Informality and Aggregate Productivity: The Case of Mexico*

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Abstract

This paper develops and estimates a quantitative model to analyze the aggregate productivity consequences of informality in Mexico. While informality is typically viewed as prevailing solely among small firms, we use rich census data to document a high and rising share of large informal firms between 1998 and 2013. The model features an intensive and extensive margin of informality, and it is quantified using the observed size and productivity distributions of both informal and formal firms. We use the model to assess the role of changes in labor market regulations, entry costs and enforcement in contributing to the rise in informality and decline in TFP observed in Mexico from 1998 to 2013. We estimate that regulatory changes during the 2000s contributed to over a third of the observed rise in the informal employment share, but without large aggregate productivity consequences. Rising entry costs and declines in enforcement explain almost half of the decline in TFP from 1998 to 2013, though partially offset by improving within-sector allocative efficiency.

Key words: Productivity, Informality, Labor Market Regulations, Misallocation, Mexico.

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1 Introduction

Many developing economies are characterized by informal sectors accounting for a large share of employment and output (La Porta and Shleifer, 2014). The prevalence of small and unproductive informal firms is often viewed as being in part the result of labor market frictions and regulations (Levy, 2018; Dix-Carneiro et al., 2021; Mancellari, 2021).[1] The impact of such frictions on misallocation and aggregate productivity depends on how they affect the joint distributions of firm size and revenue productivity (Hsieh and Klenow, 2009; Bento and Restuccia, 2017). While existing quantitative evaluations of the impact of informality on aggregate productivity do a good job of matching the size distribution of informal and formal firms (Ulyssea, 2018), they do not try to capture the firm productivity distribution, which exhibits tremendous dispersion even conditional on firm size (Syverson, 2011).

In this paper, we develop and estimate a quantitative model which captures the joint size and productivity distributions of informal and formal Mexican firms. Mexico is an ideal country in which to conduct this analysis as it has detailed census data on the universe of formal and informal firms, as well as survey data on worker informality. In contrast to the common perception that informality is concentrated among small firms, we document that a high share of mid-sized and large firms are also informal. This share rose sharply over time — informality among firms with 6 to 50 employees rose from 21% in 1998 to 44% in 2013.[2] In addition, we show that informal contractual arrangements are very common within large formal firms.[3] We use the model to evaluate the causes of the simultaneous increase in informality and decline in aggregate TFP in Mexico from 1998 to 2013. Levy (2018) argues that these trends were in large part the result of labor regulations introduced in the early 2000s that incentivized informal contractual arrangements.[4] We estimate that the labor market regulations introduced during the 2000s explain an increase in the in-

[1] See Ulyssea (2020) for a broader review of the link between informality and economic development.

[2] We define firms as being informal if they do not report social security contributions, which are legally required for full-time workers. Appendix A.4 discusses how stylized facts on large informal firms are robust to alternative definitions.

[3] Ulyssea (2018) and Mancellari (2021) similarly document this in Brazil and Albania respectively

[4] The literature has emphasized the role of taxation, social security contributions, non-contributory benefits, the limited value of contributory benefits, and the effect of size-specific tax regimes and enforcement policies in inducing labor and capital misallocation towards the informal sector. Levy (2018) provides a summary and expanded discussion of this research and concludes that formalization frictions lead to significant aggregate TFP losses in Mexico.

formal employment share of over a third that observed in the data, but with no adverse impact on aggregate productivity. In contrast, we estimate that changes in entry costs, enforcement on informal firms, and the extent of within-sector misallocation had large impacts on aggregate TFP.

The model is based on Ulyssea (2018), which provides a useful framework for capturing various margins of informality. On the one hand, entrepreneurs can choose to set up formal or informal firms, requiring different entry and registration costs, and subject to different sets of distortions when operating. This is the *extensive margin* of informality. On the other hand, formal firms can choose to hire formal or informal workers as part of their operations. The trade-off formal firms face is whether to pay mandatory social security contributions and taxes required for formal workers, or risk penalties from hiring informal workers. This is the *intensive margin* of informality. We extend Ulyssea (2018) by assuming that, not only do firms face different entry and homogeneous labor costs according to their formality status, but they also face idiosyncratic distortions whose distributions are different in the formal and informal sectors. These idiosyncratic distortions allow us to map the model not only to firm-level data on size distributions, as in Ulyssea (2018), but also to the Mexican Economic Census data on firm revenue productivity (TFPR). This extension allows the model to capture alternative potential sources of misallocation in Mexico across firm types (without taking a precise view on the fundamental origin of such idiosyncratic distortions as in Hsieh and Klenow (2009)), and to explore how they change the effects of policy reforms we consider.

We estimate the model using micro-data from the Mexican Economic Census for 2013 and from the national employment surveys (ENOE). These include a rich set of moments on the intensive and extensive margins of informality, the size distributions of informal and formal firms, and the revenue productivity distributions of informal and formal firms. We calibrate the formal sector labor market wedge to reflect estimates from Levy (2018) regarding the implicit cost of labor market regulations. We provide an intuitive discussion of how the model parameters are identified based on the differing sensitivity of the model moments to each parameter, and validate the model by showing that it matches some non-targeted moments of the informal and formal firm size distributions.

We first use the model to analyse the aggregate and firm-level impacts of four counterfactual policy reforms. The first of these is the removal of the formal sector regulatory labor distortions from taxation and social security, which Levy (2018) estimates contributed to around a 12pp increase in the formal sec-

tor labor market wedge between 1998 and 2013. We find that removing this wedge reduces the informal employment share by around 6pp, over a third of the 14 pp increase observed in Mexico from 1998 to 2013 (based on ENOE). Intuitively, reducing labor distortions makes formal workers relatively cheaper, and primarily affects the *intensive* margin of informality. Effects on the *extensive margin* from these distortions are less prominent, since only marginal firms at the low end of the firm-size spectrum are affected. Accordingly, we find that the removing these policies would lead to almost no change in aggregate TFP. In contrast, we find that reducing formal sector entry costs leads to a simultaneous substantial decrease in informal employment and increase in aggregate productivity. The third policy counterfactual we consider is an increase in enforcement on firms in the informal sector. We find that this would almost halve the informal employment share, albeit with no aggregate TFP gains. This results from two offsetting forces: on the one hand, the increase in enforcement reduces within-sector misallocation, on the other hand, it increases the marginal revenue productivity of informal firms to more than in the formal sector, amplifying cross-sector misallocation. Lastly, we find that reductions in idiosyncratic distortions in the informal sector both reduce informality and lead to substantial improvements in aggregate productivity by reducing informality among large firms, thereby improving allocative efficiency.

We next re-estimate the model to match data moments on informality and the firm size distribution for 1998, and quantify to what extent changes in entry costs, enforcement and idiosyncratic distortions contributed to the increase in informality and decline in aggregate TFP from 1998 to 2013. We estimate that entry costs in both the formal and informal sectors increased over time, that enforcement on informality for formal firms increased but decreased for informal firms, and that the dispersion of idiosyncratic distortions decreased within both the formal and informal sectors. We find that, together, changes in these frictions contributed to a reduction in TFP of 0.9 percent. While economically significant, this does not come close to explaining the 13 percent decline in aggregate TFP during this period. However, we find that this overall change hides offsetting forces. The increase in entry costs contributed to a reduction in TFP of 4.4 percent (but a 1 pp decrease in informal employment because the relative informal/formal entry costs remained comparatively unchanged), and the decrease in enforcement on informal firms reduced aggregate TFP by an additional 1.2 percent. Together, increasing entry costs and declining enforcement can almost account for half of the decline in aggregate TFP. However,

these losses were offset by an improvement in within-sector misallocation due to a reduction in the dispersion of within-sector distortions, which contribution to an increase in TFP of 3.9 percent.

The main modeling contribution relative to Ulyssea (2018) is that we incorporate idiosyncratic distortions which generate misallocation. These idiosyncratic distortions are critical in our estimation for matching the high share of relatively large firms that are informal. However, an open question remains: how important is it *quantitatively* to allow for these distortions when evaluating reform impacts? To assess this, we re-estimate the model without idiosyncratic distortions to match the 2013 data (except for the revenue productivity moments). We show that they are quantitatively very important when evaluating the aggregate TFP impact of increasing enforcement. We estimate a 5 percent *decrease* in TFP in the model without distortions, in contrast to no change in TFP in the model with distortions. This is due to an important new mechanism in our model — increasing enforcement *increases* within-sector allocative efficiency rather than reducing it, because it offsets the large implicit subsidies from non-compliance which lead to a significant right tail in the size distribution of formal firms.

Our results complement recent modeling approaches and an extensive empirical literature studying the effects of regulation on informality and aggregate outcomes. Ulyssea (2018) and Erosa, Fuster and Martinez (2023) study the importance of the extensive and intensive margins of employment in Brazil. Ulyssea and Ponczek (2018) and Dix-Carneiro et al. (2021) develop a similar framework linking informality distortions to trade. Meghir, Narita and Robin (2015) develop a wage-posting framework and find positive effects from tightening enforcement. Haanwinckel and Soares (2021) study a search model in informal labor markets with a rich and realistic set of labor regulations and frictions. Charlot, Malherbet and Terra (2015) propose a model of formal and informal firms facing product and labor market imperfections. D'Erasmo and Boedo (2012) and Franjo, Pouokam and Turino (2022) develop frameworks with capital market frictions that emphasizes the role of credit access on the extensive margin of informality. Close to our emphasis on the intensive margin, Bertrand, Hsieh and Tsivanidis (2015) use a model of firm growth and firing costs to study the effect of informal labor contracts on TFP growth in India. Mancellari (2021) uses a quantitative model to evaluate the importance of informal workers at formal firms for the dynamics of hiring and firing in response to shocks. For the case of Mexico, Leal (2014) proposes a dynamic model to study the link between

tax collection, informality and productivity, and Lopez-Martin (2019) proposes quantitative model with firm dynamics in which informality is driven by credit constraints and formal sector taxes. Our paper is also partly related to recent literature on the aggregate consequences of tax evasion (Kotsogiannis and Mateos-Planas, 2019; Di Nola et al., 2021; Fernandez-Bastidas, 2023).

In terms of empirical studies, Bruhn (2011, 2013) and Kaplan, Piedra and Seira (2011) find limited positive effects on formal business registration from speeding-up business startups, and Antón, Hernández and Levy Algazi (2013) and Bosch, Cobacho and Pages (2014) highlight the effects of Mexican social security systems on informal employment. Other recent studies focusing on the impact of tax and entry cost regulation on informality and aggregate outcomes include Rocha, Ulyssea and Rachter (2018), Monteiro and Assunção (2012), Fajnzylber, Maloney and Montes-Rojas (2011), Almeida and Carneiro (2012), and De Andrade, Bruhn and McKenzie (2013).

The rest of paper proceeds as follows. Section 2 describes the regulatory environment, defines informality in that context, and documents a number of empirical facts about informality in Mexico from the worker and firm perspectives. Section 3 describes the model's mechanics. Section 4 outlines the estimation of the model and Section 5 shows the results of policy counterfactual exercises. Section 6 concludes.

2 Institutional context and facts about informality in Mexico

This section first describes how the regulatory environment in Mexico shapes informality, then introduces the data sets and informality definitions used in the analysis, and lastly presents an empirical characterization of informality from the firm and worker perspectives.

2.1 Regulatory environment and definitions of informality

The Mexican regulatory system has a number of features which affect the formalization decisions of firms and workers—many of which were introduced or reformed between 1998 and 2013. On the one hand, firms must pay a wide array of registration costs to be legally registered and pay taxes. On the other hand, even if legally registered, firms can decide how many workers to hire with salaried

contracts with full legally obliged benefits (formal workers) vs. how many workers to hire through alternative informal contracts. There are four broad reasons why firms may be reluctant to operate formally: non-compensated social security contributions for formal workers, hiring and firing costs, taxes, and formal entry costs. We proceed to describe the main regulations associated with these in greater detail.

First, formally registered firms must enroll salaried workers in the social security registry (IMSS) and pay a contribution proportional to workers' wages on a scale that contains a regressive fixed cost component. Non-compliance is subject to monetary fines in the rage of 20-350 daily minimum wages per non-registered workers.[5] Social insurance contributions can comprise around 30 percent of the wage and are only mandatory for salaried employees.

These contributions are not necessarily distortionary if they are fully compensated by equally valued benefits. However, two features of the Mexican social insurance system suggest that there are limited net benefits from IMSS membership. On the one hand, the Mexican government also provides a fully financed non-contributory social insurance system through which workers receive free benefits (including health and retirement) without making contributions. Government subsidies to this system have increased substantially over time making participation in contributing programs less attractive.[6] On the other hand, IMSS benefits are bundled and only provide limited additional benefits to workers who already have an enrolled family member. A reform in 1997 also implied a substantial decrease in these benefits.[7] Overall, Levy (2018) estimates that the gap between the benefits and costs of the contributory social security systems imply an implicit tax on salaried contracts which has increased substantially over time to around 12 percent.

Second, firms hiring salaried workers can be sued for unfair dismissals, implying a contingent liability for hiring formal salaried workers. Labor lawsuits arising from this regulation often lead to long legal dispute processes that, in

[5] Bobba, Flabbi and Levy (2022).

[6] Levy(2018) documents that public resources allocated to non-contributory social insurance programs increased from 0.4 to 1.7 percent of GDP from 1996 to 2015, implying an implicit subsidy increase for non-salaried and illegal salaried contracts from three to 16.5 percent of worker's earnings during that period.

