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RESEARCH ARTICLE

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# Informality, self-employment and heterogeneous managerial ability: A model for developing countries

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## Abstract

The view of informal employment as a last resort in the labour market has recently been challenged by numerous studies documenting the existence of a high degree of heterogeneity within the formal and informal sectors. In particular, informal self-employment/employment may be voluntary or forced. There is currently not much theoretical support for these observations. We develop a theoretical model of the labour market with both formal and informal firms and a distribution of managerial skills in the population. Consistent with existing empirical evidence, this setup reconciles the undesirable and productive forms of self-employment that coexist in the economy.

**KEYWORDS**
capital cost, informal sector, managerial ability, self-employment

**JEL CLASSIFICATION**
J31, O17

## 1 | INTRODUCTION

Many of the earlier empirical studies comparing wages across sectors suggest that informal sector workers, even if equally productive, are paid less than their formal sector counterparts. A number of explanations have been offered in this regard, mostly based on the view of a segmented labour market.[1] The reality is more complex and evidence is actually mixed (Perry et al., 2007), with possibly a coexistence of segmented and competitive labour markets in many regions where informal work is present (Fields, 2009).[2] Considering the wide range of evidence overall, it seems necessary that theoretical frameworks helping to understand labour market mechanisms embrace and rationalise this diversity of situations.

  

Against this background, we suggest a model that attempts to capture such heterogeneity using a framework with search frictions. A distribution of managerial ability is at the heart of the model and can generate different outcomes for self-employed workers with different abilities. In particular, differences in managerial talents allow us to explain the co-existence of self-employment as a last resort and voluntary self-employment. Search frictions mean that in a labour market with low unemployment benefits, self-employment may be the only option for workers with weak managerial skills seeking salaried employment. At the same time, workers with good management skills may prefer self-employment to certain job offers, and those with the highest abilities will prefer self-employment to any job offer. In equilibrium, we observe the coexistence of low-wage employees in the informal sector (less paid than equally skilled employees in the formal sector), own-account self-employed workers who would prefer any job offer than their current state, and a range of self-employed managers who may decide to be formal or informal depending on their managerial ability as reflected in their firm size.

The model builds on El Badaoui et al. (2010) (EB from now on), which considers only employees and combines search frictions in the labour market with heterogeneity in managerial abilities. The size of the firms, the distribution of wages, and the decision to operate as a formal firm (i.e. to pay taxes) follow from the manager type. We prove a number of propositions in a reasonably general framework, showing that there will be a hierarchy of firms with the following properties. Firms with high-ability managers pay higher wages and hire more workers, which makes them more likely to be inspected and, therefore, more likely to pay taxes. Low-tier managers run smaller firms and find it profitable to evade taxes and be informal. Self-employment will be the residual sector for workers with the lowest managerial skills: they prefer any job to self-employment but are constrained due to search frictions.

We believe our setting applies mainly to labour markets in developing countries. In particular, it accommodates the complexity of the self-employment we observe there. We also try to be transparent about the main limitation of our framework: the whole labour market allocation follows from an exogenous distribution of talent. Drawing from Burdett and Mortensen (1998), we also provide a more specific illustration of what the mechanisms of the model entail. In the first example, managers default to avoid paying taxes but risk being caught and having to pay penalties. In the second, we allow for heterogeneous costs of capital for formal and informal firms: informal firms are restricted to informal capital markets where poorer enforcement implies higher risk and interest rates. We show that a higher tax rate will increase the expected penalties facing defaulters as well as the costs of complying. The share of employees in the formal sector will rise as the costs of compliance fall or as the gap between capital costs in the formal and informal sectors increases. The analytic comparative static results demonstrate that managerial productivity has an important role in determining the size of these effects. That is, the extent to which formal work increases will be higher, the higher the managerial productivity in the firm led by the marginal manager, that is, the one indifferent between formal and informal sectors.

We can locate our contribution in the literature using search models to analyse informal sectors. It is particularly related to Albrecht et al. (2009), who extend the Mortensen and Pissarides's (1994) matching model to incorporate a self-employed informal sector with heterogeneity in workers' productivity. Accordingly, more productive workers may opt to wait for a formal sector job, while others may select into the informal sector. Ulyssea (2010) develops a matching model incorporating key institutional features of the Brazilian economy and conducts policy simulations. Boeri and Garibaldi (2006) develop a matching model with supervision where heterogeneous workers in the informal sector cannot avail of unemployment benefits, suggesting that policies aimed at reducing the size of the informal sector may increase unemployment. Alternatively, Fugazza and Jacques (2004) incorporate psychic costs of being informal in a matching model where workers direct their search to informal sector firms. Poschke (2019) develops a matching model and examines the coexistence of high rates of unemployment and self-employment in developing countries. A key difference between this model and our framework is that the equilibrium search model we suggest allows for on-the-job search (workers do not lose the opportunity to seek salary work when they enter self-employment). Meghir et al. (2015) outline an equilibrium search model with formal and informal sectors. They simulate the model for the Brazilian economy and find that tighter enforcement can increase wages without increasing employment by improving the allocation of workers across sectors. Narita (2020) incorporates self-employment

into a two-sector model similar to Meghir et al. (2015) to analyse the impact of payroll taxes. The model is most similar to the model we develop here in that it is an equilibrium search framework that builds on the Burdett and Mortensen (1998) model and allows for self-employment and heterogeneity in managerial ability. Meghir et al. (2015) and Narita (2020) allow for separate wage distributions in the formal and informal sectors in a model with an on-the-job search. In contrast, our model has a single wage distribution, which greatly simplifies the analysis. In particular, it allows solving explicitly for the wage distribution to carry out comparative static analysis and highlight the extent of formal work explained by the model depending on managerial ability.

