 3.11 p.p. (6.2%) more likely to work in an informal enterprise after the policy reform. Similarly, workers were 1.8 p.p. (11.2%) more likely to work as casual workers (Column 2) and 5.75 p.p. (15.1%) more likely to work on informal contracts (Column 3), where an informal contract is defined as one where a worker is either paid in cash/kind on a piece-rate basis or else, paid on a daily/weekly frequency. Lastly, average wages fell by 5.81 log-points (6%) after the policy reform (Column 4). Taken together, these results imply that the policy reform, which was targeted (and reduced) the use of contract workers in formal firms, also led to a decline in wages and an increase in the size of the informal sector (perfectly consistent with the key theoretical predictions).[34]

To increase our confidence in the results, we conduct a placebo exercise using two rounds of the NSS data prior to the policy reform, namely in 1993-94 and 1999-2000. We assign 1999-2000 as a (placebo) treatment year, and continue to use Andhra Pradesh as the treated state. A limitation of using prior NSS rounds is that while data on casual

or informal.

[34]In Section 5.4 and Appendix Table A2, we show that the reform had no impact on the probability that a worker was unemployed, or the probability of working in agriculture. The estimated coefficients are small in magnitude and statistically insignificant at conventional levels. This implies that the supply of labor to the non-agriculture sector was not affected due to the reform, a key assumption in our theoretical model.

employment and daily wages are available for the 1993-94 round (Columns 2 and 4 of Table 3), details of firm characteristics and mode of payment are not available (Columns 1 and 3). Nevertheless, we estimate Equation 10 for this placebo exercise and report the results in Table A5. As is clear, the results show the absence of any (pre-reform) differential effects in Andhra Pradesh (as compared other states), both on the probability of being a casual worker (Column 1) as well as on daily wages (Column 2).

5.2.1 Analysis using the in the Economic Census

We use two rounds of the Economic Census of India (1998 and 2005) to measure the impact of the policy on the number of firms in the formal and informal sector. Unlike the ASI, the EC (by definition) is a census of all non-agricultural firms in the country, thus allowing us to observe the entire distribution of firms–including the sector (formal/informal) that they operate in. More importantly for our analysis, the EC reports a firm's total employment, and whether the firm is registered across a range of government institutions (such as State Directorate of Industries, Textile/Jute Commissioner, Coir Board, etc.). The latter allows us to define a binary variable which takes the value 1 if a firm is registered (and thus formal) and 0 otherwise.[35]

Given that the EC is a repeated cross-section of firms, we aggregate our firm-level data to the district-year level to obtain variables capturing aggregate measures of informality within a district over time. We estimate the following regression:

$$Y_{dt} = \beta Treat_d \times Post_t + \kappa_t + \theta_d + \varepsilon_{dt} \tag{11}$$

where Y_{dt} is: (a) the fraction of unregistered firms in a district d in year t; (b) the fraction of workers in a district d and year t who work in these informal firms. We include district (θ_d) and year (κ_t) fixed effects, and cluster standard errors at the state-year level.

Our theoretical model hypothesizes that the policy reform should make it costlier for firms–particularly the larger ones–to operate in the formal sector and thus the marginal firm (deciding between formalizing or not) would want to remain informal after the reform. On the other hand, the policy should not impact smaller firms who would have wanted remain informal anyway. To test this implication, we classify firms as "small" (below 10 workers), and "large" (above 10 workers), and separately calculate the outcome variable (Y_{dt}) for each category. The results, reported in Table 4, are broadly consistent with these model predictions.

From Column 1, we find that the fraction of large firms in Andhra Pradesh (relative

[35] As discussed earlier (in Section 4), while rounds of the EC are available in 1993-94 and 2013-14, they do not report firms' registration status and hence we are unable to determine whether they are formal or informal. Hence we do not use them for our analysis.

Table 4: Impact on the Size of the Informal Sector, Economic Census

	Frac. of Unregistered Firms			Frac. of Workers in Unreg. Firms		
	Large	Small	All	Large	Small	All
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Treat	0.124***	-0.054	-0.056	0.164***	-0.044	0.027
	(0.032)	(0.036)	(0.037)	(0.040)	(0.035)	(0.035)
N	1,066	1,066	1,066	1,066	1,066	1,066
R^2	0.759	0.677	0.685	0.715	0.737	0.740
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The above table uses data from the 1998 and 2005 rounds of the Economic Census of India and has been aggregated to the district-year level. Frac. of Unregistered Firms are the fraction of firms (in a district-year) who are not registered with any government agency. Frac. of Workers in Unreg. Firms is the fraction of workers (in a district-year) who work in these unregistered firms. Post is defined as 1 for years after 2003, and 0 before that. Treat is defined as 1 for Andhra Pradesh, and 0 for other states. Large refers to firms with 10 or more hired workers, while Small refers to firms with less than 10 hired workers. Robust standard errors clustered at the state-year level in parentheses; *** -statistical significance at 1%; **- statistical significance at 5%; *-statistical significance at 10%.

to other states) that remained unregistered after the policy reform, and the fraction of workers who worked in them (Column 4) increased by 12.4 p.p. (18%) and 16.4 p.p. (26%) respectively. On the other hand, we do not find any effect on the fraction of unregistered small firms (Column 2) or fraction of workers in small firms who work in unregistered firms (Column 5). Lastly, since most firms in India are small to begin with (see Table 1), we do not see any differential changes when we pool all these firms together (Columns 3 and 6).[36]

5.3 Discussion

Our analysis offers three distinct insights on the impact of the policy reform on both margins of informality, which we now summarize below. First, on the intensive margin of informality, we find a large and persistent decline in the usage of contract workers, and a consequent increase in the usage of payroll workers by formal firms. Second, this translates into a higher probability that workers also report working in informal enterprises as well as on informal contracts, and with lower wages. Lastly, the policy reform results in an increase in the fraction of unregistered firms, particularly larger ones who would have potentially been the marginal ones prior to the reform (indifferent

[36] As discussed in Section 5.4 and Table A6, we show that these results are robust to using alternate cutoffs for firm size thresholds of 15 and 20 workers (instead of 10) for classifying a firm as "large".

between formalizing or not), and now choose to remain informal. Put together, the policy reform does impact both margins of informality and is consistent with the insights provided by the theoretical model.

5.4 Robustness of the Results

We now conduct a series of analysis to examine the robustness of our main results.

Impact on Non-core Activities: Since the policy reform only affected workers in the primary or "core" activities of a formal firm, as opposed to allied "non-core" activities (such as cleaners, janitors office boys, and *chaiwalas* for example), we examine the effects of the policy on non-core activities of the firm as a placebo check. While the ASI does not provide the number of workers in these activities, it provides the number of worker-days in them, which we use to replicate our analysis in Section 5.1 separately for core and non-core activities. As reported in the Appendix Table A3, we find that the effects of the policy are entirely driven by a decline (increase) in the use of contract (regular) workers in core activities (Columns 1-3), and not in non-core activities (Columns 4-6), where the estimated magnitudes are very small and statistically insignificant at conventional levels.

Using Only Neighboring States as a Control Group: Our preferred specification uses all other states in India except Andhra Pradesh as a control group. However, we also check the robustness of our results using only the states bordering Andhra Pradesh (such as Odisha, Chhattisgarh, Maharashtra, Karnataka, and Tamil Nadu) as a control group instead. As reported in Panel A of Appendix Table A4, we see that the results are similar to those in Table 2.

Dropping Neighboring States from the Control Group: In contrast to the previous exercise, a concern might be that there are spatial spillovers across state borders. Therefore, in Panel B of Appendix Table A4, we report the results with a control group that *excludes* the states bordering Andhra Pradesh. The results are again similar to those in our preferred specification (Table 2).

Categorizing Small and Large Firms: Our analysis using the Economic Census data in Section 5.2 categorizes firms as "small" and "large" based whether they employ less than or more than 10 workers respectively. While this is a natural cutoff in the Indian context (Amirapu and Gechter, 2020), we show that our results documenting the increase in the share of large firms that remain unregistered (see Table 4) is robust to alternate size cutoffs at 15 and 20 workers as well (Appendix Table A6).