[7] The reform changed the pension system from a heavily subsidized pay-as-you-go defined-benefit scheme to a defined-contribution one, while increasing the minimum contribution period for pension eligibility from 10 to 24 years. A large share of workers who began formal employment after 1997 will not obtain full retirement benefits as a result of this rule change. Levy (2018) estimates that three out of four workers contributing in the new regime will not meet the threshold as opposed to three out of 10 under the old regime.

the past, led to an accumulation of payments owed by firms directly linked to the length of the dispute. Heckman and Pages (2004) estimate an implicit costs from severance pay regulations of around 3.2 percent of wages.[8]

Third, taxation policies favor non-salaried and informal employment. State payroll taxes of around three percent apply only to salaried workers, and have increased since the late 1990s.[9] Federal income taxes apply to all workers but firms are only required to withhold income taxes for salaried workers. This leads to widespread evasion of the tax by non-salaried workers, who pay about one-fourth of the expected contributions based on aggregate estimates.[10] Over time, the combined effect of statutory rate and deduction changes, as well as decreases in salaried wage subsidies and income tax thresholds used in real terms, has implied an increase in the relative tax-burdens of salaried workers compared to non-salaried ones—with a stronger effect in the lower half of the wage distribution.[11]

Beyond the barriers to hiring formal salaried workers, entry costs and distortionary policies also disincentivize entrepreneurs from establishing formally registered firms. To establish a legal company, an entrepreneur needs to obtain authorization for the use of the company name, incorporate the company through a notary, file incorporation with the Public Registry of Commerce, obtain a tax registry number with federal and local tax authorities, register at IMSS, notify the local government of the opening of a mercantile establishment, register with the National Business Information Registry and pay fees associated with each these steps.[12] In addition, firms face many taxes and regulations which increase in firm size. Of these, the most prominent is the Small Contributor Regime (Repeco), which absorbs 93 percent of firms, 52 percent of labor, and 25 percent of capital of the economy (Levy, 2018). Another is that small firms are less likely to face penalties due to tax evasion or regulatory violations. Evidence suggests that tax evasion by small firms might have worsened over time, as tax revenues from the Repeco regime fell sharply as a share of GDP

[8] The 2017 and 2019 labor reforms has limited these firing costs and has allowed for processes aimed at facilitating dispute resolution processes.

[9] Levy (2018) documents that the six largest states increased state payroll tax rates from 2 to 3 percent from 1996 to 2015.

[10] Levy (2018) reports that taxes collections from salaried workers account for 2.5 percent of GDP while tax collections from non-salaried employment account for only 0.1 percent.

[11] See Levy (2018) for a full discussion and tax-burden calculation details.

[12] Doing Business (2019). Mexico ranks 94th out of 190 economies in costs and procedural burdens of starting a business. The cost of starting a business is estimated at 17 percent of income per capita.

even as statutory rates did not change.[13]

Several informality definitions are possible in this context: either based on registration and tax compliance on the firm side, or based on the use of fully salaried formal labor contracts on the worker side. In this paper, we will focus on the latter. We therefore refer to a firm as being formal if it pays *any* social security contributions for salaried workers. This decision is motivated by the fact that benefits and worker protections (including dismissal protections) are defined based on the salaried status of a worker according to Mexico's constitution. This regulatory feature yields the wide array of frictions affecting the use of salaried contracts previously described, which Levy (2018) argues is the most relevant aspect of informality when studying the link between informality and productivity in Mexico. Informality under this definition is not necessarily illegal, as legal non-salaried contracts are lawful as long as the employer-employee relationship is not one that resembles regular salaried employment at the firm. Occasional service providers would be an example of a legal non-salaried contractual relationships, but hiring regularly attending workers whose pay is not linked to specified outputs without salaried contracts is not legal.[14] Appendix A.4 discusses alternative definitions and their implications.

Our definition gives rise to the two margins of informality previously described: an *extensive margin* where firms decide whether or not to hire any formal workers and pay social security contributions, and an *intensive margin* where formal firms can choose how many formal and informal workers to hire. Fully implementing this definition in the data carries challenges as labor surveys containing detailed worker-level characteristics only provide very broad employer characteristics (mainly size) and no employer identifier, while the detailed firm-level data do not provide employee-level characteristics. The next sub-section describes the data sets used, how informality definitions are implemented, as well as facts about both of these margins of informality in Mexico. Appendix A provides additional stylized facts, and discusses their robustness to alternative definitions of informality.

[13] Levy (2018) documents a decrease from 0.036 to 0.022 percent of GDP in Repeco revenues from 2000 to 2013.

[14] The interaction between our definition of informality and legality is discussed at length by Levy (2018)

2.2 Data description

Mexico is a particularly well-suited environment for this study due to the availability of two exceptionally good data sets containing information on informality from both the firm and worker perspectives.

The first data set is the establishment-level Mexican Economic Census, which is the main data set used for calibrating the model.[15] The Mexican National Institute of Statistics and Geography (INEGI) compiles the data set every five years, for which we use the waves from 1998, 2003, 2008, and 2013. This includes millions of observations covering the universe of non-agricultural Mexican firms that have fixed establishments in urban areas across all industries. Importantly the information is collected outside of the tax collection systems, so informal practices are more likely to be reported. The census covers a wide array of firm characteristics including employment, location, revenues, value added, wage bill and other labor costs, and social security contributions. Given our focus on the worker-perspective definition of informality from a contractual point of view, we classify firms that make any social security contribution as formal when reporting moments from census data.[16] The data set does not contain information on individual employee contracts, but does report the share of remunerated workers in firms that report social security contributions. We use the complement of this share as our measure of the intensive margin of informality within formal firms when reporting moments from census data, including those used in the model calibration.[17] In total, there are over three hundred thousand formal firms and three million informal firms with reported employees in the 2013 Mexican Economic Census. The average formal firm is larger with 23.8 workers per establishment compared with 2.7 workers per establishment at informal firms. Table 1 provides summary statistics on these firm characteristics.

The second data set is the National Employment Survey (ENOE), which is the main data set used when characterizing worker and wage heterogeneity in the stylized facts section. This nationally representative survey includes both formal and informal workers, and records both demographic characteristics as well as

[15] See INEGI (2013) for a more detailed description of the data.

[16] Appendix A.4 shows additional moments under alternative definitions.

[17] It is possible that some remunerated workers within social-security paying firms do not receive social security contributions and should therefore be counted as informal according to our preferred definition of informality. If that is the case, the share of informal workers we measure might understate the true share. However, the total share of informal workers that we measure using this approach is broadly in line with the estimate using the ENOE definition (58 vs 56 percent). This indicates that these measurement issues are unlikely to be so large as to lead to large quantitative errors in our analysis.

Table 1: Firm characteristics by informality status

	1998		2003		2008		2013	
	Inf.	For.	Inf.	For.	Inf.	For.	Inf.	For.
Share of firms	0.82	0.18	0.87	0.13	0.89	0.11	0.89	0.11
Share of labor	0.32	0.68	0.41	0.59	0.48	0.52	0.49	0.51
Workers per firm								
Mean	2.0	19.2	2.5	23.8	3.1	26.4	2.7	23.8
S.d.	21.4	135.3	17.5	165.4	37.7	323.8	24.7	366.5
Share of salaried								
Mean		0.83		0.81		0.80		0.85
S.d.		0.24		0.22		0.23		0.21
V.A. per porker								
Mean	2.54	3.81	2.92	4.20	2.82	4.14	3.04	4.45
S.d.	1.20	1.02	1.26	0.98	1.36	1.13	1.37	1.02
TFPR								
Mean	1.01	0.95	1.65	1.66	1.50	1.53	1.48	1.56
S.d.	0.67	0.74	1.00	1.00	0.97	0.99	0.93	0.94
Number of firms	1.88	0.42	2.37	0.35	2.48	0.31	3.19	0.38

Notes: Data from Mexican Economic Census. Formal firms defined as those that reported social security contributions. Share of labor refers to total workers reported by formal/informal firms as a share of total workers reported by all firms. Share of salaried workers reflects the average share of remunerated workers in firms that reported social security contributions. V.A. refers to the log of value added per worker. TFPR refers to the log of Revenue Total Factor Productivity. Number of firms in millions.

information on the worker's contractual status and employer type.[18] Worker demographic characteristics include gender, age, educational attainment, and municipality. In addition, the survey also reports the employment status of the worker, labor earnings, hours worked, social security benefits received, and whether the worker is salaried or non-salaried. Employer characteristics in this data set include economic sector, firm size (as reported by the employee), and information related to the formality status of the firm.

Because the ENOE neither contains information on social contributions paid by firms nor firm identifiers, we must implement slightly different definitions of informality when using this data set while aiming to preserve the focus on salaried contracts requiring social security contributions. We identify informal workers in the ENOE as workers at non-agricultural informal firms, self-employed agricultural workers, unpaid workers, non-salaried workers (at all firm types), and workers without access to social security health services. All workers in non-salaried contractual relationships, independent of employer type, are therefore included in the informal worker category. Because the ENOE neither contains information on social contributions paid by firms nor firm identifiers, we identify informal firms as those in subsistence agriculture, domestic work, and firms classified as informal by INEGI based on reported name, family ownership, and accounting practices. Most firms in this category would not be expected to make significant social security contributions given the nature of their operations.

A key feature of the ENOE is its rotating panel structure, where each household is followed for five consecutive quarters. The ENOE samples over one hundred thousand households per quarter who are continuously replaced to guarantee national and regional representativity. This allows for the documentation of transitions between formal and informal worker status and transitions into and out of formal firms. It also allows the estimation of formal-informal wage gaps accounting for worker fixed effects. For this reason, the ENOE will be the focus of study when exploring the nature of wage gaps and providing evidence of integrated labor markets in section 2.4. Summary statistics for the ENOE are reported in Table 2.

[18] This study focuses on workers aged 14 to 65 who report being employed.

2.3 Informality structure and trends

We first document the structural features of informal employment and informal firms in Mexico in 2013. We then describe some of the key trends in both productivity and informality from the late 1990s on.

The structure of informality Firstly, Tables 1 and 2 show that informality in Mexico is high. Around half of workers work at informal firms as per the Mexican Economic Census data and around 58 percent of all workers are informal based on employment surveys such as ENOE. Informal firms account for 89 percent of firms. These shares are higher than those of other major Latin American economies.[19]

Secondly, informal firms are small and produce less value added per worker on average, but there is a lot of heterogeneity in the size and productivity distributions of formal and informal firms. The ratio of mean firm sizes between the formal and informal sector is close to 9. As shown in Figure 1a, while smaller firms are much more likely to be informal (i.e. have no workers on formal contracts), a substantial share of larger firms are also informal. This includes over 40% of firms with 6 to 50 workers—a feature that is robust to alternative formality definitions (Appendix A.4). This is notably different from the patterns documented by Ulyssea (2018) for Brazil, where the share of informal firms among firms with more than 7 employees is less than 20%. Moreover, mean value added per worker (in logs) is 50% higher in the formal sector, but the gap is much smaller when considering Revenue Total Factor Productivity (TFPR).[20] The latter accounts for differences in capital and material intensities between sectors. Notably, the mean gaps are much smaller than the overall dispersion within each sector, with the distributions of the formal and informal sector productivity measures largely overlapping each other (see Figure A2 in Appendix A).

Thirdly, informal employment within formal firms is large and negatively correlated with firm size. The across-firm mean share of formal workers employed at formal firms was 85 percent in 2013, implying that 15% of workers in formal firms do not have formal contracts. Figure 1b shows the share of informal workers in formal firms by firm size. While formal firms with three to five workers hire 21 percent of them in non-salaried informal contracts, this is only eight percent when looking at firms with 51+ workers.

[19] See comparison in Appendix A.

[20] We estimate TFPR as firm revenues divided by a Cobb-Douglas aggregate of of employment, capital and intermediate inputs, with the factor shares estimated from cost shares.

Trends in productivity and informality An important feature of Mexico's growth over the last two decades was a sharp decline in aggregate productivity which began in the 2000s. Levy (2018) and others have argued that an important driver of this trend was changes in the policy environment that shifted workers into informality and worsened resource misallocation. We document here how the main structural features of informality previously described changed over time.

Figure 2 shows that labor employed at informal firms did indeed rise substantially, from 32 percent in 1998 to 49 percent by 2013 (based on the Mexican Economic Census data). This increase occurred mainly along the *extensive margin*, with the share of informal firms increasing from 82 percent to 89 percent as shown in Table 1. Notably, Table A1 shows that this shift occurred across the firm size distribution. The share of informal firms among firms with 3-5 employees increased from 63 to 81 percent during this period, a substantial increase. More dramatically, this share increased from 21 to 44 percent among firms with 6 to 50 employees.

Along the *intensive margin*, the mean share of formal workers employed at formal firms declined from 83 to 80 between 1998 and 2008, before increasing to 85 percent in 2013 with mixed patterns across firm size categories. When comparing the earliest and latest year, the intensive informality margins increased among larger firms while they moderately decreased among smaller firms (Table A1). The increase in informality in Mexico is therefore not solely a small firm phenomenon. Explanations for the increase in informality and how it impacted aggregate productivity need to be able to rationalize these facts.

Before moving to a model of informality in Mexico which can match these patterns, we also consider informality from the worker perspective. An important question is whether informal labor markets are segmented from formal labor markets, or whether informal employment is a choice for workers as well. This is a key empirical question that motivates the right modelling of informality. Using the rich worker-side data from the ENOE, we explore this question next.

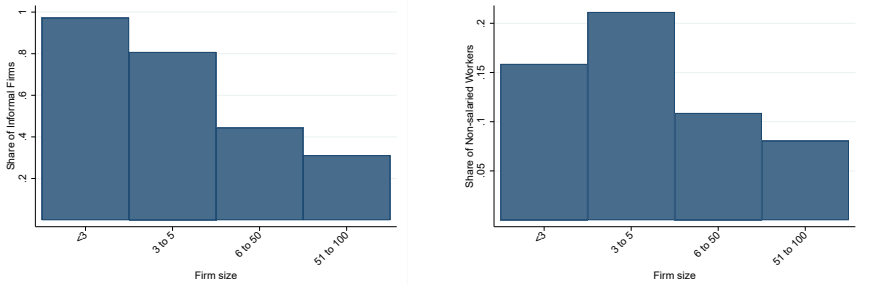
Table 2: Informality prevalence in ENOE employment survey

	Formal	Informal at formal firm	Informal at informal firm
Share of employed	41.94	21.60	36.46
By education			
Less than high school	27.02	24.75	48.23
High school	51.08	19.77	29.14
More than high school	70.31	15.55	14.14
By age			
Less than 25 years old	29.39	32.12	38.50
25–55 years old	46.37	18.96	34.67
More than 55 years old	34.71	19.64	45.65
Avg. log(wage)	3.40	2.82	3.02
S.d. of log(wage)	0.68	0.77	0.74
N	0.29	0.13	0.21

Notes: Data from 2013 ENOE employment survey. Informal workers include unpaid workers and those without access to social security or health services. Informal workers at informal firms include those working in self-subsistence agriculture, domestic work, or other establishments identified as informal by INEGI. All other establishments are considered formal. Shares of workers shown as percentages of all employed workers in each category. Wages refer to labor income per hour worked. N is the total number of observations in millions.