The remainder of our article is organized as follows. In the next section, we present stylised facts on informality. These stylised facts are captured in our theoretical model that we outline in Section 3. Concluding remarks are given in the final section.

## 2 | STYLISED FACTS ON INFORMALITY

The model we adopt captures four of the most important stylised facts characterising informality. To do this, we provide statistical regularities using firm-level data from two sets of standardised surveys conducted by the World Bank on business owners and private sector establishments: the Informal Enterprise Surveys (IFS) and the Enterprise Surveys (ES).[3] We present descriptive plots to give concrete support to the stated stylised facts, using data covering 22 developing countries for which World Bank surveys on both formal and informal firms are available.[4]

*Larger firms are more likely to be formal*. The first stylised fact concerns the relationship between a firm's size and its formal/informal status. In our theoretical contribution, we model informal employment and argue that large firms are more visible and will typically be formal (El Badaoui et al., 2010).[5]

Based on the number of paid and unpaid workers in the month preceding the ES and IFS surveys, six firm size categories are defined: 1 worker, 2–4 workers, 5–9 workers, 10–19 workers, 20–49 workers, and 50 workers or more. In Figure 1, we plot firm size separately for informal and formal firms. We show that informal firms are small, consisting mostly of either a single worker or two to four workers. In contrast, formal firms are relatively large, composed predominantly of five or more workers.[6]

*Larger formal firms tend to be more productive*. A second stylised fact on informality is that larger formal firms are more productive (El Badaoui et al., 2010; La Porta & Shleifer, 2014). The World Bank's informal and formal surveys allow us to give empirical evidence of the relationship between informality and productivity. The data provide firm-level total sales and the total number of workers for the last completed month (fiscal year) preceding the survey.[7] We use sales per worker to measure labour productivity. As basic statistics show in Table 1, differences in productivity can be observed, where informal firms and small firms (i.e. those with one worker or two to four workers, mostly operating in the informal sector) have lower productivity on average. Own-account workers represent over 17% of the total sample of firms and are, on average, the least productive. In Table 2 (column 2), we show the results of the estimation of the determinants of labour productivity (in logarithm). Our main explanatory variables are the indicator of the informal sector and firm size defined as (log of) the total number of workers at the firm during the last completed month preceding the survey. We include a dummy for manufacturing, the firm's age (in years), the capital intensity per unit of labour, and four dummies for the firm's locality size (in number of inhabitants). Given that the firms' size may have different impacts on labour productivity in the informal firms compared to formal firms, we further include the interaction term between the informal firm dummy and firm size. Country and year fixed effects are also employed. After controlling for missing values on variables of interest, we retain a sample of 11 052 (formal and informal) firms. Importantly, the results in column 1 in Table 2 show that (i) firms operating in the informal sector have lower productivity and (ii) average labour productivity increases with the number of workers, but not in the informal sector, where productivity decreases with firm size (see columns 2–4 in Table 2).

*Some self-employed have low managerial ability, others high*. The third stylised fact that the model explores is the heterogeneity in managerial ability among the self-employed,[8] with both high and low types choosing to operate as