6 Model Estimation

After documenting the impact of the policy on both margins of informality, we now turn to estimating the model. This exercise is useful to be able to quantify the welfare effects of the policy, as well as examine the impact of alternate policies that aim at reducing the use of contract workers in the formal sector, such as reducing the red-tape around hiring payroll workers, for example. In Section 6.1, we discuss the assumptions that help in taking the model to the data. In Section 6.2 we provide details on estimation of the parameters, and discuss the results in Section 6.3. Lastly, in Section 6.4, we show the fit of the model with key data moments, and provide a structured discussion around the identification of model parameters in the spirit of Kaboski and Townsend (2011); Bick et al. (2021), and Chiplunkar and Goldberg (2021).

6.1 Parameterization

We assume that Andhra Pradesh is a closed economy. We aggregate all industries at the two-digit level using the National Industry Classification (NIC), which gives us a final set of $J = 19$ industries. We assume that the pre-entry productivity for an entrepreneur in industry j, denoted by x, follows a log-normal distribution with mean 0 and variance σ_x^2 i.e., $x \sim \log N(0, \sigma_x^2)$. The post-entry productivity is then given by $z = x\varepsilon$ where $\varepsilon \sim \log N(0, \sigma_\varepsilon^2)$. The number of potential entrants, M, is calculated by subtracting the total number of entrepreneurs and workers in the formal and informal firms in Andhra Pradesh from the total adult workforce of Andhra Pradesh as reported in the 2001 Population Census of India.

The model has the following set of parameters: production function parameters, $\mathcal{P} = \{\rho, \nu, \sigma_x^2, \sigma_\varepsilon^2, \{\theta_j\}_{\forall j}\}$, additional marginal costs incurred by formal firms in hiring contract and payroll workers $\mathcal{B} = \{b_c, b_r\}_{\forall j}$, fixed costs $\mathcal{F} = \{E_i, E_r\}_{\forall j}$, sales tax ($t_j$), and share of consumer demand allocated to an industry j (κ_j). We set ρ to 0.738, the average labor share in output from the ASI data. We set the elasticity of substitution between contract and regular workers (ν) to be 3.[37] The share of consumer income allocated to each industry (κ_j) is derived from the share of sales (across both formal and informal firms) in industry j as a fraction of total sales in the economy. Sales tax t_j is the average tax paid by a firm in an industry j in the ASI and ranges from 3-6 across these industries.

[37] We follow a method similar to Acemoglu, Autor and Lyle (2004) to validate this elasticity. Using the ASI data and Equation 1, we regress the log of relative wages for contract to permanent workers on the log ratio of contract workers to permanent workers. This gives us an estimate of the elasticity of substitution of 2.94.

6.2 Estimation

The $5J+2$ parameters – $\varphi = \{\sigma_x^2, \sigma_\varepsilon^2, \{\theta, b_c, b_r\}_{\forall j}, \{E_i, E_r\}_{\forall j}\}$, are then identified using the following $5J+2$ moments in the data:

(a) the number of firms in each sector and industry ($2J$ moments)

(b) the average firm size in each sector and industry ($2J$ moments)

(c) the ratio of contract to payroll workers in each industry (J moments)

(d) the average variance in firm size in the informal and formal sector (2 moments)

We provide an intuition for identifying these parameters here and refer the reader to Section 6.4 for a more rigorous test of identification. The intuition for identification is as follows: given the distributional assumption on the productivity distribution, the number of firms in each industry-sector allows us to calibrate the productivity thresholds for entry into each industry-sector i.e. x_I^* and x_F^*. Given these thresholds, the variance of log firm-size in the formal and informal sectors (conditional on entry), allows us to identify $\{\sigma_x^2, \sigma_\varepsilon^2\}$. From Equation 4, the average firm size in the informal sector is a function of the penalty of operating in the informal sector (θ). Similarly, from Equation 2, the average firm size in the formal sector depends on taxes and the marginal cost of hiring contract and payroll workers (b_c and b_r respectively). Moreover, the ratio of contract workers to payroll workers (Equation 1) helps us identify b_c and b_r separately, since $b_r = (l_c/l_r)^{1/\nu} \times b_c$. Lastly, the fixed costs of entry are then identified from the zero-profit condition in the informal sector and the indifference condition for entering the formal sector (Equation 7).

We summarize the estimation algorithm here and provide detailed steps in Appendix D. For a given set of parameters φ, we can use iterative mapping to find the price vector $\mathbf{p} = \{\{p_j\}_{\forall j}, w\}$ that clears the goods and labor markets. We can then simulate the set of moments (a)-(d) above (denoted by $M^{Sim}(\varphi)$) and use Simulated Method of Moments (McFadden, 1989; Duffie and Singleton, 1993) to choose the parameter values φ that minimize the distance between the simulated moments and their data counterparts (denoted by M^{Data}). Define $g(\varphi) = (M^{Sim}(\varphi) - M^{Data})/M^{Data}$. The estimator is then given by $\widehat{\varphi} = \text{argmin}_\varphi \; g(\varphi)' \; W \; g(\varphi)$, where W is a $5J+2 \times 5J+2$ weighting matrix that is selected efficiently using a two-step process. Appendix D discusses the details of the estimation algorithm as well as computation of standard errors.

6.3 Estimation Results

We now turn to discussing the parameter estimates. We estimate σ_x to be 0.26 (s.e. = 0.06) and σ_ε to be 0.37 (s.e. = 0.002). We estimate $\{\theta, \mathcal{B}, \mathcal{F}\}$ for each industry separately and

Table 5: Summary of Parameter Estimates across Industries

Parameter:	θ	b_c	b_r	E_I	E_R
	(1)	(2)	(3)	(4)	(5)
Food, Textiles, and Apparel	1.55	1.04	1.4	0.24	1.09
	(1.13, 1.57)	(0.89, 1.59)	(0.89, 1.75)	(0.19, 0.6)	(0.64, 2.44)
Wood, Rubber, and Plastic	1.67	2.63	2.43	0.74	0.73
	(1.57, 1.69)	(1.48, 3.47)	(2.19, 3.08)	(0.3, 1)	(0.72, 0.85)
Metals and Chemicals	1.54	3.2	3.92	1.09	0.85
	(1.19, 1.85)	(1.49, 4.77)	(2.5, 5.26)	(0.59, 1.57)	(0.5, 1.36)
Machinery and Transport	1.69	2.9	4.28	1.34	1.43
	(1.58, 1.91)	(2.7, 4.13)	(3.22, 4.41)	(1.15, 2.26)	(1.41, 1.7)
All industries	1.58	2.68	2.89	1.00	1.00
	(1.29, 1.86)	(1.23, 4.13)	(1.75, 4.41)	(0.3, 1.41)	(0.7, 1.7)

Notes: The above table reports the parameter estimates across all 2-digit industries as well as five major industry groups. The median value across industries within the group is reported in each row, along with the 25-75th percentile reported in parentheses below.

report the results in two ways. First, in Table 5, we aggregate the 19 industries into four key industry categories: (i) Food, Textiles and Apparel; (ii) Wood, Rubber and Plastic; (iii) Metals and Chemicals; (iv) Machinery and Transport. We then report the median and 25th-75th percentile values of the parameters for each industry group, as well as across all industries in the economy. This gives us a broad insight into the range of the parameters as well as differences across these key industrial categories. Figures A2 and A3 in the Appendix then report the estimates (and the associated standard errors) across each of the 19 industries. We turn to discussing these parameter estimates below.

Penalty of operating in the informal sector (θ): As reported in the last row of Column(1) of Table 5, the median value of θ is 1.58 across all industries, with the 25th-75th range from 1.29-1.86. Note that θ captures the penalty of operating in the informal sector, where $\theta = 1$ would imply no penalty. Looking at the variation across industries (Figure A2c), we see that while some industries like Food Products and Textiles have low penalties of operating in the informal sector (θ ranging from 1.1-1.2), others like Transport and Instruments have high penalties ($\theta > 1.9$).