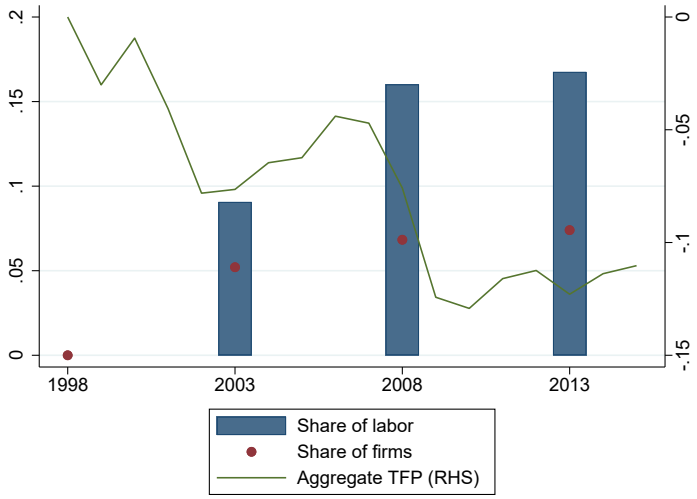
Figure 1: Extensive vs Intensive Margins

(a) Extensive margin (b) Intensive margin (at formal firms)



Notes: Data from 2013 Mexican Economic Census. Left panel shows share of informal firms out of all firms for each firm-size bin. Right panel shows cross-firm average shares of informal workers at formal firms consistent with Table 1 definitions.

Figure 2: Evolution of aggregate productivity and informality



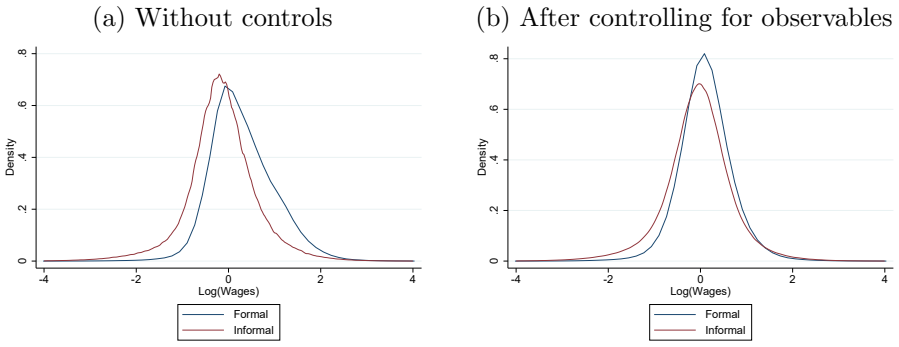
Notes: Data from Penn World Table and Mexican Economic Census. All variables shown in changes from 1998 levels. TFP refers to total factor productivity in constant national currency units. Shares of formal firms and workers estimated from the Mexican Economic Census as defined as in Table 1.

2.4 Evidence of integrated formal-informal labor markets

Three pieces of evidence suggest that there are broadly integrated formal-informal labor markets, where workers and firms are able to continuously match using different labor contract types.

First, informality can be found across education and wage levels. Although informal workers earn less and are less educated than formal ones (Table 2), informality is not an exclusive feature of the poorest and least educated workers. Table 2 shows the prevalence of informality by education level, which has been relatively stable in Mexico. Although informality rates are higher among workers without a high school degree, there is still a significant share of educated workers who are informal: around half of workers with a high school degree and around 30 percent of workers with higher education. Figure 3 shows the density of log wages for both sectors before and after controlling for worker demographics including age, education, and gender. There is a substantial overlap in the distribution of wages in both sectors, with the variance of log wages being 0.74 among formal workers and 0.65 among informal ones. This overlap is present even after accounting for differences in observable demographics (including age and education). Informality is thus prevalent, not only across different education groups, but also among both low and high paying jobs. The prevalence of informality across sectors, income strata, and both formal and informal firms paints a picture of a market duality that permeates all of the Mexican economy.

Figure 3: Distribution of wages



Notes: 2013 data from ENOE employment survey. Residuals from regressions with log labor income per hour as a dependent variable and formal status as an independent variable. Left panel includes controls for each age and education level.

Second, wage gaps tend to be small after considering worker composition, challenging a view of segmented labor markets with largely different formal-informal equilibrium wages. Table 3 shows the estimated wage gap between the formal and informal sectors controlling for age, education, time, economic sector, and worker fixed effects. Relative to informal workers outside of formal firms, formal workers earn a premium of 41 log points in the raw data and of 47 log points once sectoral differences are accounted for. Taking specifications with sector controls as a baseline, controlling for differences in education and age between workers reduces this gap from 47 to 23 log points. This implies that differences in demographics and education account for over half of this overall gap in wages. Crucially, informal workers at formal firms do not get a premium, as they tend to report wages that are lower than informal workers at informal firms on average. A large share of this discount is explained by their younger age and the sectors that they work for. Controlling for these differences reduces the gap between informal workers at formal and informal firms from -21 to -3 log points. Moreover, accounting for both observable and unobservable characteristics, the formality premium is further reduced. Controlling for individual fixed effects lower the formality premium from 23 to 4 log points, relative to the specification with only observable demographics. Altogether, the results imply that differences in worker composition, as controlled by observable and fixed unobservable characteristics, account for 92 percent of the overall wage gap.[21] This low residual wage gaps suggest a limited role of firms in determining average wage differences between formal and informal firms. Transitions into formal firms involve only a modest wage premium.

Third, workers frequently move between formality and informality in Mexico, as shown in Figure 4. Around four percent of workers move from formality to informality in a given quarter, with a similar proportion moving in the opposite direction. When dissecting transitions to informality between workers moving to informal firms and those moving to informal positions (mostly non-salaried) at formal firms, we see similar bidirectional flows.The most common transitions are those between holding formal and informal jobs within formal firms, indicating

[21] Result of comparing columns (2) and (6) in Table 3. It is important, however, to qualify this statement as the latter wage premiums are only estimated using workers who switch across sectors. These switchers do not form a representative sample of the population; therefore, it might still be the case that gains from formalization are greater for workers who do not switch across sector. In addition, given that the panel structure of the dataset follows a worker for only five quarters, wage premiums are exclusively affected by short-term gains from transitioning across sectors. This implies that, although estimated short-term wage premiums are relatively small, long-term gains from formalization might still significant.

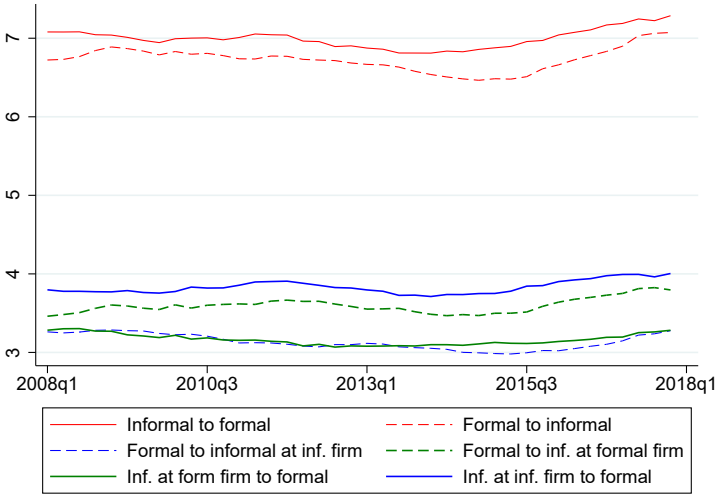
Table 3: Formality wage premiums

	No controls		Age and education controls		Worker fixed effects	
	(1)	(2)	(3)	(4)	(5)	(6)
Formal	0.406***	0.472***	0.154***	0.233***	0.00470**	0.0392***
	(0.00103)	(0.00109)	(0.00103)	(0.00109)	(0.00213)	(0.00216)
Informal at	-0.210***	0.0457***	-0.222***	-0.0261***	-0.108***	-0.0448***
formal firm	(0.00130)	(0.00137)	(0.00126)	(0.00132)	(0.00197)	(0.00202)
Education effects	No	No	Yes	Yes	No	No
Age effects	No	No	Yes	Yes	No	No
Sector effects	No	Yes	No	Yes	No	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Worker effects	No	No	No	No	Yes	Yes
N	6,231,902	6,231,902	6,231,902	6,231,902	6,231,902	6,231,902
R^2	0.127	0.173	0.267	0.290	0.790	0.791

Notes: Regressions with log(wage) as the dependent variable. Year, sector, education and age included as a vector of age and education dummies. Education categories are none, primary, secondary, high school, tertiary technical degree and > college completed. Sectors are agriculture, construction, manufacturing, and services. Data from ENOE. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

a degree of fluidity in contracting practices within formal firms.

Figure 4: Worker flow patterns in and out of informality in Mexico



Notes: Data from 2013 ENOE employment survey. Total switches shown as a percentage of workers employed in the post-transition period. Worker classification defined as in Table 2.

The prevalence of informality across worker types, the modest wage premiums from formality, and the presence of bidirectional formality-informality flows suggest that differences in productivity and pay between the formal and informal sectors are not arising from large frictions preventing the movement of workers from one sector to another. This motivates our view of Mexican market duality, to be formalized by the model, as the equilibrium of a system were workers can move freely between sectors.

3 A model of informality and misallocation

In order to assess how regulatory and non-regulatory distortions interact with informality in Mexico, we build on the work of Ulyssea (2018) by modeling heterogeneous firms who choose to be formal or informal; the extensive margin of informality. In addition, formal firms choose how many formal and informal workers to hire; the intensive margin of informality. Firms face both regulatory

and idiosyncratic barriers distorting their input and formality choices, leading to a misallocation of inputs across firms which lowers aggregate productivity. Following the evidence shown in the previous sections, we make the simplifying assumption that workers are homogeneous and are indifferent between being informal and formal.[22] We now describe each of the model's components in detail. The model extends Ulyssea (2018) by allowing for idiosyncratic firm distortions which we calibrate to moments on the dispersion of revenue productivity (TFPR) from the Mexican Census data.

3.1 Heterogeneous firms

There are two sectors in the economy: formal (F) and informal (I). Firms in both sectors have access to the same technology and produce a homogeneous good which acts as the numeraire. The production function of firm i is given by $y_i = \theta_i l_i^{\alpha}$, where θ_i is the firm's idiosyncratic productivity, l_i is the labor used in production, and $\alpha < 1$ is the rate of decreasing returns to scale.

Informal firms face two types of distortions: i) regulatory distortions which are faced by all informal firms and increase in firm size: $r^I(l_i)$, and ii) idiosyncratic distortions: τ_i^I. The regulatory distortions are consistent with the regulatory barrieres described in the previous section. While hiring informal workers is not necessarily illegal, any worker-firm relationship which resembles a full employment contract should provide full legal benefits under the law. Firms that only hire workers without providing these benefits (informal firms under our definition) are therefore at risk of being caught in breach of regulations. Our assumption that the regulatory cost is increasing in firm size is consistent with detection probability being higher for larger firms (Ulyssea, 2018). The idiosyncratic distortions capture any other idiosyncratic factor that would drive a wedge between a firm's marginal revenue and its marginal cost. These wedges could be due to markups, transport costs, financial frictions, corruption, or a myriad of other idiosyncratic factors introducing dispersion in marginal revenue products. While we only model these factors as 'reduced form' wedges, they are critical for being able to generate the dispersion in revenue productivity which we observe in the data. In addition, informal firms face overhead costs of operation c^I which are measured in units of labor such that: $c^I = w\gamma^I$. The informal firm profit function therefore takes the following form:

[22] We could introduce multiple skill levels into the model, following Ulyssea (2018), but the mechanisms we emphasize here would not change.

$$\pi_i^I = max_{l_i}\ \theta_i l_i^\alpha - (1+\tau_i^I) r^I(l_i) w l_i - c_I$$

where $r^I(l_i)$ is parameterized as in Ulyssea (2018):

$$r^I(l_i) = \left(1 + \frac{l_i}{b^I}\right)$$

Formal firms also face 'regulatory' distortions $r^F(l_i)$, idiosyncratic distortions $\tau_i^F$and overhead costs $c^F = w\gamma^F$. When hiring informal workers, they face a regulatory distortion parameterized as $r^F(l_i) = \left(1 + \frac{l_i}{b^F}\right)$ which increases in the number of informal workers. This captures the risk of sanctions from illegal informal hiring at formal firms. When hiring formal workers, they face a regulatory distortion taking the form of a constant wedge τ_w. This wedge captures the broad set of taxes and social security contributions firms need to pay for formal workers, while informal workers instead obtain benefits from non-contributory government programs.

Given that the marginal cost of hiring informal workers is increasing while the marginal cost of hiring formal workers is constant, there is a unique threshold $\tilde{l}$ above which formal firms only hire formal workers. As shown in Appendix B, this threshold is given by $\tilde{l} = \frac{\tau^w}{2} b_F$. The formal firm profit function therefore takes the following form:

$$\pi_i^F = max_{l_i}\ \theta_i l_i^\alpha - (1+\tau_i^F) r^F(l_i) w l_i - c_F$$

where:

$$r^F(l_i) = \begin{cases} \left(1 + \frac{l_i}{b^F}\right) & \text{if } l_i < \tilde{l} \\ \frac{\tilde{l}}{l_i}\left(1 + \frac{\tilde{l}}{b^F}\right) + (1+\tau^w)\frac{(l_i - \tilde{l})}{l_i} & \text{if } l_i \geq \tilde{l} \end{cases}$$

An implication of the threshold $\tilde{l}$ is that the share of formal workers in formal firms is increasing in firm size, a feature of the data we documented in the previous section.