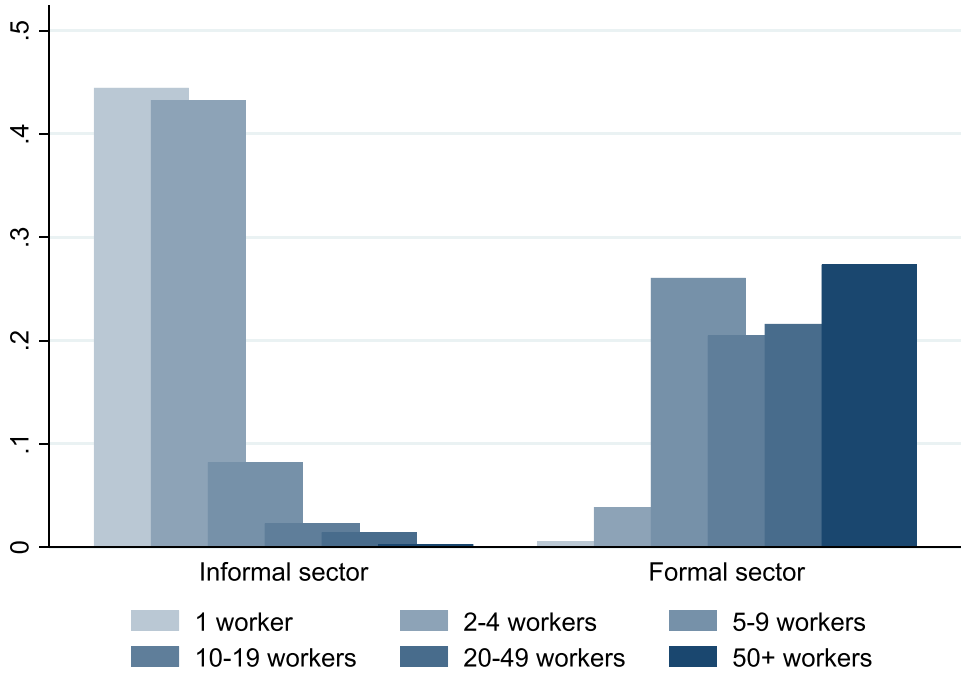


**FIGURE 1** Proportion of firms, by size and formal/informal status.

**TABLE 1** Labour productivity by firm size and formal/informal status.

| | | Productivity (log) | |
|---|---|---|---|
| | Obs. | Mean | SD |
| Total sample | 16 016 | 9.842 | 3.145 |
| Informal firms | 6094 | 8.417 | 2.956 |
| Formal firms | 9922 | 10.718 | 2.930 |
| Firm size | | | |
| 1 worker | 2,768 | 8.290 | 2.745 |
| 2–4 workers | 3,024 | 8.982 | 3.110 |
| 5–9 workers | 3,087 | 10.270 | 3.105 |
| 10–19 workers | 2,172 | 10.738 | 3.191 |
| 20–49 workers | 2,233 | 10.540 | 2.997 |
| 50 + workers | 2,732 | 10.602 | 2.873 |

self-employed in the formal or informal sector. A low-ability group would prefer any salaried job to self-employment or own-account employment, and a high-ability group would prefer to be employer. La Porta and Shleifer (2014) note that '*Many informal entrepreneurs would gladly close their businesses to work as employees in the formal sector if offered the chance ….*' They also note that '*In production function estimates, managerial human capital emerges as a quantitatively large and statistically significant determinant of productivity*.' Nguimkeu (2022) gives evidence of

**TABLE 2** Relationship between firm's size and labour productivity.

| | Total sample | | Informal firms | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| Informal dummy | −1.350*** | (0.061) | | | | | | |
| (Log) firm size | 0.189*** | (0.015) | −0.285*** | (0.042) | −0.339*** | (0.042) | −0.344*** | (0.043) |
| Informal dummy × (log) firm size | −0.281*** | (0.041) | | | | | | |
| (Log) Capital intensity | 0.254*** | (0.020) | 0.512*** | (0.045) | 0.465*** | (0.044) | 0.465*** | (0.044) |
| Manufacturing activity | −0.531*** | (0.036) | −0.254*** | (0.047) | −0.271*** | (0.048) | −0.254*** | (0.048) |
| Years of activity of the firm | 0.008*** | (0.001) | 0.004 | (0.003) | 0.003 | (0.003) | 0.003 | (0.003) |
| City size | | | | | | | | |
| 1 million | −0.112** | (0.051) | −0.030 | (0.064) | −0.056 | (0.064) | −0.035 | (0.064) |
| 250 000 to 1 million | −0.111** | (0.046) | −0.029 | (0.069) | −0.024 | (0.067) | −0.020 | (0.068) |
| 50 000 to 250 000 | −0.101** | (0.048) | −0.374*** | (0.114) | −0.314*** | (0.115) | −0.296** | (0.116) |
| Less than 50 000 | 0.085 | (0.077) | 0.081 | (0.216) | 0.103 | (0.224) | 0.114 | (0.223) |
| Owner's characteristics | | | | | | | | |
| Age | | | | | 0.047*** | (0.012) | 0.045*** | (0.012) |
| Age squared | | | | | −0.001*** | (0.000) | −0.000*** | (0.000) |
| Woman | | | | | −0.249*** | (0.047) | −0.233*** | (0.047) |
| Primary education level | | | | | 0.115 | (0.103) | 0.120 | (0.104) |
| Secondary education level | | | | | 0.331*** | (0.105) | 0.330*** | (0.106) |
| Vocational training | | | | | 0.444*** | (0.117) | 0.446*** | (0.118) |
| University degree | | | | | 0.512*** | (0.131) | 0.522*** | (0.132) |
| Firm's premises and infrastructure | | | | | | | | |
| Within HH premises | | | | | | | −0.183*** | (0.053) |
| Use electricity | | | | | | | 0.039 | (0.051) |
| Use water | | | | | | | 0.025 | (0.048) |
| Obs. | 11 052 | | 2425 | | 2425 | | 2425 | |
| *R*-squared | 0.720 | | 0.865 | | 0.870 | | 0.871 | |

*Notes*: (i) Column (1) refers to the total sample of 22 countries of (formal and informal) firms, and columns 2–4 refer to the sample of informal firms. (ii) We report OLS estimation results. (iii) Capital intensity is the capital amount (vehicles, machinery and tools) per unit of labour. (iv) Capital city is the reference category for the city size. (v) Country and year dummies are included. (vi) Robust standard errors are in parentheses.

***$p < 0.01$, and **$p < 0.05$.

a U-shaped relationship between entrepreneurs' education and their decision to formalize. Moreover, Levine and Rubinstein (2017) show that incorporated self-employed engage in activities that demand comparatively strong cognitive abilities, while the unincorporated firms perform tasks demanding relatively strong manual skills. Thus, formally incorporated business owners tend to be more educated and score higher on learning aptitude tests.

*Educated managers tend to run larger, more productive formal firms*. Lastly, we argue that education plays a role in empowering managerial ability by improving the quality of human capital and the ability to take advantage of existing opportunities. We thus consider the owner's education level as a proxy for managerial ability. Focussing on the education level of the largest owner of the firm, available solely for informal firms, only 5% of the firm owners in our sample have no education at all, as shown in Table 3.[9] The vast majority have some education, including primary education (21%), secondary education (34%), vocational training (15%) and a university degree (17%). In our sampled countries, the education level of firm owners is higher among the relatively larger firms (see Table 3). However, this positive correlation between the owner's education level and firm size is due to differences in firm size between the owners with primary and secondary education (i.e. firms with a single worker and two to four workers) and those with university education (i.e. firms with five workers or more). The firm-size owner-education dichotomy relates to (i) the formal/informal status of the firm, discussed previously, and (ii) the level of labour productivity, where productivity increases with the firm size (as shown in column 4 in Table 2). Overall, low-educated owners are more likely to run small, low-productivity informal firms, and high-educated owners are more likely to run large, high-productive formal firms.