Additional marginal cost of hiring workers in the formal sector (b_c, b_r): b_c and b_r capture the additional marginal cost of hiring a unit of contract and regular labor in the formal sector, as compared to the informal sector respectively. As reported in Table 5, the median value for b_c (b_r) is 2.68 (2.89), but there is substantial variation across industries as well (see Figures A2a and A2b in the Appendix).

Fixed costs of entry and registration (E_I, E_R): To make the comparisons of the estimated fixed costs more meaningful, we normalize each cost by the median in the economy. As reported in Table 5 and Figure A3, Apparel (6.9%), Textiles (18.5%) and Tobacco (27.3%) have the lowest entry costs (relative to the median), while entry costs are more than twice the median costs to enter Electrical Machinery, and Automobiles and Transport. Similarly, the fixed costs of formalization are less than two-thirds of the median in Apparel, Wood and Food Products and more than twice in Textiles (2.4 times), Automobiles and Transport (5.6 times) and Tobacco (13.3 times).

6.4 Model Fit and Identification

Model Fit: Table A7 shows the fit of the model with ten key moments in the data. Since we can generate these moments for each of the 19 industries, we report the average and standard deviations in this table, while reporting the fit for each industry separately in Figures A4 and A5. Column 1 of Table A7 reports the simulated moments from the model, while Column 2 reports the moments from the data. As can be seen from the table (and figures in the Appendix), the model matches the key targeted moments such as the number and size of formal and informal firms as well as variance in the firm-size distribution in each sector very well. We also find that the model has a good fit of the non-targeted moments like the fraction of labor and firms in the informal sector as well as in an industry j.

Identification: Section 6.2 provides heuristic arguments of how various data moments help identify the key parameters of the model. However, we now adopt a more systematic approach for establishing identification in the spirit of Kaboski and Townsend (2011), Bick et al. (2021) and Chiplunkar and Goldberg (2021). Specifically, for the key model parameters, namely: distortions in hiring contract and payroll workers (b_c, b_r), productivity distribution (σ_x and σ_ε) and penalty of operating in the informal sector (θ), we compute the derivative of a moment with respect to each parameter.[38] To do so, we re-solve the model each time by increasing one parameter by 1% above its estimated value (keeping all others the same) and compute the resulting percent changes in the simulated moments. We report the results in Table A8. Each number in a row r and column c reports the percentage change in the moment in row r (averaged across industries) when the parameter in column c is increased by 1 percentage (keeping all other parameters the same). As the table shows, the results are consistent with the discussion in Section 6.2. From Columns 1 and 2, we see that the variance in firm-size in the informal and formal

[38]Note that the fixed costs of entry and formalization are not identified directly from a data moment, but computed from the the zero-profit conditions. Accordingly, we do not consider them here.

Table 6: Impact of Employment Protection Policies

	Baseline	Penalizing Contract Workers		Subsidizing Payroll Workers	
		$\triangle b_c = 10\%$	$\triangle b_c = 20\%$	$\triangle b_r = 9\%$	$\triangle b_r = 17\%$
	(1)	(2)	(3)	(4)	(5)
Policy change	1.00	1.10	1.20	0.91	0.83
Panel A: Intensive Margin of Informality					
Frac. Contract Workers	0.61	0.49	0.38	0.49	0.38
Panel B: Extensive Margin of Informality					
Frac. Informal Firms	0.90	0.93	0.95	0.85	0.79
Frac. Informal Labor	0.50	0.57	0.62	0.45	0.39
Panel C: Productivity of the Marginal Firm					
Formal Sector	1.36	1.40	1.44	1.34	1.32
Informal Sector	1.00	0.99	0.98	1.01	1.03
Panel D: Aggregate Effects					
TFP	1.00	0.99	0.98	1.01	1.015
Real Wages	1.00	0.97	0.95	1.03	1.06
Real Income (Welfare)	1.00	0.98	0.97	1.02	1.05

Notes: The above table reports the impact of two labor laws on the margins of informality. Column (1) reports the baseline values, which have been normalized to 1 where appropriate. Columns (2) and (3) report the impact of a 10% and 20% increase in b_c across all industries, relative to its baseline value. Columns (4) and (5) report the impact instead of decreasing b_r across all industries to achieve the same reduction on the fraction of contract workers as in columns (2) and (3) respectively.

sector is most sensitive to the changes in σ_x and σ_ε respectively. Conditional on this, changes in the average firm size in the informal sector is most sensitive to a change in θ (Column 3). Lastly, a change in b_c and b_r affects the average size of a formal firm, and the fraction of contract workers (Columns 4 and 5).

7 Impact of Labor Law Reforms

We now turn to discussing the impact of counterfactual EPL policies on informality and welfare. We begin by implementing a policy reform similar to the one in Andhra Pradesh, where formal sector firms are penalized for hiring contract workers (Section 7.1. In Section 7.2, we then implement another counterfactual reform where we instead reduce the costs incurred by formal firms for hiring workers on payroll (such as red-tape around hiring/firing payroll workers for example).

7.1 Penalizing Hiring Contract Workers

Consider a policy reform similar to the one implemented in Andhra Pradesh, that of penalizing a firm in the formal sector for hiring workers "off-the-books". Through the lens of the model, we discuss two scenarios (as shown in Table 6) where the policy increases b_c by 10% (Column 2) and 20% (Column 3). On the intensive margin of informality, as reported in Column 2 (3) of Panel A, a 10% (20%) increase in b_c improves compliance and reduces the fraction of contract workers by 12 (23) p.p. as compared to baseline (Column 1). However, the extensive margin of informality, measured by both the fraction of firms and labor in the informal sector (Panel B), increases by 3 (5) and 7 (12) p.p. respectively as compared to baseline. The above observations are consistent with a 4 (8) p.p. increase in the productivity of the marginal firm which is indifferent between formalizing or not, and a 1 (2) p.p. decrease in the productivity of the marginal firm which is indifferent between entering the informal sector or not entering at all (see Panel C) . Lastly, as reported in Panel D, aggregate productivity (TFP) decreases by 1% (2%), real wages decrease by 3% (5%), and real income (our measure of welfare) decreases by 2% (3%).[39]

As discussed earlier, the underlying mechanisms are intuitive in the framework of the model. A policy that penalizes hiring contract workers in the formal sector increases the marginal costs for a firm to operate in the formal sector. The direct effect of this policy (keeping wages and prices fixed) implies that a firm now has to be even more productive to operate in the formal sector, which results in a higher threshold productivity of formalizing (in Panel C). This implies that firms sort to operate in the informal sector (Panel B), which lowers TFP as well as aggregate labor demand, and therefore real wages (Panel D). Although this indirect channel of lower real wages (in general equilibrium) mitigates the impact of the direct effect in the formal sector, it does not offset it, resulting in lower informality on the intensive margin, but higher informality on the extensive one.

7.2 Reducing Costs of Hiring Payroll Workers

An alternate policy advocated by entrepreneurs, and supported in the academic literature as well (Ahsan and Pagés, 2009; Besley and Burgess, 2004; Chaurey, 2015; Sodhi, 2014), is the simplification of complex and cumbersome employment protection laws (such as government approvals for hiring and firing workers, long notice periods, etc.). Through the lens of our model, such policies would reduce the costs for hiring payroll workers i.e., lower b_r. We decrease b_r in such a way so that its impact on the intensive margin of informality (fraction of contract workers) is the same as in the previous case (Section 7.1). This allows us to make the impact of the two policies comparable on the intensive

[39] We define aggregate TFP = $\prod_j Z_j^{\alpha_j}$, where $Z_j = (\sum_s Y_s)/(\sum_s L_s)^{\rho}$.

margin–a key objective of EPL reforms. The results, reported in Columns 4 and 5 of Table 6, imply a 9% and 17% decrease in b_r.