Time is discrete and there are no aggregate shocks or idiosyncratic productivity shocks post-entry. Firms in each sector face a constant probability of exit each period: δ^I and δ^F. This is a strong albeit standard assumption in the literature, given that there are no post-entry firm dynamics in the model that would lead a firm to endogenously exit. Given that aggregate prices remain constant in the steady state equilibrium, the firm value function takes the following form:

$$V^S(\theta_i, \tau_i^S) = max\{0, \frac{\pi^S(\theta_i, \tau_i^S, w)}{\delta^S}\} \quad , \quad S = I, F$$

3.2 Entry

There is a continuum of entrepreneurs of mass M every period. Entrepreneurs do not know their productivity θ_i or their idiosyncratic distortions τ_i^I and τ_i^F before making the entry decision. They do however observe a noisy signal ν_i of their productivity before entry, which leads to selection of higher productivity entrepreneurs into the formal sector. Allowing for uncertainty in distortions or productivity is critical for generating significant overlap in the size distributions of firms in the informal and formal sectors.[23] The fact that entrepreneurs do not get a signal of their distortion reflects that many of these factors may not be ex-ante knowable, for example the likelihood of getting a government contract, a loan from a bank, exposure to corrputon costs, or the risk of sanctions from illegal informal practices.

After observing the signal ν_i, the entrepreneur chooses among the following options: i) enter the informal sector after paying an entry cost E^I in units of output, ii) enter the formal sector after paying an entry cost E^F, and iii) not enter either sector. Firms with signals below a cutoff $\underline{\nu}$ choose not to enter at all, firms with signals above a cutoff $\bar{\nu}$ choose to enter the formal sector, and firms with $\underline{\nu} < \nu_i < \bar{\nu}$ enter the informal sector. The reason that firms that expect to be more productive ex-ante enter the formal sector is that the cost function for hiring workers in the informal sector is convex, while it is constant in the formal sector once firms start hiring formal workers. Firms that anticipate becoming larger therefore expect to be more profitable in the formal sector, while firms that expect to remain small enter the informal sector.

After entry, the entrepreneur observes θ_i and τ_i^I (τ_i^F) and exits before beginning production if $\pi_i^I < 0$ ($\pi_i^F < 0$). Because there are now two random variables which determine the profitability of a firm (θ_i and τ_i), the endogenous exit decision cannot be summarized by cutoffs in terms of either of the variables independently. If $\pi_i^I \geq 0$ ($\pi_i^F \geq 0$) the entrepreneur starts production and becomes an incumbent firm as described in the previous sub-section. From this point on, the firm only exits due to the random exit probabilities δ^I and δ^F.

[23] In our baseline estimation we assume that the signal of productivity is perfectly informative, as uncertainty about distortions is sufficient to generate the overlap in the firm size distributions. We allow for uncertainty about productivity when evaluating the role of idiosyncratic distortions in the model.

Importantly, the decision to be informal/formal is taken upon entry and fixed forever that point on until the firm exits. When making the entry decision the entrepreneur knows the true distributions of ν_i, τ_i^I and τ_i^F. The entrepreneur's pre-entry value function is therefore given by:

$$V^0(\nu, w) = E[V^S(\theta, \tau^S, w)|\nu], \ S = I, F$$

3.3 Equilibrium

To close the model we need to make assumptions about the demand-side of the economy. There is a representative household who gains utility $U(C) = C$ each period from consuming the homogeneous good, who cannot save and who inelastically supplies labor $\bar{L}$. We focus on the stationary equilibrium, where aggregate prices and all distributions remain constant.[24] We assume that revenues from distortions get rebated to the representative household. Total consumption is therefore given by $wL + \Pi + T$, where wL is aggregate labor income, Π is aggregate profits minus entry costs and T is aggregate revenues from all distortions. The difference between aggregate output Y and aggregate consumption C is therefore given by aggregate entry costs and overhead costs. Because the distributions remain constant, we must also have that the mass of entrants in each sector is equal to the mass of incumbents times the exit rate. A stationary equilibrium is therefore defined by the following conditions:

- Labor markets clear: $L^I + L^F = \bar{L}$
- Firms maximize expected profits subject to their budget constraints
- The free entry condition holds in both sectors
- The size of each sector remains constant

3.4 Aggregate productivity and misallocation

The model is equipped to analyze how differences in resource misallocation across firms interact with policies affecting informality. In the model, dispersion in distortions generates dispersion in marginal products, which lower aggregate TFP. Marginal revenue productivity is given by simple expressions. For informal

[24] Ulyssea (2018) provides a proof of existence and uniqueness of the equilibrium in a version of this model without idiosyncratic distortions.

firms, in Appendix B we show that:

$$MRP_i^I = \frac{y_i}{l_i} = \frac{1}{\alpha}(1+\tau_i^I)(1+2\frac{l_i}{b^I})w.$$

Dispersion in revenue productivity therefore comes both from dispersion in the idiosyncratic distortions and from the regulatory distortion. The regulatory distortion creates a positive correlation between marginal products and productivity. Bento and Restuccia (2017) show that such size-dependent distortions can have potentially large impacts on aggregate productivity. For formal firms that hire only informal workers ($l_i < \tilde{l}$) we show in Appendix B that:

$$MRP_i^F = \frac{1}{\alpha}(1+\tau_i^F)(1+2\frac{l_i}{b^F})w$$

and for firms that hire formal and informal workers ($l_i > \tilde{l}$)), we have that:

$$MRP_i^F = \frac{1}{\alpha}(1+\tau_i^F)(1+\tau_w)w$$

Marginal revenue products are therefore initially increasing in firm productivity for formal firms but are uncorrelated with firm productivity above the threshold $\tilde{l}$. Distortions in the model reduce aggregate productivity both by misallocating resources *within* the informal and formal sectors, as well as *across* the two sectors because of $\bar{\tau}^F$.

Aggregate consumption is very sensitive to the assumption that revenues from distortions get rebated to the household. However, it is not clear to what extent these distortions are wasted or should get rebated. Rebating them to households makes sense if they reflect real expenses by firms on transport or distribution (Peter and Ruane, 2022). However, costs due to corruption or violence may be wasted. To avoid taking a stance on this, in our counterfactuals we therefore restrict ourselves to analyzing aggregate production Y and we define aggregate productivity as $TFP \equiv \frac{Y}{\bar{L}}$.

4 Estimation

In this section, we lay out how we quantify the model. We proceed in two steps. First, we calibrate a subset of parameters to match documented features of the regulatory environment in Mexico. Second, we estimate the remaining parameters by targeting moments from the 2013 Mexican Economic Census.

We compare non-targeted data moments to those generated from the model as a validation exercise.

4.1 Calibration and Targeted Moments

We make the following distributional assumptions: ν_i is drawn from a Pareto distribution with scale ν_0 and shape ξ, and the idiosyncratic distortions are normally distributed such that $ln(1+\tau_i^I) \sim N\left(0, \sigma_I^2\right)$ and $ln(1+\tau_i^F) \sim N\left(0, \sigma_F^2\right)$. We assume that the signal firms receive about their productivity is perfectly informative. This implies that uncertainty about post-entry profitability is the result of uncertainty about the idiosyncratic distortion the firm will face.[25]

We calibrate five parameters in the first step of the quantification:

$$\{\tau_w, \delta^F, \gamma^F, \gamma^I, \nu_0\}$$

We set the regulatory labor wedge (τ_w) to 0.348. We calculate this using the approach from Levy (2018) as the sum of the estimated net tax from contributory programs (0.12), net payroll tax on salaried employment from (0.01), benefits from non-contributory programs (0.162) and the net tax from evasion of income taxes (0.056). We choose δ^F to match the exit rate of formal firms in the Mexican Census data between 2008 and 2013. We set γ^F such that overhead costs for formal firms are equal to half the monthly wage following Ulyssea (2018). We set γ^I such that overhead costs in the informal sector are half as large as those in the formal sector. We set the Pareto scale parameter ν_0 so that the size of a firm in the informal sector with no distortion and $\theta = \nu_0$ is equal to 1.

We estimate 9 parameters in the second step of the quantification:

$$\{b^F, b^I, \delta^I, \gamma^I, E^F, E^I, \alpha, \sigma_I, \sigma_F\}$$

Given a wage w, these parameters are sufficient to completely describe firm behavior and solve for aggregate output. We choose 10 data moments from the Mexican Census data to target with these 9 parameters. These moments are informative about the extensive and intensive margins of informality, the size distributions of formal and informal firms, and the distributions of revenue pro-

[25] Unlike Ulyssea (2018), we do not include a productivity shock after a decision on the informality status of the firm is taken. As described below, we are able to match firm size and productivity distributions without this additional productivity dispersion shock. We relax this assumption when assessing the role of idiosyncratic distortions in our model.

Table 4: Model Fit

	Data	Model
Share of informal workers	57%	57%
Extensive informality margin		
Share of informal firms	89%	89%
Share of informal firms among firms with 6-50 workers	44%	44%
Intensive informality margin		
Informal workers within formal firms of size 1-5	19%	19%
Size distribution of informal firms		
Informal firms with ≤ 5 workers	96%	96%
Size distribution of formal firms		
Formal firms with $\leq$20 workers	86%	89%
Formal firms with 20-50 workers	8.0%	8.1%
Productivity distribution		
Average ln(TFPR) gap between informal and formal firms	0.08	0.08
Standard deviation of ln(TFPR) for informal firms	0.58	0.58
Standard deviation of ln(TFPR) for formal firms	0.58	0.56

Notes: All data moments are from the 2013 Mexican Census. Standard deviation of ln(TFPR) for informal and formal firms constructed after residualizing on municipality, industry and year fixed effects.

ductivity[26] for informal and formal firms. Our estimator minimizes the sum of the absolute log-difference between the model and data moments. The targeted moments are reported in Table 4 and the estimated parameters are shown in Table 5.

4.2 Identification

The parameters are jointly identified by all the moments, but the moments differ in their sensitivity to the nine parameters. We now provide intuition for the identification of the model parameters by showing how changing each parameter around its estimated value changes a subset of key moments.

We first consider the four parameters whose identification relies on formal

[26] We use the standard deviation of TFPR, conditional on sector controls, as our productivity dispersion measure. This is done to account for capital intensity differences.

Table 5: Parameter Estimates

Parameter	Description	Value
Calibrated Parameters		
τ_w	Regulatory tax wedge in formal sector	0.35
δ^F	Exit rate in formal sector	0.08
γ^F	Overhead costs in the formal sector	0.45
γ^I	Overhead costs in the formal sector	0.23
ν_0	Location parameter of Pareto distribution	1,577
Estimated Parameters		
b^F	Cost parameter of informal workers for formal firms	2.19
b^I	Cost parameter of informal workers for informal firms	12.20
δ^I	Exit rate for informal firms	0.13
ξ	Shape parameter of Pareto distribution	2.74
E^F	Entry costs in formal sector	35,111
E^I	Entry costs in informal sector	10,930
α	Decreasing returns to scale	0.38
σ_I	Post-entry distortion shock in informal sector	0.78
σ_F	Post-entry distortion shock in formal sector	0.60

Notes: Parameter estimates for the model described in Section 3 using the two-step estimation approach described in Section 4.

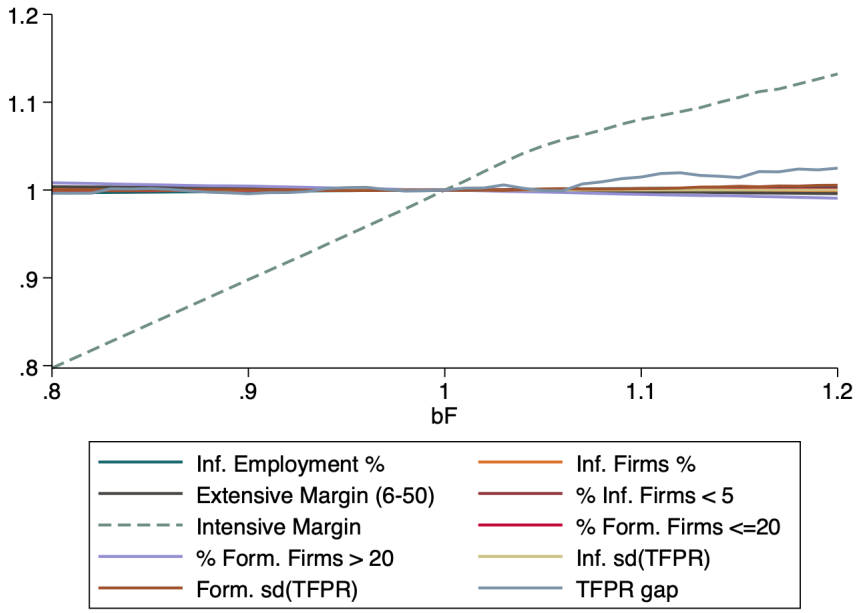
firm moments: b^F, σ_F, E^F and α.

b^F governs the cost of hiring informal workers in formal firms. A higher b^F raises the employment threshold where firms switch from hiring informal workers to formal workers ($\tilde{l} = \frac{\tau^w}{2} b^F$). b^F is therefore identified by the intensive margin of informality. Accordingly, Figure 5 shows that changing b^F has large impacts on the share of informal workers within formal firms, but very little impact on any of the other moments.