In line with the stylized facts that emerge from our statistical analysis, La Porta and Shleifer (2014) outline a range of stylised facts about informal firms drawing on their more detailed analysis outlined in La Porta and Shleifer (2008), which is based on World Bank surveys of both formal and informal firms across a range of developing countries. Many of the key features of informal firms from this evidence are in keeping with our model. In particular, La Porta and Shleifer (2014) show that informal firms are small, unproductive and stagnant.[10] They cite the limited supply of skilled entrepreneurs as an important bottleneck limiting economic growth and leading to a large informal sector in many developing countries. Our model reflects this fact also since the exogenous distribution of managerial skill is an important determinant of the structure of wages across formal and informal firms, including a group of low-productivity own-account workers.

The model presented in the article's main body does not include capital costs to keep the basic framework as simple as possible. However, there is a great deal of evidence that in many developing countries, access to capital is an important constraint facing firms. For example, Buyinza and Bbaale (2013) find that, within the East African Community, the majority of firms are credit constrained, and high performing firms, exporters, medium and large firms have a higher probability of accessing the formal credit market.[11]

One obvious reason for being formal that our model does not capture is that official certification may be necessary for a self-employed professional or tradesman, in particular occupations or types of small firms (such as doctors

**TABLE 3** Owner's education level and firm size.

| | | Education level | | | | |
|---|---|---|---|---|---|---|
| | Obs. | No | Primary | Secondary | Vocational | University |
| 1 worker | 2731 | 0.067 | 0.332 | 0.441 | 0.109 | 0.052 |
| 2–4 workers | 2797 | 0.066 | 0.257 | 0.433 | 0.146 | 0.092 |
| 5–9 workers | 1436 | 0.061 | 0.168 | 0.279 | 0.193 | 0.185 |
| 10–19 workers | 902 | 0.024 | 0.094 | 0.212 | 0.198 | 0.327 |
| 20–49 workers | 836 | 0.016 | 0.068 | 0.163 | 0.161 | 0.390 |
| 50 + workers | 758 | 0.005 | 0.025 | 0.053 | 0.136 | 0.463 |
| Total sample | 9460 | 0.052 | 0.214 | 0.336 | 0.148 | 0.173 |

and lawyers), who will be in the formal sector. Others, such as artists or writers, may be highly visible, and the possibility of being caught not paying taxes can have high reputation costs. For these reasons, we do not expect that all small firms will be informal and that some formal small firms will have high wage rates.[12]

The following section outlines the model in a general framework without explicitly solving it. Appendix B uses the Burdett and Mortensen (1998) framework to solve the model explicitly and allows for the possibility that capital is more expensive for informal firms.

## 3 | THE MODEL

We will assume that worker types (indexed by *i*) are ordered according to their productivity in self-employment. That is, type-*0* has the lowest productivity parameter *($p_0$)*, type-*1* the second lowest *($p_1$)*, and so on, up to type-*g*, the highest productivity workers. There is a mass $L_i$ of type-*i* workers in the economy where the total mass of workers is $L = \sum_{i=0}^{g} L_i$. Workers can be unemployed, self-employed or salaried. Since we shall focus on a stationary equilibrium, we suppress the time subscripts to avoid clutter. The self-employed shall choose to manage a formal or an informal firm. While each worker's type differs in his/her productivity as a potential manager, all workers are equally productive as employees. In reality, as we will see below, there will be differences in workers' productivity in employment which may differ across top skills and low skills managers and across formal and informal sectors. We can think of this assumption as a simple way of ensuring that some workers have a comparative advantage in self-employment.

The model we present is one where, at any point in time, workers can choose to enter own-account self-employment or to manage a firm with some positive level of employment. The relative benefits of these different self-employment options will depend on the workers' managerial ability. These workers will also receive wage offers which sometimes may attract them away from self-employment into salaried employment. While we give a specific role of capital in the example in Appendix B, we implicitly bundle into managerial ability at this stage in that individual lacking cash is akin to low-productivity self-employment.

Formal sector firms differ from informal firms in that they pay taxes while informal ones do not. Informal firms risk incurring the penalty associated with non-compliance. Smaller firms that are more costly to monitor are less likely to be caught and, thus, more likely to be in the informal sector. Here we follow EB[13] and introduce a tax rate *t* on wage income that is paid by firms. We outline a general model with a positive and continuous relationship between a firm's employment *n* and the wage *w*, *n(w)*, in a stationary equilibrium but do not specify why this positive relationship exists.[14] Firms have the production function $p_i q(n)$ where $p_i$ is the productivity of a type *i* worker as a manager and *q(n)* is the output. We assume that $q_n(n) > 0$ and $q_{nn}(n) \leq 0$. Explicitly solving an equilibrium search model typically involves assuming constant productivity because of the complexity of these models. Indeed, in the example we solve later in Appendix B, we will need to assume constant productivity to solve the model.