The impact of this policy, by construction, is the same on the intensive margin of informality (Panel A) as compared to the previous one (Section 7.1). However, the effects on the extensive margin of informality are in sharp contrast with those from the previous policy (Panel B). While the previous policy (Section 7.1) increased the extensive margin of informality with more firms and workers in the informal sector, this policy results in a reduction in the size of the informal sector. The fraction of firms and workers in the informal sector decrease by 5 (11) p.p. Since the marginal firm now wants to formalize, the productivity of the marginal firm in the formal sector now decreases by 2 (4) p.p., while that in the informal sector increases by 1 (3) p.p. (Panel C). Since firms are more productive in the formal sector, overall TFP increases by 1% (Panel D). Lastly, real wages and income increase by 3% (6%) and 2% (5%) respectively.

The above policy simulations highlight the importance of effectively targeting EPL reforms, and its impact on different margins of informality. First, penalizing non-compliance with EPL (as was the policy implemented in Andhra Pradesh) does reduce informality on the intensive margin, but increases informality on the extensive margin. Moreover, it lowers aggregate TFP, real wages and income as well. On the other hand, policy reforms that reduce the burden of hiring payroll workers reduce informality on both margins, and increase TFP, real wages, and welfare.

7.3 Endogenous Labor Supply

Our model assumes a fixed labor supply i.e., a perfectly inelastic labor supply curve. However given that the policy reform was implemented only in the manufacturing sector (that employs around 20% of the workforce in India), it is possible that it results in changing the number of workers in manufacturing i.e., the labor supply curve is elastic. This would impact the quantification exercise and hence real income and welfare.

To make progress, we do the following: first, we examine the validity of this assumption by examining the wage and labor supply changes in response to the policy reform in Andhra Pradesh. As discussed in Section 5.2, we document a decrease in the wages after the policy. Additionally, as reported in Table A2, we find no effect of the policy on either on the probability of (un)employment (Column 1) or being employed in agriculture (Column 2). Both the magnitude is small and the coefficients are not statistically significant at conventional levels. This suggests therefore, that the policy reform did not have any substantial changes in total labor supply.

Aditionally, we also redo our analysis in Sections 7.1 and 7.2 under a scenario where labor supply is perfectly elastic. Our simulations indicate that this in fact exacerbates

the welfare effects (both gains and losses) of these policies. For example, a policy that penalizes the hiring of contract workers (a 10% increase in b_c, Section 7.1) decreases welfare by around 15% when labor supply is perfectly elastic, as opposed to 3% when it is inelastic (Section 7.1). Similarly, a corresponding policy that reduces the costs for hiring payroll workers (a 9% decrease in b_r, Section 7.2) increases welfare by around 20% when labor supply is perfectly elastic, as opposed to 2% when it is not (Section 7.2). This exercise, while unlikely in our empirical context, provides valuable insights on how the elasticity of labor supply can bound the welfare effects more generally.

Intuitively, the contrast is because wage adjustments in equilibrium play a key role in partially offsetting the direct effects of the policy. To elaborate, a policy that penalizes the hiring of contract workers reduces aggregate labor demand by increasing the marginal cost of operating in the formal sector. In the case where labor supply is inelastic, lower labor demand lowers wages (and hence marginal costs) in equilibrium, which partially offsets the direct effect of the penalty. However if labor supply is perfectly elastic and wages do not change in equilibrium, this indirect effect is not present, thus exacerbating the welfare loss. With the same intuition, the opposite is true under the second policy counterfactual i.e., welfare gains are larger when a policy reduces the costs of hiring payroll workers and labor supply is perfectly elastic, as opposed to when it is inelastic.

8 Conclusion

Low compliance with EPL remains an important policy challenge in developing countries. In this paper, we show, both theoretically and empirically, that the presence of an informal sector plays a key role in understanding this. We study the impact of a unique natural experiment in India the penalized the use of contract workers in the formal sector. A key insight from our analysis is that while the reform increased EPL compliance in the formal sector i.e., firms hired fewer contract workers, it also made them more likely to operate in the informal sector all together, lowering wages, aggregate productivity, and welfare. On the contrary, we argue that designing and targeting EPL, especially around lowering bureaucratic costs and constraints in hiring workers on payroll can meaningfully reduce both margins of informality and increase welfare. More broadly, as the world continues to grapple with the aftermath of the Covid-19 pandemic, and automation and globalization continue to redefine the nature of work and the relationship between workers and firms, defining and enforcing employment protection legislation–particularly in contexts with high informality–remains an important challenge. These regulations should be carefully targeted to increase the productivity of the workforce and the overall welfare of the economy.

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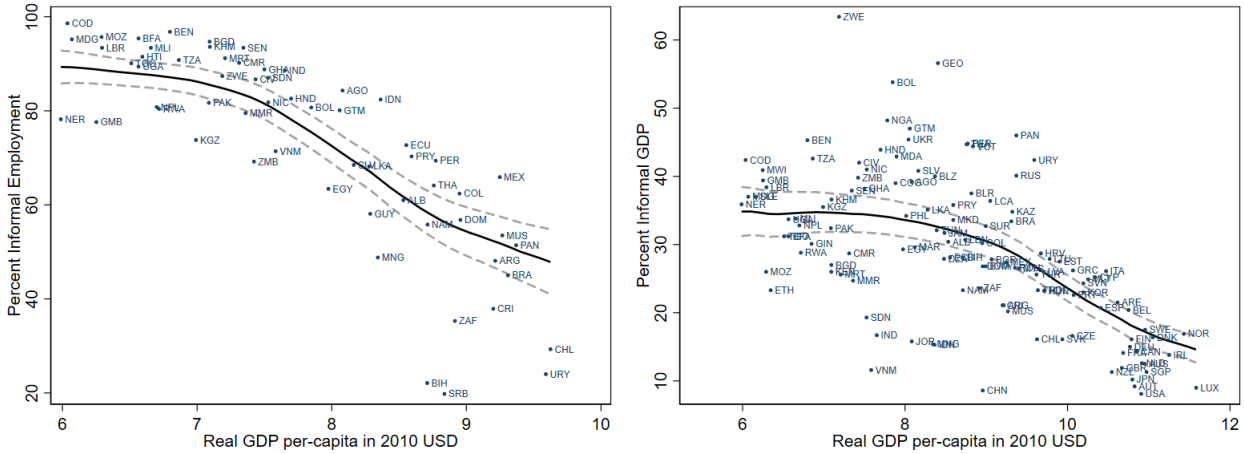
APPENDIX

A Figures and Tables

Figure A1: Fraction of Workers and Output in the Informal Sector

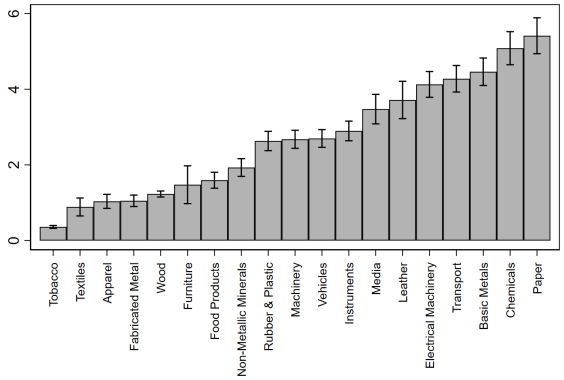


(a) Fraction of workers

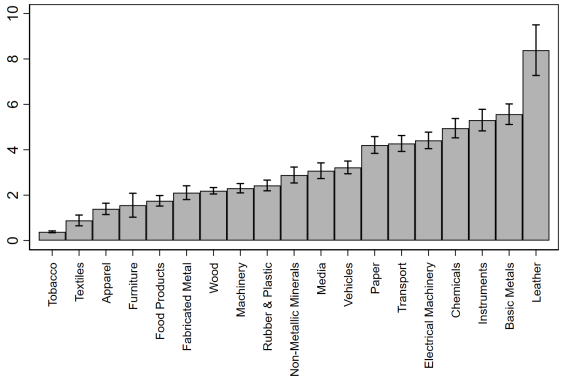
(b) Fraction of output

Note: Data on informality is taken from Elgin, Kose, Ohnsorge and Yu (2021). Informal output are estimates calculated by Elgin et al. (2021) using dynamic general equilibrium models (DGE) and reported as a percentage of official GDP. We use 2018 values across all countries. Data on Real GDP per-capita is taken from the World Bank.