σ_F governs the dispersion in idiosyncratic distortions in the formal sector. Figure 6 (a) shows that a higher σ_F decreases the informal employment share, increases the large formal firm share and increases TFPR dispersion. A higher dispersion of distortions increases the likelihood that firms become very large. The effect is asymmetric on firm profits because firms that receive large implicit taxes can exit. A higher dispersion of distortions therefore induces more entry into the formal sector. Crucially, σ_F is identified by the standard deviation of log(TFPR), as it is the only parameter which meaningfully changes TFPR dispersion (recall that for formal firms hiring formal workers, τ_i^F is the only source of TFPR dispersion).

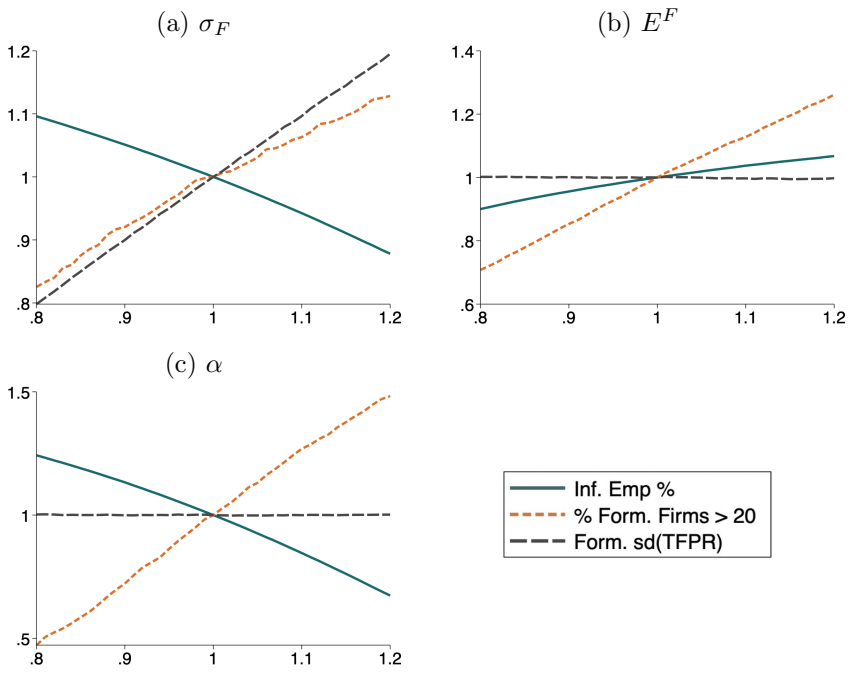
Formal sector entry costs E^F and the returns to scale α are particularly important in determining the size distribution of formal firms, and so we consider their identification together. As α approaches one, the market share of the most productive firm in the economy tends to one (because firms produce a homogeneous good). Correspondingly, Figure 6 (c) shows that a higher α increases the share of formal firms with more than 20 employees. Similarly, higher formal entry costs E^F increase the productivity threshold for entering the formal sector, thereby increasing the proportion of high productivity firms in the formal sector and the share of formal firms with more than 20 employees (Figure 6 (b)). However, these parameters can be separately identified from their opposite impact on the informal employment share. Increasing α makes being in the formal sector more profitable, induces entry and increases the size of formal firms, thereby shrinking the size of the informal sector and the informal employment share. However, raising E^F reduces the expected profitability of entering the formal sector net of entry costs , and therefore *increases* the informal employment share.

Figure 5: Identification of b^F



Notes: The figure shows the proportionate change in all model moments against the change in b^F from its estimated value, holding all other parameters at their estimated values. For both the moments and parameters, a value of 1 corresponds to no change.

Figure 6: Identification of σ_F, E^F and α



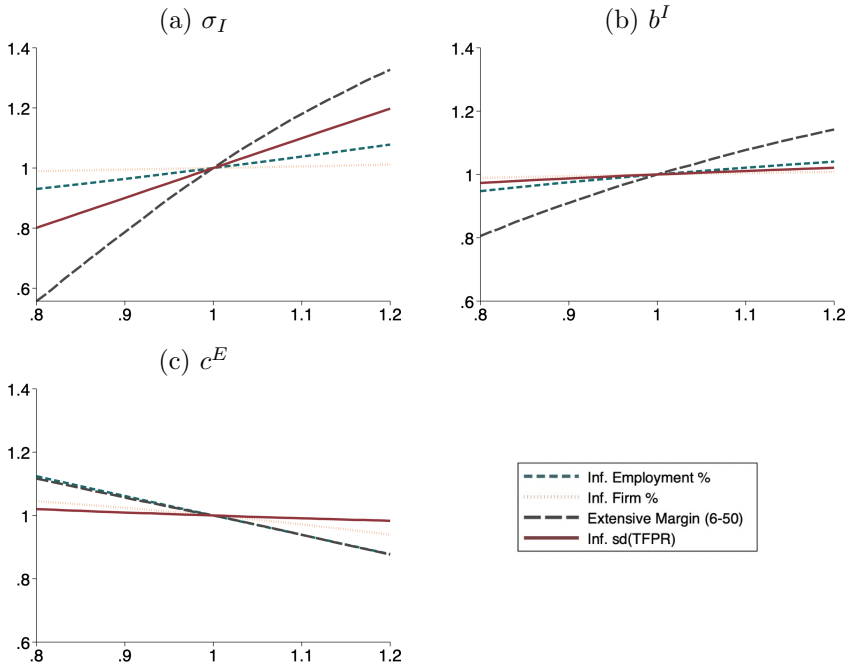
Notes: The figures show the proportionate change in the informal employment share, the share of formal firms with more than 20 employees, and the standard deviation of log(TFPR) in the formal sector, against the change in one parameter from its estimated value, holding all other parameters at their estimated values. For both the moments and parameters, a value of 1 corresponds to no change.

We next consider the identification of the key frictions affecting informal firms: σ_I, b^I and E^I. σ_I determines the dispersion in idiosyncratic distortions in the informal sector, and therefore is primarily identified by the standard deviation of log(TFPR) in the informal sector. Figure 7 and Appendix Figure A3 confirm that the only parameter that TFPR dispersion is very sensitive to is indeed σ_I. Figure 7 (a) shows that increases in σ_I also increase the informal employment share and the share of informal firms with 6-50 workers. This follows because firms are insured against downside risks by having the possibility of exiting after observing their distortion, while firms that receive large implicit subsidies grow to become large.

A higher b^I implies a lower regulatory cost of being a large informal firm and therefore increases the size of the right tail of the informal firm size distribution, and the extensive margin overlap among large (6-50 employee) firms. Figure 7 (b) shows that, while an increase in b^I slightly increases the informal employ-

ment share and the share of informal firms, the moment that is most sensitive to it is the share of informal firms with 6-50 workers. Conversely, reductions in entry costs matter relatively more for the left tail of the informal firm size distribution. Figure 7 (c) shows that, qualitatively, a reduction in informal sector entry costs has the same effects on the moments as b^I. However, the relative sensitivity of the moments to entry costs is very different. Reducing entry costs has the *same* proportionate impact on informal employment as on the extensive margin among firms with 6-50 workers, and has a greater impact on the overall share of informal firms.

Figure 7: IDENTIFICATION OF σ_I, b^I AND E^I



Notes: The figures show the proportionate change in the informal employment share, the informal firm share, the informal firm share among firms with 6-50 employees, and the standard deviation of log(TFPR) in the informal sector, against the change in one parameter from its estimated value, holding all other parameters at their estimated values. For both the moments and parameters, a value of 1 corresponds to no change.

Lastly, ξ is the shape parameter of the Pareto distribution. It jointly affects the size distribution of informal and formal firms — higher ξ makes the distribution have higher mass at the bottom of the productivity distribution, increasing the informal employment share while *decreasing* the share of formal firms with

more than 20 employees (Appendix Figure A4). This stands in contrast to, for example, b^I and c^E and δ^I, which move the informal employment share and share of large formal firms in the *same* direction. The exit rate of informal firms, δ^I, governs the overall profitability of being in the informal sector as opposed to the formal sector. Qualitatively, δ^I moves the informal employment share, large firm extensive margin and share of large formal firms in the same direction as b^I and c^E. Quantitatively however, decreasing δ^I has a very large impact shifting mid-sized formal firms into the informal sector. Accordingly, the share of informal firms among firms with 6-50 workers and the large formal firm share increase roughly in proportion, with a relatively smaller increase in the overall employment share. Appendix Figure A4 plots ξ, δ_I, b^I, c^E and σ_i against the moments most relevant for their identification.

4.3 Discussion of Estimates and Model Validation

We almost perfectly hit all the targeted moments in the estimation, despite the model being overidentified by one moment.[27] We also confirm in Appendix C.2 that the objective function is not flat around the estimated parameters, following Adda, Dustmann and Stevens (2017) and Ulyssea (2018).

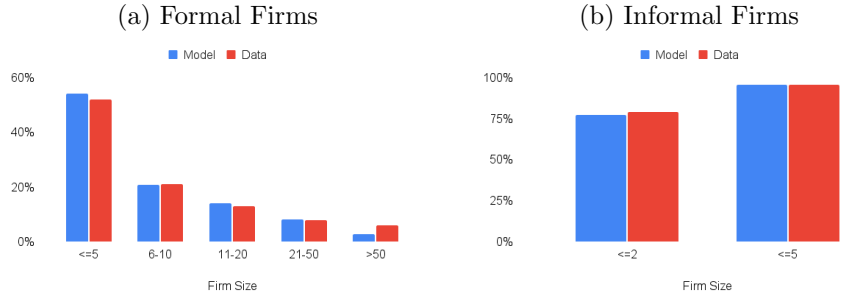
The estimated parameter values are broadly intuitive. We estimate an exit rate of informal firms of 13%, in contrast with the measured exit rate of 8% for formal firms. We estimate a much lower regulatory cost for hiring informal workers in the informal sector than in the informal sector, which follows from the high share of large informal firms we measure in the data. We estimate that entry costs are roughly three times as large in the formal sector as informal sector. Despite a similar measured dispersion of TFPR in the informal and formal sector, we estimate a higher dispersion of idiosyncratic distortions in the informal than formal sector. The reason for this is that the regulatory distortion b^I compresses TFPR dispersion in the informal sector, while this is only true in the formal sector for small formal firms below the threshold $\tilde{l}$. Lastly, we estimate a relative low degree of returns to scale. This follows from the relatively low share of formal firms with 21-50 workers — given our estimated productivity distribution and the large dispersion in idiosyncratic distortions, this must be explained by strong decreasing returns to scale.[28]

[27] The only two moments we miss are the share of formal firms with less than 20 workers and the dispersion of TFPR in the formal sector, which we miss by 3.5 and 3.6 percent respectively.

[28] We note that a low α in this model captures a combination of low returns to scale, strong span of control restrictions and a low elasticity of substitution across the products produced

Lastly, before using the model for counterfactual analysis, we validate by comparing the model to the data for some non-targeted moments. We focus in particular on non-targeted moments of the size distribution of formal firms, and the extensive margin of informality along the size distribution. Figure 8 (a) shows that the overall formal firm size distribution generated from the model lines up well with the data, with a slight underestimation of the share of formal firms with more than 50 workers. Similarly, Figure 8 (b) shows that the non-targeted share of informal firms with fewer than 2 employees lines up extremely closely with the data. In summary, while the model does not perfectly fit all non-targeted moments, it is generally in line with the data.

Figure 8: Targeted and Non-Targeted Moments of Firm Size



Notes: The figures shows model moments and their data counterparts of the formal and informal size distributions. The share of formal firms with 21-50 workers and the share of informal firms with less than 5 workers were targeted as part of the estimation, but all other reported moments were not targeted.

5 Counterfactual Policy Experiments

We first use the estimated model to conduct a broad set of counterfactual policy experiments starting from the 2013 calibration of the model to quantify the effects of changes in regulatory labor costs, entry costs and distortions on aggregate TFP and informality. We then re-estimate the model without idiosyncratic distortions and compare this to our baseline specification. We highlight how capturing the dispersion in marginal revenue products in the data can have large quantitative implications. Finally, we re-calibrate the model to the Mexican data for 1998 and evaluate the impact of changes over time in each of the inferred frictions on aggregate output.

by firms.

5.1 Counterfactual Reform Analysis

Reducing the cost of formal contracts

Levy (2018) estimates that the incentive gap between formal and informal contracts is around 12pp, largely due to reforms to contributory and non-contributory programs since 1998. We therefore simulate a reduction in τ_w from 35 to 23 percent. The main results are presented in Table 6, while Table A4 additionally shows how the full set of moments change for each counterfactual.

We find that reducing the formal sector regulatory wedge reduces the informal share of employment but results in almost no change in output. The informal employment share falls from 57 to 51 percent while the share of informal output falls from 56 to 52 percent. The decline in informal employment is driven both by a decline in the extensive margin and intensive margin of informality, with the intensive margin declining from 19% to 13%. The share of informal firms falls from 89 percent to 86 percent. The policy induces some large informal firms to formalize — the share of informal firms among firms with 6 to 50 employees falls moderately from 44 percent to 37 percent. The lack of impact on aggregate productivity in the model counterfactual results from the fact that the labor wedge does not lead to large systematic reductions in misallocation, either across or within sectors. In particular, given the overall small measured ln(TFPR) gap between informal and formal firms of 0.08, shifting marginally productive entrepreneurs from the informal to formal sector has limited productivity effects.

In addition to estimating aggregate effects, Table A3 in Appendix C.3 shows how the reduction in τ_w heterogeneously affects firms across the productivity distribution. Firm value increases for *formal* firms due to the direct reduction in costs, but decreases for *informal* firms due to wage increases in general equilibrium. Similarly, all but the most productive switchers (firms that switch from the informal to the formal sector) see reductions in value due to the general equilibrium increase in the wage. The least productive informal firms are most negatively affected.

Reducing formal sector entry costs

It is commonly argued that the removal of barriers to entry and red tape could generate substantial entry into the formal sector and hence productivity gains. We therefore consider the effects of a large reduction of formal sector entry costs, from three times to twice the level in the informal sector.