Initially, we assume an exogenously given wage distribution and, under this assumption, the results below hold whether marginal productivity is constant or diminishing. There is a tax rate *t* on wages and a Poisson arrival rate of negative shocks, $\delta$, which will destroy the firm. The Poisson arrival rate of tax inspectors is a positive function of the number of employees at the firm, $\Theta[n(w)]$. If firms are caught not paying their taxes, they are punished and must pay a fine according to the function $\Omega[wtn(w)]$, which is increasing in the per period tax bill $wtn(w)$. In a stationary equilibrium, a firm's labour supply times the separation rate equals the hiring rate: $n_i(w) = \frac{h_i(w)}{d_i(w)}$, where $h_i(w)$ is the hiring rate for a firm of type *i* and $d_i(w)$ is the separation rate. We assume for now that the hiring rate is increasing in the wage, noting that we will explicitly solve for the hiring rate in an example later in the article.

We note that workers may have legal obligations to pay a tax on their wages in formal firms, and this may affect their decision about whether to work in the formal sector. While the model only imposes a legal obligation to pay tax on the worker, we note that the legal incidence of taxes generally does not matter. That is, in equilibrium, the net of tax wage will almost certainly be the same whether we impose the legal obligation to pay the tax on the firm or whether the firm deducts the tax from workers in lieu of a tax liability incurred by the worker. From a modelling point of view, it

is much more straightforward to set the tax as an addition to the cost of employment, and this is how we proceed. Of course, one should interpret the tax rate $t$ as encompassing the sum of employer and employee taxes.

The flow of profits in self-employment for a manager of type-$i$ managing a defaulting ($d$) or compliant ($c$) firm in a stationary equilibrium at any wage $w$ *is*:

$$\pi_i^d = p_i q[n(w)] - wn(w) - \Theta[n(w)]\Omega[wtn(w)] \pi_i^c = p_i q[n(w)] - wn(w) - wtn(w) \tag{1}$$

Defaulting firms pay the wage and no tax but incur a cost if they are caught defaulting, the probability of which depends on the number of workers, while compliant firms do not incur this cost but pay the tax.

The flow value of managing a firm for a defaulting ($d$) and a compliant ($c$) self-employed type-$i$ manager is given below where $w_*$, which is fixed in Equations (2), is the profit maximising wage that the manager chooses.

$$\begin{aligned} rV_i^d(w_*) &= \pi_i^d(w_*) + \lambda \int_{\underline{w}}^{\overline{w}} \left\{ \max\left[V_i^d(w_*), E_i(x)\right] - V_i^d(w_*) \right\} dF(x) - \delta V_i{}^d(w_*) rV_i^c(w_*) \\ &= \pi_i^c(w_*) + \lambda \int_{\underline{w}}^{\overline{w}} \left\{ \max\left[V_i^c(w_*), E_i(x)\right] - V_i^c(w_*) \right\} dF(x) - \delta V_i{}^c(w_*) \end{aligned} \tag{2}$$

The flow value of the firm, where $r$ is the discount rate, is the dividend stream (flow of profits) plus any capital gain/loss in the firm's value, which comes from employment opportunities and the arrival rate of negative shocks that destroy the firm. The exogenously given job offer distribution is $F(w)$ where $\underline{w}$ is the lowest wage offered and $\overline{w}$ is the highest wage offered. This job offer distribution gives us the probability that any offer received has a wage of $w$ or less. We make the simplifying assumption that the stream of job offers is the same for an employee, a self-employed worker or an unemployed worker. We will see below that the value of these job offers will differ across workers depending on their productivity in self-employment, which varies across workers. All workers receive job offers at a Poisson arrival rate $\lambda$. The gain associated with an employment offer with value $E_i(w)$ is $\left[E_i(w) - V_i^j(w_*)\right]$ where $j \in (d,c)$, or zero for offers worse than the current state. We get the expected value of offers by integrating over the wage offer distribution. Unemployment has the flow value:

$$rU = b + \lambda \int_{\underline{w}}^{\overline{w}} [\max\{U, E_i(x)\} - U] dF(x) \tag{3}$$

The stream of unemployment benefits is $b$. If we think of the value of unemployment in Equation (3) as an asset, the worker has the possibility of a capital gain in the asset value if a job offer that is better than unemployment arrives. The gain associated with an employment offer with value $E_i(w)$ is $[E_i(w) - U]$. If the worker receives an offer no better than the current state, he/she stays in self-employment, and the capital gain term is zero. Self-employment is preferred to unemployment if the expected value of self-employment net of the setup cost of a firm is better than the expected value of unemployment:

$$\max\left[V_i{}^d, V_i{}^c\right] > U \tag{4}$$

The flow value of employment in any job is

$$rE_i(w) = w + \lambda \int_{\underline{w}}^{\overline{w}} [\max\{E_i(w), E_i(x)\} - E_i(w)] dF(x) - \delta\left[E_i(w) - \max\left\{V_i{}^d, V_i{}^c, U_i\right\}\right] \tag{5}$$

This is the flow value of the wage plus the value of higher wage job offers times the arrival rate of such offers integrated over the job offer distribution, plus the arrival rate of negative shocks that lead to job loss times the capital loss from losing a job. The latter is the difference between the value of the current state and the maximum between the value of unemployment and the value of self-employment (net of the cost of setting up a firm).