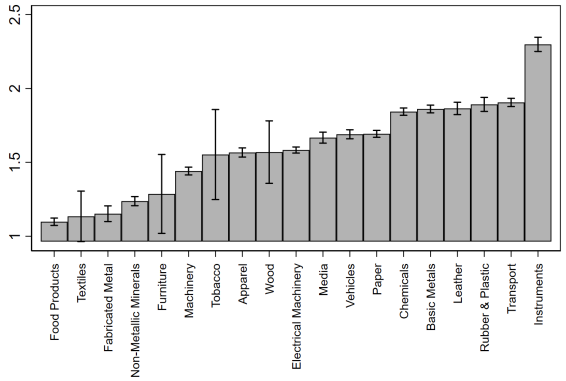
Figure A2: Parameter Estimates Across All 19 Industries



(a) Estimates for b_c



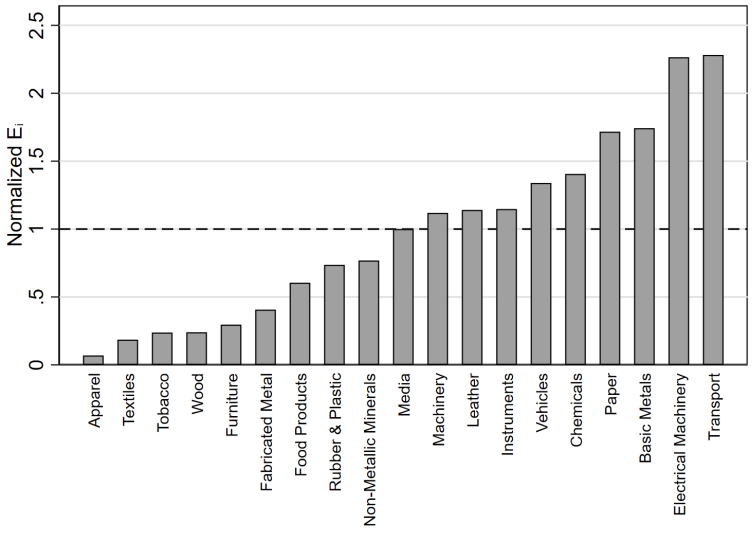
(b) Estimates for b_r



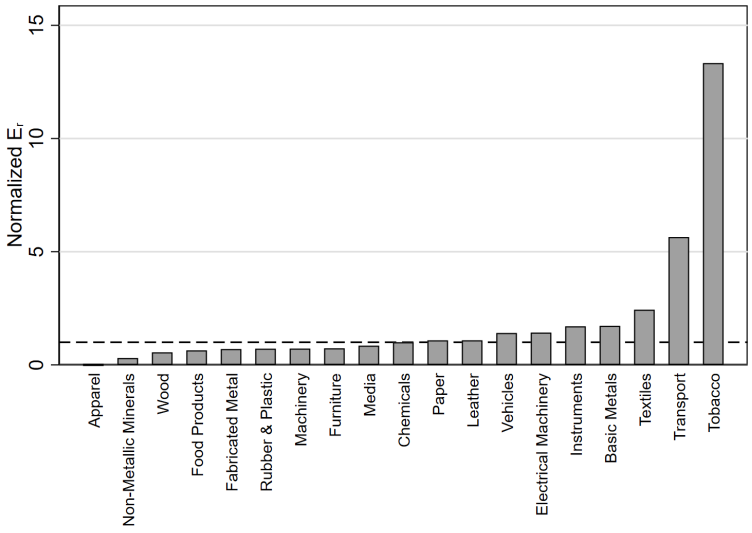
(c) Estimates for θ

Notes: The above figures report the estimates of b_c, b_r and θ across industries. They are sorted from smallest to largest. Error bars report the 95% confidence intervals.

Figure A3: Fixed costs E_i and E_r across industries



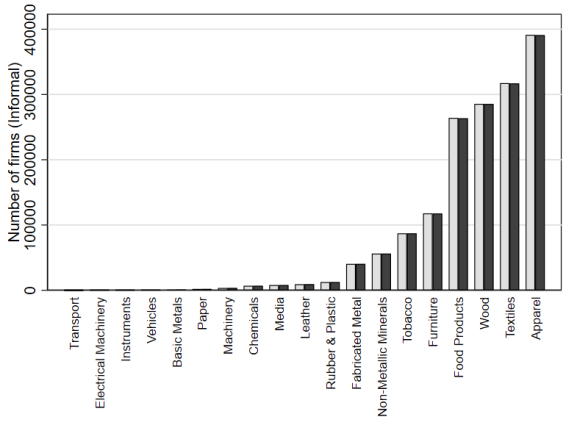
(a) Estimates for E_I



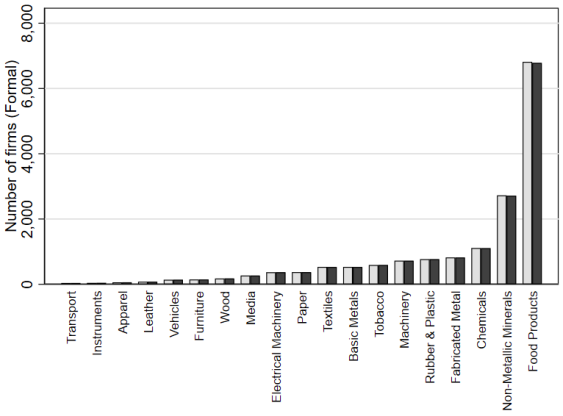
(b) Estimates for E_R

Notes: E_I and E_R have been normalized by their median values in the economy.

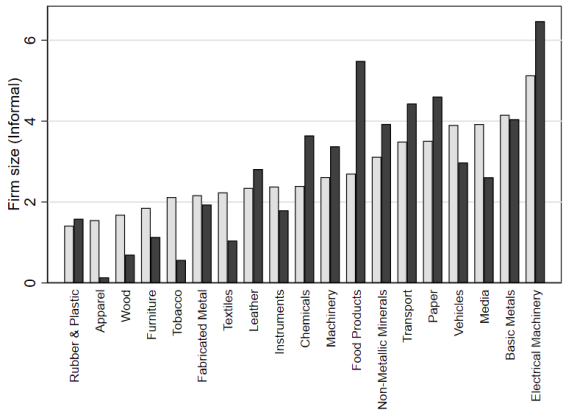
Figure A4: Model Fit Across Industries I