We estimate that this reduction in entry costs increases aggregate productivity by 3 percent. This is accompanied by a reduction in the share of informal firms from 89 to 72 percent, in the share of informal employment of 12 percentage points, and in the share of informal firms among firms with 6 to 50 employees from 44 percent to 25 percent. The gains come largely from an overall increase in the mass of operating firms, especially in the formal sector where there are no size dependent frictions above the threshold $\tilde{l}$. This contrasts with the effects of reducing the formal labor wedge, which acts primarily on the intensive margin of informality. We also consider equalizing entry costs in the formal sector with those in the informal sector and find correspondingly larger impacts. All firms choose to be formal in this scenario. We find a significant impact on aggregate productivity of 15 percent, with a reduction in the informal employment share of 39 percentage points to reach a level of 18 percent, operating entirely at the intensive margin. Notably, the intensive margin of informality for firms with 1-5 employees increases from 19 to 24 percent, due to the fact that the share of small formal firms increases, with these firms hiring a large number of informal workers.

Table A3 shows that firm value increases substantially for formal firms. This is particularly the case for low productivity formal firms where entry costs are a larger share of total firm value. Similarly to reductions in τ_w, firm value declines for firms that stay informal or switch from informality to formality, apart from the most productive switchers.

Increasing enforcement on the extensive margin of informality

In our third set of counterfactuals, we consider an increase in enforcement of the extensive margin of informality, due for instance to increased government auditing or monitoring. We consider an increase in enforcement in the informal sector such that it is equal to enforcement in the formal sector (we set $b_I = b_F$).

Table 6 shows that the reform leads to a substantial decline in the share of informal firms, from 89 percent to 76 percent, and in the informal share of aggregate employment, from 57 percent to 29 percent. The larger impact on employment results from the fact that enforcement disproportionately affects large informal firms. In our calibration, operating large informal firms becomes virtually prohibitive and the share of firms with 6-50 workers that are informal collapses from 44 percent to 1 percent (Table A4). Despite these large changes in informality, the productivity gains from the experiment are negligible due to offsetting impacts on aggregate output. On the one hand, enforcement in the

informal sector reduces informal sector TFPR dispersion by almost a quarter, given that large informal firms tend to have high implicit subsidies (this channel would not be present in a model without idiosyncratic distortions). This increases informal sector productivity substantially, which can be seen from the fact that employment in the informal sector falls by roughly half while output declines by only a third. On the other hand, average marginal revenue products of informal firms also rise.[29] For example, an informal firm with no idiosyncratic distortion will shrink relative to its socially optimal size due to the increased enforcement. In our calibration, the increase in informal sector enforcement raises marginal revenue products of informal firms so much that the TFPR gap between the sectors switches from being small and positive (0.08) to negative (-0.27) (Table A4), resulting in a worsening of cross-sector misallocation. On aggregate these positive and negative forces almost exactly wash out.

Reducing dispersion in informal sector wedges

In the final counterfactual, we reduce dispersion of wedges in the informal sector to the level observed in the formal sector: $\sigma_I = \sigma_F$.[30] There are many potential policies which could have such effects, at least qualitatively. For example, infrastructure or information technology improvements could reduce information frictions which contribute to price and markup dispersion (Allen, 2014). Alternatively, conducting audits could reduce corruption which disproportionately benefits some firms (Colonnelli and Prem, 2022).

Table 6 shows that, as expected, this reform reduces TFPR dispersion in the informal sector by almost a quarter. The overall shares of informal employment and output modestly decrease by 4 and 2 percent, respectively. The main effect, however, is increasing within-informal sector productivity. The within-sector reallocation is largely driven by the fact that the number of large informal firms shrinks dramatically, from 44% to 22% for firms with 6-50 workers. Aggregate productivity correspondingly increases by 2 percent.

5.2 The role of idiosyncratic distortions

The new feature in the model relative to Ulyssea (2018) is that we allow for dispersion in idiosyncratic distortions which we match to data on TFPR dispersion. How does capturing this dispersion in idiosyncratic distortions affect our

[29] This can be clearly seen in how a reduction in b^I affects $MRP_i^I = \frac{1}{\alpha}(1+\tau_i^I)(1+2\frac{l_i}{b^I}w$.

[30] Recall that, despite similar overall levels of observed TFPR dispersion, we infer greater dispersion in idiosyncratic distortions in the informal sector than formal sector (Section 4).

Table 6: Aggregate effects from policy experiments

	Baseline	No contributory programs	Reduction in entry costs	Equalization of entry costs	Equalization of enforcement	Reduced dispersion in inf. wedges
Aggregate TFP	1.00	1.00	1.03	1.15	1.00	1.02
Inf. Share of Employment	0.57	0.51	0.45	0.18	0.29	0.53
Inf. Share of Output	0.56	0.52	0.40	0.00	0.37	0.54
sd(ln(TFPR))	0.58	0.58	0.59	0.60	0.58	0.52
sd(ln(TFPR)) in Inf. Sector	0.57	0.57	0.58	0.00	0.45	0.45
sd(ln(TFPR)) in For. Sector	0.60	0.60	0.60	0.60	0.60	0.60

Notes: This table reports the effects of our counterfactual reforms on six different macro variables. The first column reports results for the baseline calibration. The second column reports results for a counterfactual in which τ_w is reduced by 12 pp, corresponding to the importance of contributory programs. The third column reduces formal sector entry costs to twice the level of informal entry costs. The fourth column reduces formal sector entry costs to the same level as informal sector entry costs. The fifth column equalizes the enforcement parameter in the informal sector to that of the formal sector. The last column reduces the standard deviation of distortions in the informal sector to the same level as in the formal sector.

quantitative analysis of the drivers of informality and TFP in Mexico?

To answer this question, we reevaluate the aggregate TFP gains resulting from some of the previous counterfactual reforms after re-estimating the model in the absence of idiosyncratic distortions. In order to ensure that the model can still replicate the overlap in the informal and formal size distributions, we assume that the signal firms receive about productivity before entry is not perfectly informative. Instead, productivity is the product of the noisy signal and an unknown ex-ante productivity component ε_i: $\theta_i = \nu_i \cdot \varepsilon_i$ where $\varepsilon_i \sim N(0, \sigma^2)$. In order to ensure that the model estimates are broadly comparable to those from our main estimation, we fix the Pareto scale parameter ξ to its previously estimated value (2.74). We drop TFPR dispersion in the informal and formal sectors as targets, but otherwise target the same eight moments with seven parameters. We report the main moments from both our baseline calibration and the new calibration without distortions in Table A5, and the estimated parameters in Table A6. The model without distortions closely matches the targeted moments.

We report results comparing the aggregate TFP gains from two counterfactual reform scenarios in both the baseline model and model without distortions in Table 7. In the first row, we evaluate the impact of removing contributory programs, thus reducing the formal sector labor market wedge. We find that the aggregate TFP gains are near-zero in both cases. This follows from the fact that, in both models, the formal labor market wedge mostly affects the intensive margin of informality, but has much lesser impacts on the extensive margin and aggregate productivity. In contrast, we find strikingly different results between both models when we consider the effects of an increase in enforcement in the informal sector.[31] We find near-zero impacts on aggregate productivity in the baseline model, but 5 percent aggregate productivity *losses* in the model without distortions. This is due to the difference in how the two models explain the prevalence of large informal firms. In the model without distortions, large informal firms are large because they are very productive. An increase in enforcement therefore increases the size-dependent friction in the informal sector, dramatically *increasing* within-sector misallocation. Indeed, we find that TFPR dispersion in the informal sector increases from 0.31 to 0.39 and overall disper-

[31] In both cases we consider a counterfactual where we change b^I to the same level as b^F. The model estimates of b^F and b^I in the model without distortions are very similar to those in the baseline model (2.2 vs. 2.2 and 10.9 vs. 12.2), making a comparison of the counterfactual results meaningful. We do not compare the results from reductions in entry costs because the estimated entry costs are very different across the two models.

Table 7: Aggregate TFP: Baseline vs. Without Distortions

	Baseline	Without Distortions
No contributory programs	1.00	1.00
Increase in informality enforcement	1.00	0.95

Notes: This table reports the aggregate TFP in the counterfactual scenario considered relative to baseline (1 = no change) for two counterfactual experiments: a 12 percentage point reduction in the formal sector labor wedge (τ_w), and an increase in informality enforcement in the informal sector such that $b^I = b^F$. We show results both from the baseline model described in Section 3, to those from the model estimated without idiosyncratic distortions.

sion increases from 0.26 to 0.40. In contrast, and as discussed previously, an increase in enforcement in the baseline model compresses the size distribution of informal firms while also *reducing* within-sector misallocation.

Overall, these results show that incorporating idiosyncratic distortions into the Ulyssea (2018) model has quantitatively important implications for the aggregate productivity impact of key policy-relevant counterfactuals.

5.3 Changes in Informality from 1998 to 2013

In this section, we recalibrate our model to match moments from 1998 on informality in Mexico. We thereby identify which parameters drove the changes in informality over time, and the extent to which they can account for Mexico's aggregate productivity decline.

We fix the structural parameters ξ, α and δ^I to their estimated values for 2013 and calibrate $\tau_w = 0.23$. We then use our SMM estimator to estimate the frictions governing informality (b^F, b^I), entry costs (E^I, E^F), and idiosyncratic distortions (σ_F, σ_I). Given that we have three fewer parameters to estimate, we also remove three targeted moments. ξ, α and δ^I are primarily identified by the size distribution of informal and formal firms (Section 4.2). We therefore drop the corresponding three size distribution moments as targets. We hit the targeted moments from the 1998 data almost perfectly (Table A7).

Table 8 compares the estimated parameters for 1998 and 2013. The identification of the parameters is the same as described in Section 4.2. We estimate that b^F was higher in 1998 than 2013 because of the slightly higher intensive

Table 8: 1998 vs. 2013 Parameter Estimates

Parameter	1998	2013
Calibrated Parameters		
τ_w	0.23	0.35
Estimated Parameters		
b^F	3.30	2.19
b^I	7.20	12.20
E^F	28,291	35,111
E^I	9,388	10,930
σ_I	0.83	0.78
σ_F	0.69	0.60

Notes: Parameter estimates for the model described in Section 3 using the two-step estimation approach described in Section 4. Comparison of estimates from estimation on 1998 and 2013 Mexico data moments.

margin of informality (22% vs. 19%). However, we estimate a considerably lower value of b^I (stricter enforcement on the informal sector) in 1998. This is primarily identified from the lower extensive margin of informality among firms with 6-50 workers. Notably, we estimate a higher dispersion of idiosyncratic distortions in 1998 than 2013 both for the informal and formal sector. For the formal sector, this follows from the greater TFPR dispersion in 1998. In contrast, informal sector TFPR dispersion was similar in 1998 and 2013. The reason we estimate a higher value of σ^I in 1998 is the lower estimate of b^I – lower values of b^I reduce TFPR dispersion for a given σ^I and we therefore estimate a higher value of σ^I in order to obtain the same level of TFPR dispersion. Finally, in order to match the aggregate informal firm and employment shares, we estimate that entry costs in both the informal and formal sectors rose between 1998 and 2013, but slightly more in the formal sector (a 24% vs. 16% increase).

In Table 9, we use our estimated model to quantify the impact of these changes on aggregate productivity and the informal employment share. The first row shows that, had the formal sector labor wedge, entry costs, informality enforcement and the dispersion of idiosyncratic distortions all remained at their 1998 levels, aggregate TFP in Mexico would have been 0.9 percent higher in 2013 and the informal employment share 16 percentage points lower. While economically significant, the 0.9 percent higher TFP does not come close to explaining the 13 percent decline in aggregate TFP during this period.

The next rows of Table 9 decompose these net effects into the relative contributions of labor market regulations (non-contributory programs), informality enforcement, entry costs and dispersion of distortions. We implement this by starting from the 2013 estimated parameters, and then changing subsets of parameters one by one while keeping the others fixed. The second row of Table 9 shows that the increase in the labor market wedge due to non-contributory programs has only a very small, albeit positive, impact on TFP due to it leading to a small decrease in TFPR dispersion. More importantly, the change in labor market wedge resulted in a large increase in the informal employment share of 6 pp. The third row of Table 9 shows that if informality enforcement (b^F, b^I) had remained at its 1998 levels, aggregate TFP would have been 1.2 percent higher in 2013 and the informal employment share would however have been 7 percentage points lower. If informal and formal sector entry costs had not risen and instead remained at their 1998 levels, aggregate TFP would have been 4.4 percent higher in 2013, but the informal employment share would have been 1 percentage point *higher*. Rising entry costs and declining enforcement of large informal firms can therefore explain almost half of the overall decline in TFP from 1998 to 2013. Offsetting these TFP losses however, we find that the reduction in the dispersion of idiosyncratic distortions from 1998 to 2013 improved aggregate productivity by 3.9 percent. This reduction in the dispersion of distortions also contributed to increasing the informal employment share by 3 percentage points.[32]

Our findings point to various mechanisms which may have both contributed to the decline in aggregate TFP in Mexico, and also helped offset it. Notably, we find that the factors most important in explaining the decline in aggregate productivity were not important drivers of the increase in informality, and conversely, the factors most important in explaining the increase in informality had little impact on aggregate productivity. Many of these may be affected by government policy. In particular, changes to the way informal firms are treated by the government, and rising costs of creating new firms, can have significant impacts on both aggregate productivity and informality.

[32] We note that the model features strong non-linearities and interactions, and so the changes in aggregate TFP and informal employment from changing each parameter individually do not add up to the changes resulting from changing all parameters jointly.

Table 9: Aggregate TFP Impacts of Changes in Frictions over Time

Counterfactual	Change in TFP	Change in Informality
All frictions	-0.9%	+16pp
Labor market regulations only	+0.4%	+6pp
Informality enforcement only	-1.2%	+7pp
Entry costs only	-4.4%	-1pp
Dispersion of distortions only	+3.9%	+3pp

Notes: This table reports the aggregate TFP in the counterfactual scenario considered relative to baseline (1 = no change), as well as the change in the informal employment share in percentage points. We consider four counterfactuals; a change in labor market regulations, enforcement, entry costs and the dispersion of idiosyncratic distortions to their 1998 levels (first row), and each friction individually in the following rows.