The manager of a firm will choose to comply with its tax obligations if

$$V_i^c > V_i^d \tag{6}$$

We note that in a stationary equilibrium:

$$V_i^c(w_*) - V_i^d(w_*) = \frac{\pi_i^c(w_*) - \pi_i^d(w_*)}{r+\delta} = \frac{\Theta[n(w)]\Omega[wtn(w)] - wtn(w)}{r+\delta} > 0 \tag{7}$$

Rather than fully specifying an equilibrium search model, we adopt a more straightforward approach. We assume that a well-behaved equilibrium exists and show below that if all agents are optimising and there are no barriers to moving across states (other than the costs of setting up a firm) with search frictions associated with finding a job as outlined in the model, then optimising behaviour implies the four propositions outlined below. Explicitly solving an equilibrium search model, as we do in Appendix B, involves putting a lot more structure on the model. In particular, we will assume constant productivity and use an extension of the Burdett and Mortensen (1998) framework, outlined in Mortensen and Pissarides (1994), to solve for the wage distribution explicitly and show that the propositions hold.

**Proposition 1.** Higher productivity firms offer higher wages than lower productivity firms.[15] That is, if there are two firms managed by type-*i* and type-*j* managers, respectively, where $p_i > p_j$, then $w_i \geq w_j$ for all wages paid by type-*i* and type-*j* firms.

Proof in Appendix A.1

We assume that there is a stationary equilibrium with a continuous positive relationship between the number of employees and the wage rate *n(w)*. We will denote the tax bill as $B = wtn(w)$ for shorthand.

**Proposition 2.** If the expected penalty from non-compliance is increasing at least as fast as the tax bill in the wage (number of workers) and there are some compliant and some non-compliant firms of a given type in equilibrium, these are sufficient conditions such that there will be a cut-off point in firm size below which all firms will default on their taxes, and above which firms will be compliant. In other words, there will be a wage distribution with small low-wage firms in the informal sector and large high-wage firms in the formal sector.

Proof in Appendix A.2

Propositions 1 and 2 establish that higher productivity firms pay higher wages and that, under reasonable conditions, there will be a cut-off point for firm size and the wage above which firms will choose to be compliant. Large high-wage firms will be compliant, and small low-wage firms will be non-compliant. This was also the case in EB where there was no difference in productivity across firms and self-employment was not explicitly modelled. We will denote the lowest and highest wage paid by each firm type in equilibrium, respectively, as $\underline{w}_i$ and $\overline{w}_i$.

**Proposition 3.** Workers with the lowest managerial ability would prefer any job to self-employment.

Proof in Appendix A.3

Proposition 3 shows that workers with the lowest managerial ability who are self-employed will be in a secondary informal sector in the sense that any job would be better than their current state. If unemployment benefits are sufficiently low, the condition in Equation (4) will hold for the lowest ability group, and this group will prefer self-employment to unemployment. Nevertheless, if benefits are sufficiently high, the condition in Equation (4) will not hold, and this group will choose unemployment over self-employment.

We will refer to firms managed by a type-*i* worker as 'type-*i* firms' and firms with only the manager employed as 'own-account firms' from now on. We assume that an own-account worker has labour supply $n_0$ so that output for an own-account worker of type-*i* is $p_i q(n_0)$. Since the only tax is a payroll tax and own-account workers do not hire others, their profit will be

$$\pi_i = p_i q(n_0) \tag{8}$$

**Proposition 4.** As long as some firms are larger than own-account firms, the highest ability managers will prefer self-employment to any employment offer.

Proof in Appendix A.4

While Proposition 3 established that workers with the lowest managerial ability would prefer any job to self-employment, Proposition 4 establishes that there will be a group of workers (those with the highest managerial ability) who prefer self-employment to any job offer. This implies that if there are more than two ability groups, there will be much heterogeneity across the pool of self-employed workers. In particular, there will be a low-ability group who would prefer any job to self-employment, a high ability group who would not accept any job, and at least one intermediate ability group who (given that there are good and bad job offers) would accept some jobs but not others.

We follow EB and assume the Poisson arrival rate of tax inspectors is a constant $\mu$ times employment to the power of a constant $\beta$ so that large firms are more likely to be caught defaulting: $\Theta[n(w)] = \mu n(w)^{\beta}$. We specify the penalty for defaulting as $x$ times the firm's per period tax bill: $\Omega[wtn(w)] = xwtn(w)$. To save on notation, we define $z = x\mu$ as the parameter that when multiplied by employment to the power of $\sigma = \beta + 1$ determines the expected punishment for defaulters at any point in time. We will see later that when we come to writing the solution for the equilibrium profit and wage distribution of non-compliant workers, using $\sigma = \beta + 1$ will be neater. In this case, from Equation (7), compliance is optimal if

$$n(w) > z^{\frac{1}{1-\sigma}} \tag{9}$$

**Proposition 5.** For the equilibrium where the wage offer distribution is solved explicitly in Appendix B using a version of the Burdett and Mortensen (1998) model, the share of employees in non-compliance is independent of the tax rate $t$ and decreasing in the expected penalty if caught $z$.

*Proof*. From Equation (14) in Appendix B, the employee wage distribution is a monotonically increasing function of the wage offer distribution. We see from inequality (26) in Appendix B that the share of wage offers made to employees in non-compliant firms is independent of the tax rate and decreasing in the expected penalty if caught $z$.

While initial intuition might tell us that an increase in the tax rate would increase the incentive to default, Proposition 5 reminds us that we generally expect the tax rate to enter the expected penalty function as well as the expected cost of compliance if penalties for non-compliance are a function of the amount of tax owed. For the example we solve in Appendix B, because the tax rate enters both the expected cost of compliance and the expected penalty in a linear fashion, it does not affect the decision on compliance/non-compliance. An important qualification to this is that the analysis in this article focuses on an interior solution with both compliant and non-compliant firms. For example, we show in Appendix B that there is a threshold for the tax rate above which high-ability managers would opt out of being an employer and revert to own-account employment.