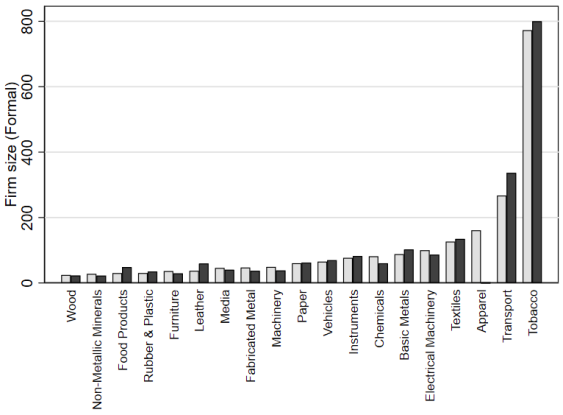
(a) No. of informal firms



(b) No. of formal firms



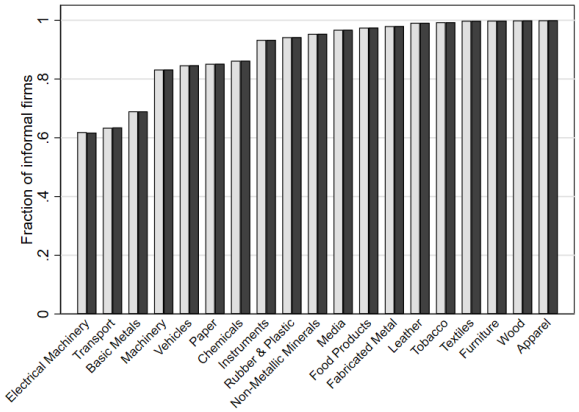
(c) Firm size in informal sector



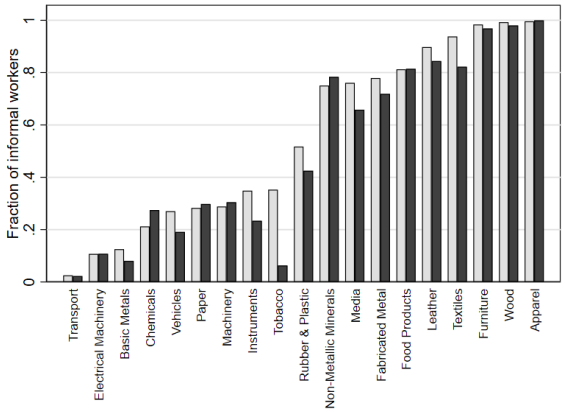
(d) Firm size in formal sector

Notes: The above figures plot the distribution of targeted moments for each industry. The grey bars report data moments, while the black bars report simulated moments. Figures (a) and (b) show the number of firms in the informal and formal sectors respectively, while Figures (c) and (d) plot the average firm size in the two sectors respectively.

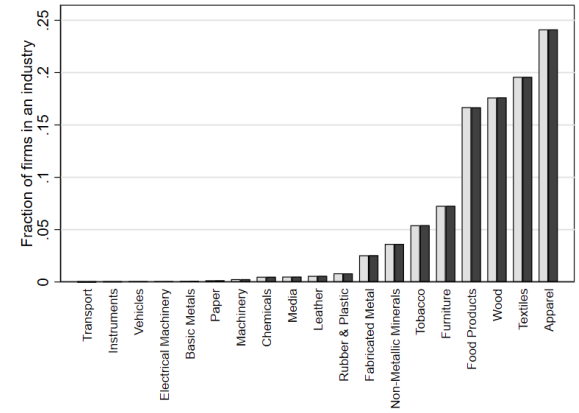
Figure A5: Model Fit Across Industries II



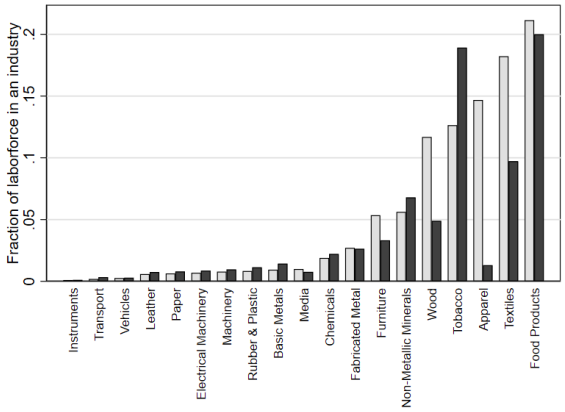
(a) Frac. of informal firms



(b) Frac. of informal labor



(c) Frac. of firms in industry j



(d) Frac. of workers in industry j

Notes: The above figures plot the distribution of moments for each industry. The grey reports the data moments, while the black bars report the simulated moments in the model. Figures (a) and (b) show the fraction of firms and workers in the informal sector for each industry respectively, while Figures (c) and (d) show the number of firms and workers in industry j as a fraction of all firms and workers in the economy.

Table A1: Event Study Regression

	Contract				Regular	
	Log Workers	Log Worker-days	Worker Share	Worker Days Share	Log Worker	Log Worker-days
	(1)	(2)	(3)	(4)	(5)	(6)
2000-2001	0.038	0.037	0.004	0.004	0.014	0.040
	(0.136)	(0.139)	(0.011)	(0.011)	(0.038)	(0.040)
2001-2002	-0.003	-0.020	-0.008	-0.008	0.009	-0.002
	(0.171)	(0.162)	(0.011)	(0.011)	(0.058)	(0.059)
2002-2003						
2003-2004	-0.348**	-0.393**	-0.032**	-0.032**	0.201***	0.151***
	(0.171)	(0.159)	(0.014)	(0.014)	(0.046)	(0.048)
2004-2005	-0.659***	-0.660***	-0.050***	-0.051***	0.275***	0.265***
	(0.204)	(0.190)	(0.014)	(0.014)	(0.060)	(0.062)
2005-2006	-0.640**	-0.643**	-0.042*	-0.042*	0.242**	0.223*
	(0.292)	(0.279)	(0.025)	(0.025)	(0.107)	(0.114)
N	165556	165674	165556	165674	165556	165674
R^2	0.795	0.794	0.810	0.810	0.852	0.857
Factory FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes	Yes	Yes	Yes
State-Trend	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Data are from the Annual Survey of Industries between 2000-2007. Columns (1)-(6) report underlying coefficients (from Equation 8) in Figure 2 for sub-figures (a)-(f) respectively. Robust standard errors clustered at the state-year level in parentheses; *** -statistical significance at 1%; **- statistical significance at 5%; *-statistical significance at 10%.

Table A2: Impact on Unemployment and Agriculture Sector

Probability of:	Unemployment	Agriculture
	(1)	(2)
Post × Treat	-0.000484	0.00316
	(0.00211)	(0.00551)
R^2	0.057	0.166
N	377,347	362,046
Year FE	Yes	Yes
State FE	Yes	Yes

Notes: Data are from the NSS. The outcome variable takes the value 1 if an individual is unemployed or is employed in the agricultural sector in Columns (1) and (2) respectively, and 0 otherwise. Post and Treat take the value 1 for years after 2003 and for Andhra Pradesh respectively, and 0 otherwise. Robust standard errors clustered at the state-year level in parentheses; *** -statistical significance at 1%; **- statistical significance at 5%; *-statistical significance at 10%.

Table A3: Impact on Core and Non-Core Activities

	Core			Non-core		
	Log Contract Worker-Days	Log Regular Worker-Days	Contract Share	Log Contract Worker-Days	Log Regular Worker-Days	Contract Share
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Treat	-0.388***	0.143***	-0.029***	-0.020	-0.082	-0.000
	(0.086)	(0.048)	(0.008)	(0.019)	(0.105)	(0.003)
R^2	0.793	0.851	0.809	0.614	0.803	0.617
N	165674	165674	165674	165674	165674	165674
Factory FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes	Yes	Yes	Yes
State-Trend	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Data are from the Annual Survey of Industries between 2000-2007. Core activity is any activity for which the establishment is set up, and other activities essential for these core activities. Non-core activities are the remaining peripheral activities (listed in the Appendix Section B). Post and Treat take the value 1 for years after 2003 and for Andhra Pradesh respectively, and 0 otherwise. Robust standard errors clustered at the state-year level in parentheses; *** -statistical significance at 1%; **- statistical significance at 5%; *-statistical significance at 10%.

Table A4: Robustness of Results to the Choice of the Control Group

	Workers				Persondays			
	(1) Log Contract	(2) Log Regular	(3) Contract Share	(4) Log total	(5) Log Contract	(6) Log Regular	(7) Contract Share	(8) Log total
A. Using only Neighbor States in the Control Group								
Post X Treat	-0.422***	0.217***	-0.040***	0.055	-0.455***	0.180***	-0.039***	0.026
	(0.105)	(0.052)	(0.010)	(0.045)	(0.102)	(0.054)	(0.010)	(0.045)
Observations	68222	68222	68222	68222	68272	68272	68272	68272
R^2	0.778	0.849	0.786	0.937	0.779	0.851	0.786	0.934
B. Removing Neighbor States from the Control Group								
Post X Treat	-0.298**	0.204***	-0.024**	0.057	-0.338***	0.164***	-0.024**	0.023
	(0.115)	(0.044)	(0.011)	(0.048)	(0.118)	(0.045)	(0.011)	(0.052)
Observations	108739	108739	108739	108739	108739	108739	108739	108739
R^2	0.796	0.844	0.809	0.939	0.793	0.851	0.809	0.934
Factory FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State-Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Data are from the Annual Survey of Industries between 2000-2007. Post is defined as 1 for years after 2003, and 0 before that. Treat is defined as 1 for Andhra Pradesh, and 0 for other states. Neighbor states to Andhra Pradesh are Odisha, Chhattisgarh, Maharashtra, Karnataka, and Tamil Nadu. Robust standard errors clustered at the state-year level in parentheses; *** -statistical significance at 1%; **-statistical significance at 5%; *-statistical significance at 10%.