6 Conclusion

As in other developing economies, Mexican firms operate in an environment where regulatory requirements interact with idiosyncratic distortions as well as firm and worker characteristics to produce large informal markets. The large share of informal firms across firm-size categories and economic sectors, as well as the large share of employees who are employed in informal contractual relationships at formal firms, indicate that both the intensive and extensive margins of informality are quantitatively significant in Mexico.

The link between informality and aggregate productivity is ambiguous, however, as policy distortions can result in significant informal employment without necessarily generating sizeable losses in aggregate output. When looking at the Mexican experience from 1998 to 2013, we find that the most important drivers of informality increases during that period contributed only moderately to the aggregate productivity decline. Looking forward, the key challenge is identifying the most salient distortions inducing informality and how they misallocate resources across production units. In the case of Mexico, reducing the level of labor costs induced by payroll taxes and contributory social security systems could lead to large growth in formal employment while only having moderate effects on aggregate productivity. We find that reducing entry costs in the formal sector and increasing enforcement might lead to larger aggregate productivity

gains.

It is important to acknowledge that labor regulations and explicit and implicit taxes discussed in this paper fail to explain a large share of resource misallocation, as measured by dispersion in revenue productivity. In our framework, most misallocation is attributed to idiosyncratic distortions, whose exact nature and causes are left unidentified. This remains another crucial point for future study, as the analysis in this paper assumes that the policies studied do not change the distribution or magnitude of these idiosyncratic distortions. Future work should continue the search for the quantitatively most important distortions depressing aggregate productivity within both formal and informal sectors, pinpoint the fundamental mechanisms generating them, and shed light on the corresponding policies to address them.

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Appendix

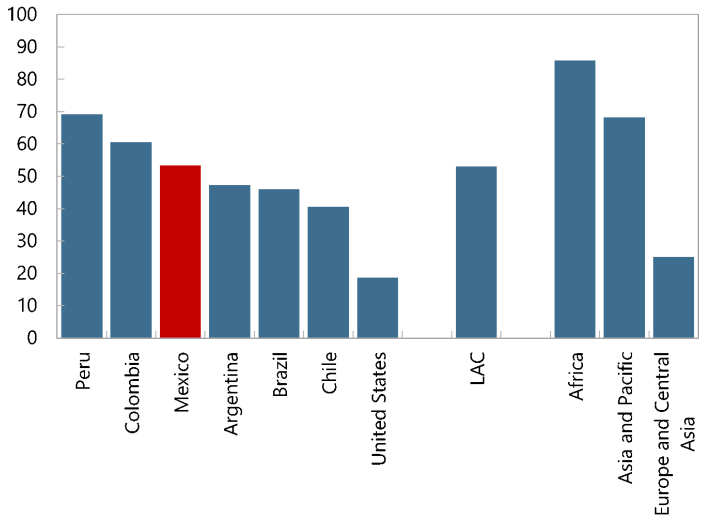
A Additional stylized facts on informality

This section presents additional statistics complementing the characterization of informality presented in the main text.

A.1 Cross-country informality comparisons

Figure A1 compares the levels of worker informality with other countries and regional averages using indicators compiled by the International Labour Organization (ILO). Mexico exhibits slightly higher informality levels than the Latin American and Caribbean average.[33]

Figure A1: Worker informality in Mexico vs other economies



Notes: ENOE employment survey and ILO 2018.

A.2 Extensive and intensive margins of informality by firm size, year, and sector

Table A1 shows additional statistics on the extensive and intensive margins of informality by year, sector and firm size. These are estimated using the

[33] Consistent cross-country comparisons of firm informality are not available.

Mexican Economic Census. Qualitative relationships between firm size and informality margins discussed in the paper hold across all waves of the Mexican Economic Census and broad sectors. First, the extensive and intensive margins of informality decline with firm size across all years as well as when looking at only manufacturing firms, only non-manufacturing firms, or all firms. The levels of both the extensive and intensive margins appear to be of similar orders of magnitude both in manufacturing and non-manufacturing firms—although there are moderate differences between sectors when looking at individual firm size bins. Importantly, the presence of medium and large informal firms is a feature of the data both when looking at manufacturing or non-manufacturing firms.

In terms of changes over time when looking at the entire 1998-2013 period, several patterns appears across sectors. First, there is an increase in the extensive margin of informality across firm sizes. Second, there are larger increases in the extensive margin of informality among larger firms—although with a more pronounced pattern among non-manufacturing firms. Third, there are moderate declines in intensive margins of informality among small firms, which were accompanied by moderate increases in the intensive margin of informality among larger firms. The cross-sectoral consistency relative to the large difference in levels and changes over time and across firm sizes motivate our focus on single sector drivers in the paper.

A.3 Dispersion in value added and TFPR measures

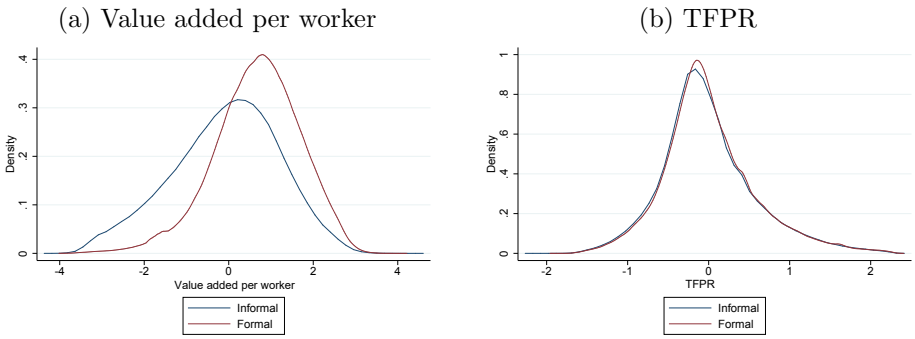
Figure A2 documents the dispersion in value added per worker and Revenue Total Factor Productivity (TFPR) within the formal and informal sectors. The dispersion shown in the figure is conditional on economic sector and municipality fixed effects. Although there is a mean gap between the formal and informal sectors, there is significant overlap in the formal and informal distributions.

Table A1: Extensive and intensive margins of informality, by firm size

	1998		2003		2008		2013		Change 1998-2013	
Firm size	Ext.	Int.	Ext.	Int.	Ext.	Int.	Ext.	Int.	Ext.	Int.
All sectors										
0-2	0.94	0.21	0.97	0.21	0.98	0.22	0.97	0.16	0.03	-0.05
3-5	0.63	0.23	0.78	0.28	0.85	0.28	0.81	0.21	0.17	-0.01
6-50	0.21	0.10	0.38	0.15	0.49	0.15	0.44	0.11	0.24	0.01
51-100	0.09	0.04	0.19	0.06	0.29	0.07	0.31	0.08	0.23	0.04
101-500	0.06	0.03	0.15	0.05	0.25	0.07	0.30	0.08	0.25	0.06
Manufacturing										
0-2	0.94	0.21	0.97	0.22	0.98	0.26	0.98	0.18	0.04	-0.03
3-5	0.71	0.24	0.81	0.30	0.87	0.32	0.85	0.25	0.14	0.01
6-50	0.24	0.09	0.38	0.14	0.52	0.17	0.45	0.11	0.22	0.02
51-100	0.03	0.03	0.09	0.04	0.14	0.04	0.15	0.05	0.13	0.02
101-500	0.02	0.02	0.10	0.03	0.16	0.05	0.18	0.06	0.16	0.04
Non-manuf.										
0-2	0.94	0.21	0.97	0.21	0.98	0.22	0.97	0.16	0.03	-0.05
3-5	0.62	0.22	0.77	0.27	0.85	0.28	0.80	0.21	0.18	-0.02
6-50	0.20	0.10	0.37	0.15	0.49	0.15	0.44	0.11	0.25	0.01
51-100	0.12	0.05	0.22	0.07	0.33	0.08	0.36	0.09	0.24	0.05
101-500	0.09	0.04	0.18	0.07	0.29	0.08	0.36	0.10	0.27	0.06

Notes: Extensive margin refers to the share of total firms reporting social security contributions (formal). Intensive margin of informality refers to the average share of non-salaried workers at formal firms. Firm size reported as employee ranges.
Data from Mexican Economic Census.

Figure A2: Productivity dispersion of formal vs informal firms



Notes: Data from 2013 Mexican Economic Census. Dispersion of value added per worker and Revenue Total Factor Productivity (TFPR) conditional on sector and municipality controls.

A.4 Moments under alternative informality definitions

The main section of the paper focuses on a definition of firm informality that is based on whether a firm makes any contributions to social security. Our definition is consistent with that of Levy (2018) in its study of Mexican informality, but differs from other definitions that either include firm size explicitly or determine firm formality based on business or tax registration (as in Ulyssea (2018)). Levy (2018) argues that a definition based on social security is the most relevant definition when studying informality and productivity in Mexico since (i) formal firms making social security contributions are presumably registered; (ii) benefits and worker protections (including dismissal protections) are defined based on salaried workers vs non-salaried workers according of Mexico's constitution (and not based on tax registration); and (iii) a registered firm can evade all costs of providing formal employment contracts. Informality is not necessarily illegal[34] under this definition, implying that not all firms classified as informal are necessarily excluded from formal credit access, government procurement or export-import capabilities.

As there is no clear identifier for a "registered" firm in the Mexican Economic Census, it is not possible to generate alternative moments of the data that are directly comparable with studies from other countries that use tax registration. It is possible, however, to construct an imperfect measure of registration based

[34]Levy (2018) discusses the interaction between this definition and legality.

on self-reporting status on whether the firm has its assets owned by an entity that is different from the business owner. This has been used by Levy (2018) to construct an imperfect measure of incorporation. As a robustness exercise, we can define a formal firm as one that self-reports being 'incorporated'. The definition of an informal worker is left unchanged.

Table A2 shows the comparison of informality levels and firm size distributions under this alternative definition relative to the baseline definition used in the paper. The share of firms that are informal is slightly higher (91 vs 89 percent), while the share of of workers that are classified as informal is left unchanged (by definition). The firm size distribution of formal firms is qualitatively the same, with the share of smallest formal firms being moderately lower (42 vs 52 percent). Regarding the distribution of informal firms, most firms remain small with firms under 5 workers accounting for around 96 percent of firms under both definitions. The share of medium-sized firms with 6-10 workers are also broadly similar accounting for around 4 percent of total informal firms. Importantly, the extensive margin of informality in firms with 6 to 50 workers (a key moment we target) is very similar under both definitions at around 45 percent.

Given the imperfection of the incorporation metric (e.g. there is a large share of small firms that are not incorporated but make social security payments nonetheless), as well as the importance of the social security system in determining intensive and extensive informality margin decisions, we focus on a social-security-based definition in the paper. The observation that firm size distributions seem largely unchanged, even under the imperfect 'incoproration' metric, suggests that the results from the analysis and model simulations are not qualitatively sensitive to an alternative definition.

Table A2: Moments of informality under alternative definitions of firm informality

	Baseline definition	Definition based on self-reported incorporation
Share of informal workers out of total workers	56.50	56.50
Share of informal firms out of total firms	89.32	91.46
Firm size distribution of formal firms		
1–5 workers	52.18	42.00
6-50 workers	41.81	49.42
All	100.00	100.00
Firm size distribution of informal firms		
1–5 workers	95.70	96.21
6-50 workers	3.99	3.77
All	100.00	100.00
Extensive margin of informality		
1–5 workers	93.88	96.08
6-50 workers	44.39	44.96
All	89.32	91.46

Notes: All moments are calculated based on the 2013 Mexican Economic Census. Shares shown in percentages. Extensive margin of informality refers to the unweighted share of firms that are informal under alternative definitions. Formality based on self-reported incorporation based on metric by Levy (2018).

B Additional model derivations

Informal firms Profit Maximization Problem. The informal firm's problem is simply to solve the profit maximization problem:

$$\pi_i^I = max_{l_i}\ \theta_i l_i^\alpha - (1+\tau_i^I)\left(1+\frac{l_i}{b^I}\right)wl_i - c_I$$

the first order condition yields that:

$$\alpha\theta_i l_i^{\alpha-1} = w(1+\tau_i^I)\left(1+2\frac{l_i}{b^I}\right)$$

and therefore:

$$\alpha\frac{y_i}{l_i} = w(1+\tau_i^I)\left(1+2\frac{l_i}{b^I}\right)$$

as reported in Section 3.4.