We note in the example in Appendix B that $F(w)$ will be continuous since, if there was any mass point in the equilibrium wage offer distribution, a manager of a firm offering the wage at that mass point could gain a first-order increase in labour supply and profits by increasing their wage infinitesimally and attracting a group of workers from the firms who are bunched at the mass point.[16] We also note that the lowest wage firm will attract no workers from other firms, and all workers in these firms will accept any offer from any other firm since they will offer a higher wage than their current wage. For these reasons, the lowest wage firm, which hopes to attract type-L workers as employees, has the incentive to reduce the wage they offer to the reservation wage of a self-employed worker.

## 4 | CONCLUSION

This article provides a formal model that can make sense of the growing body of empirical evidence indicating that, in contrast to the earlier literature which tended to analyse whether formal status is an indicator of being in a secondary sector, there may be a good deal of heterogeneity within the formal/informal sectors. An important aspect of the model is that while formality is highly correlated with high or low wage employment, the structure of wages is determined by the underlying structure of the economy, not by formality status. We outline a model combining heterogeneity in managerial ability with search frictions in the labour market, allowing for a richer set of outcomes, where self-employment may be desirable or undesirable, but an unavoidable state for different groups of workers.

The model incorporates two examples based on the Burdett and Mortensen (1998) model. Firstly, we consider the case where informality is chosen to avoid paying tax but where the cost is the probability of being caught and penalised for tax evasion. The comparative static results for the model demonstrate the importance of taking equilibrium effects into account when analysing the impact of changes in the tax rate. In a model with some defaulting firms, a change in the tax rate will affect the penalties of those caught defaulting as well as the costs of complying so that the share of the workers in defaulting firms may rise or fall. Secondly, in the example where firms pay a cost to formalise in return for lower capital costs, the comparative static results are as one would expect.

Lower formalisation costs will increase the share of the formal sector, as will lower relative capital costs in the formal sector. The size of these effects depends on the productivity of the manager, which is consistent with the findings of the empirical literature, which tends to find that for many low-productivity firms, the costs of formalising are prohibitive. Indeed, many of the lowest productivity firms may not be able to bear the costs of formalising and would close under its weight if forced to comply.[17]

### CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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## ENDNOTES

[1] Some studies focus on the possible presence of barriers to entry into the formal sector (Fields, 1975; Mazumdar, 1975), matching friction (Satchi & Temple, 2009) or a lower bargaining power among informally employed workers (Carneiro & Henley, 1998). Other studies highlight the possible evidence of segmentation by pointing to large wage gaps between formal and informal sectors, even after controlling for workers' heterogeneity (Funkhouser, 1997; Gong & van Soest, 2002). For further empirical support of the segmentation view, see Mazumdar (1981), Heckman and Hotz (1986), Roberts (1989), Pradhan and van Soest (1995), or Gong and van Soest (2002).

[2] Some studies find that the informal sector wage penalty tends to disappear when individual heterogeneity is accounted for (El Badaoui et al., 2008; Pratap & Quintin, 2006). Heterogeneity can be observed. A wage penalty in the informal sector may depend on the level of education (Gong & van Soest, 2002) or firm size (El Badaoui et al., 2010; Falco et al., 2011). It may also depend on unobserved ability, which can be controlled using panel data. Recent evidence exploring heterogeneity along the wage distribution finds situations where the controlled wage gap disappears (Bargain & Kwenda, 2014; Falco et al., 2011; Tannuri-Pianto & Pianto, 2002). While evidence for Latin America, and Mexico in particular, point to self-employment as a frequently desirable informal activity (Maloney, 2004; Marcouiller et al., 1997), a mixed situation is often described whereby low and high tiers of informal enterprises coexist (e.g. Cunningham & Maloney, 2001), which seems true also for some African countries (Bargain & Kwenda, 2011; Günther & Launov, 2012). Mixed situations are also not fixed: the performance of labour markets may be asymmetric during business cycles, with voluntary decisions to join the informal sector observed more frequently during expansionary periods, while segmentation might prevail during recessions (Bosch & Maloney, 2006).

[3] We further rely on general statistics (from ILO, OECD and the World Bank) to provide evidence on informal employment in a number of developing countries.

[4] The sample covers the period 2005–2020 and includes the following countries: Angola, Argentina, Botswana, Burkina Faso, Cambodia, Cameroon, Congo, Ivory Coast, Ghana, Guatemala, Kenya, Lao, Madagascar, Mali, Mauritius, Mozambique, Nepal, Niger, Peru, Rwanda, Zambia, and Zimbabwe.

[5] See, for instance, Dabla-Norris et al. (2006) for a survey of the literature on informality.

[6] Table C1 in Appendix C shows that small firms operate primarily in the informal sector and that the share of informal employment decreases with firm size. The statistics cover a number of developing countries and come from the ILO for the period 2017–2020.

[7] The use of monthly data for informal firms allows us to avoid potential measurement errors for yearly data on sales and employment levels due to recall errors.

[8] The model we develop does not distinguish between management and ownership, that is, the self-employed owns the firm and runs the productive activity. Based on firm data from the 22 sampled countries, the self-employed are predominantly in the informal sector (98%) and involved in service activities (66%). Importantly, self-employed firms are not co-owned (97%).

[9] We note that co-ownership increases with firm size (respectively 3%, 21%, 22%, 23%, 44%, and 100% of firms are co-owned).