Table A5: Placebo Test on Impact of the Policy

	Prob. Casual Worker	Log Daily Wage
	(1)	(2)
Placebo × Treat	-0.00685	-0.0239
	(0.00784)	(0.0180)
N	41,716	18,328
R^2	0.227	0.722
State FE	Yes	Yes
Industry-Year FE	Yes	Yes

Notes: Data are from the NSS for years 1993-94 and 1999-2000. In Column (1), the dependent variable is 1 if the worker is employed casually, and 0 otherwise. In Column (2), the dependent variable is log daily wage in INR. Placebo and Treat take the value 1 for years after 1999 and for Andhra Pradesh respectively, and 0 otherwise. Robust standard errors clustered at the state-year level in parentheses; *** -statistical significance at 1%; **- statistical significance at 5%; *-statistical significance at 10%.

Table A6: Robustness of Results to Firm Classifications

	Frac. of Unreg. Large Firms		Frac. of Workers in Large Unreg. Firms	
Large Firms:	≥15 workers	≥20 workers	≥15 workers	≥20 workers
	(1)	(2)	(3)	(4)
Post × Treat	0.123***	0.172***	0.155***	0.180***
	(0.036)	(0.042)	(0.039)	(0.044)
R^2	0.754	0.711	0.742	0.703
N	1,066	1,066	1,066	1,066
Year FE	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes

Notes: Data are from the 1998 and 2005 rounds of the Economic Census of India and has been aggregated to the district-year level. Columns (1)-(2) and (3)-(4) calculate the fraction of large firms that are unregistered as well as the fraction of workers in them respectively. Large firms are those with at least 15 (20) workers in Columns 1 (2) and 3 (4) respectively. Post and Treat take the value 1 for years after 2003 and for Andhra Pradesh respectively, and 0 otherwise. Robust standard errors clustered at the state-year level in parentheses; *** -statistical significance at 1%; **- statistical significance at 5%; *-statistical significance at 10%.

Table A7: Model Fit

		Model	Data
		(1)	(2)
No. of informal firms ('000)	Targeted	84	85
		[128]	[128]
No. of formal firms ('000)	Targeted	0.86	0.86
		[1.6]	[1.6]
Firm size in informal firms	Targeted	2.8	2.8
		[1.8]	[1.0]
Firm size in formal firms	Targeted	109	112
		[182]	[170]
Variance in log-firm size (Informal)	Targeted	0.20	0.59
Variance in log-firm size (Formal)	Targeted	1.4	1.3
Frac. Informal labor	Untargeted	0.50	0.55
		[0.35]	[0.34]
Frac. Informal firms	Untargeted	0.90	0.90
		[0.13]	[0.13]
Frac. Labor in industry j	Untargeted	0.041	0.053
		[0.06]	[0.068]
Frac. Firms in industry j	Untargeted	0.053	0.053
		[0.079]	[0.079]

Notes: The above table reports the moments in the model (Column 1) with those in the data (Column 2). Averages are reported across all industries, with standard deviations in parentheses. The variance in log-firm size does not have variation across industries, and hence no standard deviation.

Table A8: Derivatives of Moments to Parameter Changes

Moment	σ_x	σ_e	θ	b_c	b_r
	(1)	(2)	(3)	(4)	(5)
Var. Firm-size (Informal)	1.06	-0.28	-1.47	0.26	0.22
Var. Firm-size (Formal)	0.03	0.98	0.01	0.00	0.00
Avg. Firm-size (Informal)	-0.64	-0.15	-0.71	0.23	0.10
Avg. Firm-size (Formal)	-0.95	-0.41	0.43	-0.65	0.22
Frac. Contract Workers	0.00	0.00	0.00	-1.35	1.34

Notes: This table reports the derivatives of each moment with respect to each parameter. Each row is a moment calculated from the model simulation. Each number in the table indexed by row R and column C, is the percent change in the moment in row R, when a parameter in column C is increased by 1 percentage.

B Permitted Non-Core Activities for Contract Workers

1. Sanitation works, including Sweeping, Cleaning, Dusting, and Collection and disposal of all kinds of waste.
2. Watch and ward services including security service.
3. Canteen and Catering services.
4. Loading and Un-loading Operations.
5. Running of Hospitals, Educational & Training Institutions, Guest Houses, Clubs and the like where they are in the nature of support services of an Establishment
6. Courier Services which are in nature of support services of an Establishment.
7. Civil and other constructional works, including maintenance.
8. Gardening and maintenance of lawns etc.
9. Housekeeping and laundry services etc., where they are in nature support services of an Establishment.
10. Transport services including Ambulance Services.
11. Any activity of intermittent in nature even if that Constitutes a core activity of an Establishment and
12. Any other activity which is incidental to the core activity.

ONLINE APPENDIX

C Mathematical Proofs

C.1 Firms in the Formal Sector

Production Decision of Incumbents: The profit maximization problem of the incumbents in the formal sector can be broken into a two-step problem, where in the first step, firms maximise:

$$\pi_f = \max_{l_f}(1-t)pzl_f^{\rho} - w_f l_f$$

Define $w_f = \left[b_r^{1-\sigma} + b_c^{1-\sigma}\right]^{\frac{1}{1-\sigma}} w$. Taking the first order condition and solving, we get:

$$l_f^*(z) = \left[\frac{\rho(1-t)p}{w_f}\right]^{\frac{1}{1-\rho}} \times z^{\frac{1}{1-\rho}}$$
$$y_f^*(z) = \left[\frac{\rho(1-t)p}{w_f}\right]^{\frac{\rho}{1-\rho}} \times z^{\frac{1}{1-\rho}}$$
$$\pi_f^*(z) = (1-\rho)\left[\frac{\rho}{w_f}\right]^{\frac{\rho}{1-\rho}} \times ((1-t)pz)^{\frac{1}{1-\rho}}$$

Given this, the firm then choose l_r and l_c in a dual problem, given by:

$$\min\ wb_r l_r + wb_c l_c$$
$$\text{s.t. } l_f = \left[l_r^{\frac{\nu-1}{\nu}} + l_c^{\frac{\nu-1}{\nu}}\right]^{\frac{\nu}{\nu-1}}$$

Let w_f, defined above, be the Lagrangian constant so that:

$$L = wb_r l_r + wb_c l_c - w_f \left[l_f - \left[l_r^{\frac{\nu-1}{\nu}} + l_c^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}} \right] \tag{12}$$

Taking the first-order conditions with respect to l_c, l_r and w_f and solving, we get:

$$\begin{aligned} wb_p l_p &= \frac{b_p^{1-\nu}}{b_p^{1-\nu} + b_c^{1-\nu}} \times w_f l_f^*(z) \\ wb_c l_c &= \frac{b_c^{1-\nu}}{b_p^{1-\nu} + b_c^{1-\nu}} \times w_f l_f^*(z) \end{aligned} \tag{13}$$

From Equation 13, the ratio of contract to permanent workers is given by:

$$\frac{l_c}{l_p} = \left(\frac{b_c}{b_p} \right)^{-\nu}$$

Entry Decision: Let E_f be the fixed cost of entry (in units of output) into the formal sector. A firm can enter the formal sector as long as $\pi_f \geq pE_f$. This implies that there is a threshold productivity z_f^E where $\pi_f(z_f^E) = pE_f$. Rearranging the variable profit equation from above, we get:

$$z_f^E = \frac{\left[E_f / (1-\rho) \right]^1 - \rho}{(1-t)\left(\rho p / w_f \right)^\rho}$$

C.2 Incumbents in the Informal Sector

The profit maximization problem of the incumbents in the informal sector is straightforward and can be given by:

$$\pi_i = \max_{l_i} pz l_i^\rho - w_i l_i^\theta$$

Taking the first order condition and solving, we get:

$$l_i^*(z) = \left[\tilde{\rho} \times \frac{p}{w} \times z\right]^{\frac{1}{\theta-\rho}}$$

$$y_i^*(z) = \left[\frac{\tilde{\rho}p}{w}\right]^{\frac{\tilde{\rho}}{1-\tilde{\rho}}} \times z^{\frac{1}{1-\tilde{\rho}}}$$

$$\pi_i^*(z) = (1-\tilde{\rho})\left[\frac{\tilde{\rho}}{w}\right]^{\frac{\tilde{\rho}}{1-\tilde{\rho}}} \times (pz)^{\frac{1}{1-\tilde{\rho}}}$$

where $\tilde{\rho} = \rho/\theta$.