Formal Firms Profit Maximization Problem Formal firms face a regulatory distortion $\left(1+\frac{l_i}{b^F}\right)$ when hiring informal workers, and face a constant wedge tax τ^w when hiring formal workers. Because the distortion faced when hiring informal workers is convex, while the distortion faced when hiring formal workers is constant, it is clear that firms will only hire informal workers up to a certain threshold $\tilde{l}$ and only hire formal workers above that threshold. Solving for this threshold requires equating the marginal cost of hiring an informal worker with the marginal cost of hiring a formal worker:

$$w(1+\tau_i^F)\left(1+2\frac{l_i}{b^F}\right) = w(1+\tau_i^F)(1+\tau^w)$$

which implies that

$$\tilde{l} = \frac{\tau^w}{2}b_F$$

We therefore get the following profit maximization problem

$$\pi_i^F = max_{l_i}\ \theta_i l_i^\alpha - (1+\tau_i^F)r^F(l_i)wl_i - c_F$$

where

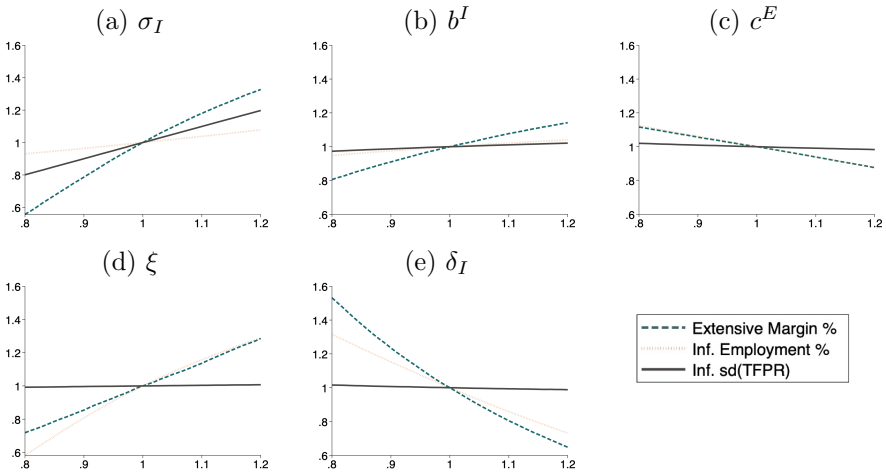
$$r^F(l_i) = \begin{cases} \left(1+\frac{l_i}{b^F}\right) & \text{if } l_i < \tilde{l} \\ \frac{\tilde{l}}{l_i}\left(1+\frac{\tilde{l}}{b^F}\right) + (1+\tau^w)\frac{(l_i-\tilde{l})}{l_i} & \text{if } l_i \geq \tilde{l} \end{cases}$$

and therefore the marginal product of labor for formal firms is either $MRP_i^F = \frac{1}{\alpha}(1+\tau_i^F)(1+2\frac{l_i}{b^F})w$ for firms that hire only informal workers and $MRP_i^F = \frac{1}{\alpha}(1+\tau_i^F)(1+\tau_w)w$ for firms that hire formal workers.

C Model Appendix

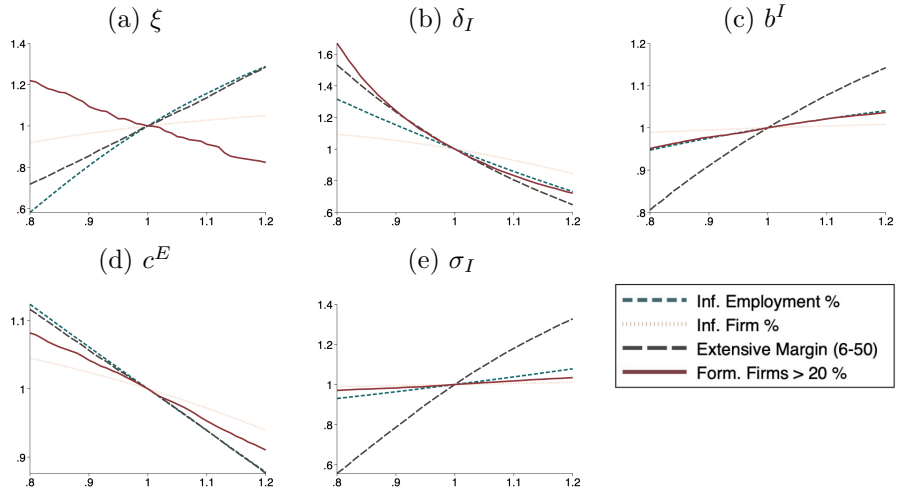
C.1 Identification Plots

Figure A3: Sensitivity of Productivity and Informality to Parameters



Notes: The figures show the proportionate change in the informal employment share, the informal firm share and the standard deviation of log(TFPR) in the informal sector, against the change in one parameter from its estimated value, holding all other parameters at their estimated values. For both the moments and parameters, a value of 1 corresponds to no change.

Figure A4: Identification of ξ, δ_I, b^I, c^E, σ_I



Notes: The figures show the proportionate change in the informal employment share, the informal firm share, the extensive margin of informality for fimrs with 6-50 workers, and the share of formal firms with more than 20 workers, against the change in one parameter from its estimated value, holding all other parameters at their estimated values. For both the moments and parameters, a value of 1 corresponds to no change.

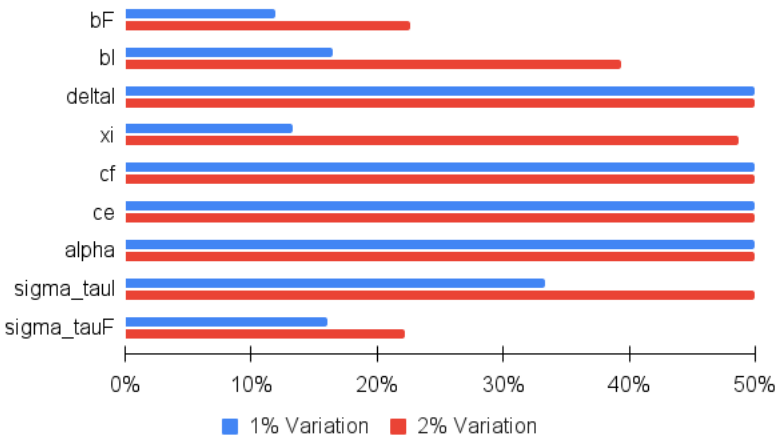
C.2 Sensitivity of Objective Function to Parameters

As an additional check that all the model parameters are identified, we follow Adda, Dustmann and Stevens (2017) and Ulyssea (2018) and estimate the sensitivity of the objective function to changes in the parameters around their estimated values. The concern is that, if the objective function is flat, the corresponding parameters will not be identified. Figure A5 shows that the objective function is indeed sensitive to all 9 parameters around their estimated values, mitigating this concern.

C.3 Heterogeneous Firm Effects

A useful way to provide insights into the mechanisms generating the aggregate productivity gains described in the previous subsections is to evaluate the heterogeneous effects by firm type of each policy. More specifically, we compute effects of removing the formal sector labor wedge and reducing the formal sector entry costs to twice the level of informal entry costs. A useful breakdown is into firms that were formal beforehand and remain formal after the reform (F-F), firms that were informal beforehand and remain informal after the reform (I-

Figure A5: Sensitivity of Objective Function



Notes: The figure shows the percentage change in the objective function for 1% and 2% changes in each parameter value, holding all other parameters at their estimated values. The horizontal axis is winsorized at 50% for readibility.

I), and finally firms that would have switched from being informal to formal (I-F).[35] The outcome we consider is the change in firm value net of entry costs:

$$\Delta V = log(V_c^S - E_c^S) - log(V_b^S - E_b^S)$$

where $S \in \{I, F\}$ and the subscript b denotes baseline and c denotes counterfactual. We calculate the change in value for each firm along the productivity grid, and then report the values for different percentiles of productivity in Table A3.[36] It is worth noting that in our model, in contrast to Ulyssea (2018), productivity does not map 1-1 into size, given that idiosyncratic distortions also play an important role in determining firm size. Nonetheless, for ease of exposition we

[35]This comparison is done by comparing the behavior of firms with the same productivity draws across the baseline and counterfactual steady states. We do not consider transition dynamics.

[36]The percentiles of productivity are calculated separately for the F-F, I-I, and I-F groups. A firm in the 5th percentile of productivity among F-F firms will therefore have a higher productivity than a firm in the 5th percentile of I-I firms in Table A3. In order to reduce the impact of outliers, we take the average across firms within 1% of the corresponding productivity percentile. For example, when calculating the change in value of firms at 5th percentile of productivity, we take the average of the change in value for firms between the 4th and 6th percentiles of productivity.

Table A3: Distribution of Reform Effects by Initial Firm Productivity Percentile

	Labor Market Wedge			Entry Costs		
	F-F	I-I	I-F	F-F	I-I	I-F
Percentile of Prod.						
5	4.3	-54.3	-82.6	24.2	-58.8	-72.2
25	4.0	-18.4	-60.2	18.2	-21.1	-26.4
50	3.8	-9.2	-35.2	11.5	-10.6	-39.9
75	3.5	-5.5	-15.0	5.4	-6.2	-7.9
95	3.3	-3.4	1.0	0.1	-3.7	9.9

Notes: This table plots the change in value for firms at different percentiles of the productivity distribution. The first three columns consider the change in value following a counterfactual in which the formal sector labor market wedge is set to 0. The rightmost columns consider the change in value following a counterfactual in which formal sector entry costs are reduced by two thirds. We take the average across firms within 1% of the corresponding productivity percentile. For example, when calculating the change in value of firms at 5th percentile of productivity, we take the average of the change in value for firms between the 4th and 6th percentiles of productivity. F-F corresponds to firms that were formal beforehand and remain formal after the reform, I-I corresponds to firms that were informal beforehand and remain informal after the reform, and I-F corresponds to firms that would have switched from being informal to formal.

plot these effects based on firms' productivity draws.

For reductions in the labor market wedge, we find that firm value increases for formal stayers, and decreases for informal stayers. This follows intuitively from the fact that formal firms see a decrease in their marginal costs. This increases labor demand and drives up the wage, which reduces the value of informal firms. Informal to formal switchers see decreases in firm value, with GE wage effects dominating other gains from changing sector. For the reductions in entry costs, we see that formal stayers tend to benefit, though mostly low productivity firms. This follows naturally from the fact that entry costs account for a larger share of their total value. In contrast, informal stayers tend to lose out, as the reduction in entry costs induces an increase in labor demand from the formal sector and drives up the wage. As with reductions in the labor market wedge, informal to formal switchers see decreases in value.

C.4 Additional Tables

This table reports the model moments from our baseline calibration, as well as for each of the counterfactuals described in Section 5. The second column reports results for a counterfactual in which τ_w is reduced by 12 pp, corresponding to the importance of contributory programs. The third column removes the labor wedge entirely. The fourth column reduces formal sector entry costs by two thirds. The fifth column reduces formal sector entry costs to the same level as informal sector entry costs. The last column reduces the standard deviation of distortions in the informal sector to the same level as in the formal sector. The model moments considered are the ones used to estimate the model, as described in Section 4 and shown in Table 4 for the baseline calibration.

Table A4: Model Moments Under Counterfactual Scenarios in Table 6

	Baseline	No contributory programs	Reduction in entry costs	Equalization of entry costs	Equalization of enforcement	Reduced dispersion in inf. wedges
Share of informal workers	0.58	0.51	0.45	0.18	0.29	0.53
Extensive informality margin						
Share of informal firms	0.89	0.86	0.72	0.00	0.76	0.87
Share of informal firms among firms with 6-50 workers	0.44	0.37	0.25	-	0.01	0.22
Intensive informality margin						
Informal workers within formal firms of size 1-5	0.20	0.13	0.24	0.33	0.21	0.19
Size distribution of informal firms						
Informal firms with ≤ 5 workers	0.96	0.96	0.97	-	1.00	0.98
Size distribution of formal firms						
Formal firms with $\leq$20 workers	0.89	0.90	0.95	0.99	0.91	0.90
Formal firms with 21-50 workers	0.08	0.08	0.04	0.01	0.07	0.08
Productivity distribution						
Average ln(TFPR) gap between informal and formal firms	0.09	0.01	0.11	-	-0.27	0.10
Standard deviation of ln(TFPR) for informal firms	0.58	0.59	0.59	-	0.46	0.45
Standard deviation of ln(TFPR) for formal firms	0.57	0.56	0.57	0.55	0.57	0.57

Table A5: Model Moments: Baseline vs. Without Distortions

	Baseline	No Distortions	Data
Share of informal workers	57%	56%	57%
Extensive informality margin			
Share of informal firms	89%	92%	89%
Share of informal firms among firms with 6-50 workers	44%	44%	44%
Intensive informality margin			
Informal workers within formal firms of size 1-5	19%	22%	19%
Size distribution of informal firms			
Informal firms with $\leq$ 5 workers	96%	97%	96%
Size distribution of formal firms			
Formal firms with $\leq$20 workers	89%	85%	86%
Formal firms with 20-50 workers	8.1%	10%	8.0%
Productivity distribution			
Average ln(TFPR) gap between informal and formal firms	0.08	0.08	0.08
Standard deviation of ln(TFPR) for informal firms	0.58	0.25	0.58
Standard deviation of ln(TFPR) for formal firms	0.56	0.12	0.58

Notes: Comparison of the targeted model moments for the baseline model described in Section 3 (with idiosyncratic distortions), to the model without idiosyncratic distortions described in Section 5.2. TFPR dispersion in the informal and formal sectors are not targeted moments for the model without distortions. All data moments are from the 2013 Mexican Census. Standard deviation of ln(TFPR) for informal and formal firms constructed after residualizing on municipality, industry and year fixed effects.

Table A6: Parameter Estimates for Model Without Distortions

Parameter	Description	Value
Calibrated Parameters		
τ_w	Regulatory tax wedge in formal sector	0.35
δ^F	Exit rate in formal sector	0.08
γ^F	Overhead costs in the formal sector	0.45
γ^I	Overhead costs in the formal sector	0.23
ν_0	Location parameter of Pareto distribution	1,577
ξ	Shape parameter of Pareto distribution	2.74
Estimated Parameters		
b^F	Cost parameter of informal workers for formal firms	2.15
b^I	Cost parameter of informal workers for informal firms	10.89
δ^I	Exit rate for informal firms	0.13
E^F	Entry costs in formal sector	90,374
E^I	Entry costs in informal sector	17,140
α	Decreasing returns to scale	0.38
σ	Post-entry productivity shock	0.81

Notes: Parameter estimates for the model without distortions described in Section 5.2 using the two-step estimation approach described in Section 4.

Table A7: Model Fit for 1998 Estimation

	Data	Model
Share of informal workers	43%	42%
Extensive informality margin		
Share of informal firms	82%	83%
Share of informal firms among firms with 6-50 workers	21%	21%
Intensive informality margin		
Informal workers within formal firms of size 1-5	22%	22%
Productivity distribution		
Average ln(TFPR) gap between informal and formal firms	-0.06	-0.06
Standard deviation of ln(TFPR) for informal firms	0.59	0.59
Standard deviation of ln(TFPR) for formal firms	0.65	0.65

Notes: All data moments are from the 1998 Mexican Census. Standard deviation of ln(TFPR) for informal and formal firms constructed after residualizing on municipality, industry and year fixed effects.