C.3 Cost Function and Probability of Detection

An alternate way to present the model is to allow for a size-dependent penalty of operating in the informal sector. Let $\tau(l)$ be the penalty function such that $\tau(l) > 0$, $\tau'(l) < 0$ and $\tau(\infty) \to 0$. Therefore maximization problem of the firm can be written as:

$$\max_l \tau(l) pz l^\rho - wl$$

Taking the first order condition and rearranging:

$$\left[\rho\tau(l) + l\tau'(l)\right] pz l^\rho = wl \tag{14}$$

Comparing it to the baseline model, we have:

$$\left[\frac{\rho}{\theta} l^{\frac{\rho}{\theta}-\rho}\right] pz l^\rho = wl \tag{15}$$

Equations 14 and 15 are therefore connected through the $\tau(l)$ function. This implies:

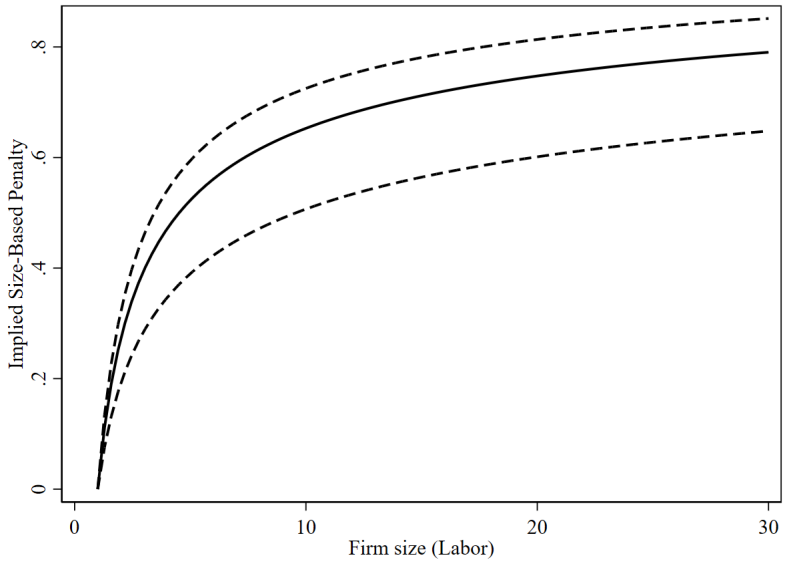
$$\rho\tau(l) + l\tau'(l) = \frac{\rho}{\theta} l^{\frac{\rho}{\theta}-\rho} \tag{16}$$

This is a differential equation of the form $ay + xdy/dx = bx^c$. This has a general solution of the form $y = \frac{bx^c}{a+c} + \frac{k}{x^a}$ where k is an integration constant. Therefore:

$$\tau(l) = \left[l^{\frac{\theta-1}{\theta}} + k \right] l^{-\rho} \tag{17}$$

Assume $\tau(l) = xl/(1+xl)$, where x is a parameter that governs the marginal change in the probability detection as firm size increases. A larger x implies a higher probability of being detected conditional on the same firm-size (l). From the calibration exercise in the paper, we have $\rho = 0.738$ and $\theta = 1.3$ and from Equations (14) and (15), this implies a value of $x = 0.088$ and a probability detection function shown in Figure A6.

Figure A6: Size-based penalty function



Notes: The above graph plots the size-based penalty function of operating in the informal sector, as a function of firm size. The solid black line show the median value across all industries, while the dashed lines show the 25th and 75th percentiles.

D Details of Estimation Algorithm

The estimation algorithm proceeds as follows:

Step 1: Take a guess for an initial set of parameters in φ (defined in the paper). Equation 1 allows us to calibrate the value of $b_{r,j}$ such that $b_{r,j} = R_j^{1/\nu} \times b_{c,j}$, where R_j is the ratio of contract to payroll workers that is observable in the data.

Step 2: Using the distributional assumptions on the productivity distribution as well as the potential entrants (M), we compute the threshold productivity in the informal and formal sectors given by:

$$\frac{N_f}{M} = 1 - F(x_f^*) \tag{18}$$

$$\frac{N_f + N_i}{M} = 1 - F(x_i^*) \tag{19}$$

where: the number of potential entrants, M, is calculated by subtracting the total number of entrepreneurs and workers in the formal and informal firms in Andhra Pradesh from the total adult workforce of Andhra Pradesh as reported in the 2001 Population Census of India.

Step 3: From Equations 2 and 4, the variance in log-labor in the formal and informal sectors will be given by:

$$Var(\ln l_f) = \frac{\sigma_f^2 + \sigma_\varepsilon^2}{(1-\rho)^2} \tag{20}$$

$$Var(\ln l_i) = \frac{\sigma_i^2 + \sigma_\varepsilon^2}{(\theta-\rho)^2} \tag{21}$$

where, $\sigma_f^2 = Var(\ln x | x \geq x_f^*)$ and $\sigma_i^2 = Var(\ln x | x \in \{x_i^*, x_f^*\})$.

Step 4: In an inner loop, we take a guess for the price vector prices and wages. Conditional on the parameter values in the outer loop, we use Equations 2, 3,

4 and 5, to calculate the total demand and supply in the goods and labor markets. We then update the price vector in an iterative loop until the goods and labor markets clear (we set the threshold tolerance for convergence to 0.5%).

Step 5: After calculating the equilibrium price and wages, we calculate the average firm size in the formal and informal sectors using Equations 2 and 4.

Step 6: Using the simulated moments from above, we then choose the parameter vector that minimizes the distance between the data moments and simulated moments such that $\widehat{\varphi} = \text{argmin}_{\varphi}\ g(\varphi)'\ W\ g(\varphi)$, where W is a $5J + 2 \times 5J + 2$ weighting matrix that is selected efficiently using a two-step process. In the first step, we set W to be the identity matrix I and calculate $\widehat{\varphi}_1$. Using $\widehat{\varphi}_1$, we can then compute $W^{TwoStep} = \frac{1}{N}[g(\varphi_1)g(\varphi_1)']^{-1}$, which we use as the weighting matrix and redo the exercise to calculate $\widehat{\varphi}^{SMM}$.

Step 7: We then use the zero-profit conditions in the informal and formal sectors (Equation 7) to calibrate the fixed cost of entry and formalization in these industries.

Step 8: Duffie and Singleton (1993) provide weak and strong consistency conditions that are satisfied in the model. Similar to Gourinchas and Parker (2002) and Ulyssea (2018), asymptotic normality holds as long as (i) φ_0 and φ^{SMM} are in the interior parameter space; (ii) the simulator used is continuously differentiable w.r.t. φ in the neighborhood of φ_0 and (iii) $G = E[\frac{\partial g(\varphi^{SMM})}{\partial \varphi}]$ exists, is finite and $G'W'G$ is non-singular. Standard errors are then calculated using the empirical gradient of G i.e., using small changes to φ^{SMM}, and given by $\sqrt{\frac{1}{N}(G'WG)^{-1}}$.