[10] Stagnant in the sense that they tend not to increase in productivity and rarely progress to being formal firms.

[11] Informal credit markets are prevalent in many developing countries. See, for instance, Bell (1990). Giné (2011) shows that formal and informal credit markets co-exist. Banerjee and Duflo (2007) show that formal credit markets benefit to wealthy borrowers (or large farms in rural areas), while informal credit markets are mainly attributed to poor borrowers or small farms. Despite the presence of some zero-interest loans, borrowers in the informal credit market usually pay high interest rates of up to 150% per year (Banerjee, 2003).

[12] Workers with high managerial ability can be constrained, for some exogenous reasons, by lack of access to financial capital due to risk aversion, poor infrastructure or safety from crime (Gindling & Newhouse, 2012). These cases are not captured by our model.

[13] Much of the following passage is taken straight from EB, who discuss the large literature that equates informality with small firms in more detail. Note that a fundamental difference with EB is that self-employment was not modelled explicitly in this earlier contribution.

[14] This positive relationship might be explained by the fact that larger firms (i) may generate higher rents as they exploit their market power to maximize profits, and these rents could be shared with workers, (ii) are likely to share a higher fraction of rents with their workers as they are more likely to be unionised and have thus more power, on average, (iii) invest more in capital goods because of lower interest rates, or (iv) are more likely to pay efficiency wages. The empirical literature with employee-level data enables measuring firm-level characteristics such as total assets, profitability or market share. See, for instance, Abowd and Lemieux (1993), Christofides and Oswald (1992), and Gibson and Stillman (2009).

[15] Burdett and Mortensen (1998), on page 268, also show this to be true in their model.

[16] Showing this formally was one of the important contributions of BM, and the argument is spelt out in detail there.

[17] For example, Badaoui and Walsh (2022) show that a substantial share of informal firms has output per worker that is less than the statutory minimum wage in their country.

[18] This assumption fits well in most developing countries where many poor people, often a majority, are self-employed in both urban and rural areas (Fields, 2019; Gollin, 2008). Fields (2019) argues that while some workers are voluntarily self-employed, others are self-employed because they cannot be wage employees and are too poor to remain unemployed and earn nothing. According to Poschke (2019), a plausible reason is that unemployment insurance benefits, $b$, are lower than wages in salaried employment, $w$, since developing countries do not provide unemployment insurance benefits. He gives evidence from Ethiopia, where the ratio $b/w$ is equal to 0.4. We consider the assumption that unemployment benefits are low enough, driving workers to choose self-employment, as being reflective of these countries (see Table C3) rather than universally representative. We recognize that there may be many other developing countries where this assumption would not be appropriate.

[19] See, for instance, Fields (2019), Narita (2020) and Poschke (2019).

[20] See Mortensen (2003) and Burdett and Mortensen (1998) for a detailed derivation of the labour supply curve.

[21] See Manning (2003), on pages 284–286, for a discussion on the matching technology.

[22] Mortensen (2003) derives the solution for the case with a positive discount rate in the case with no capital costs.

[23] An alternative reason for the different costs of capital is the firm size—that is, smaller firms face higher capital costs not because of informality but because of information asymmetries or lack of collateral (Soderbom & Teal, 2004). Since the small firm size is a good proxy for informality (El Badaoui et al., 2010), we do not view our advanced reason as contradictory to the aforementioned one.

[24] While we could assume interest rates are higher by assuming a higher discount rate for informal firms in Equation (2), this would assume the informal firm has higher costs of borrowing and returns to saving. We implicitly assume that when the manager incurs the sunk cost of setting up the firm, he/she needs some credit, which is more expensive for informal firms than formal firms. This is a way of capturing the possibility that the cost of credit for firm start-ups is higher for informal firms relying on more expensive informal lenders.

[25] We note that in this simple example where all managers have the same productivity in equilibrium, Proposition 1 does not arise.

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## APPENDIX A: PROOF OF PROPOSITIONS

### A.1 | Proof of Proposition 1

From Equation (2), a firm will maximize the expected value of the firm by maximizing the stream of expected profits. In equilibrium, a type-*i* manager pays a wage $w_i$ and a type-*j* manager a wage $w_j$. We define $\pi_i^{si}(p_i, w_i)$ as the flow of profit for the optimal choice of wage and compliance status of a type-*i* firm, where $s_i \in (c,d)$ is the compliance status of an optimizing type-*i* firm and $s_j \in (c,d)$ the compliance status of an optimizing type-*j* firm. $\pi_i^{sj}(p_i, w_j)$ is the profit a type-*i* firm would make if they adopted the same wage and compliance status as an optimal type-*j* firm. $\pi_j^{sj}(p_j, w_j)$ is the flow of profit implied by the optimal wage and compliance status of a type-*j* firm, and $\pi_j^{si}(p_j, w_i)$ is the profit a type-*j* firm would make if it adopted the wage and compliance status of an optimal type-*i* firm. It follows that

$$\pi_i^{si}(p_i, w_i) \geq \pi_i^{sj}(p_i, w_j) > \pi_j^{sj}(p_j, w_j) \geq \pi_j^{si}(p_j, w_i) \tag{A.1}$$

The first inequality in (A.1) holds since no firm can do no better than its optimal choice of wage and compliance status. Since we have assumed that $p_i > p_j$, the definition of profit in Equation (1) implies the second inequality will hold. Since $\pi_j^{sj}(p_j, w_j)$ is the level of profit for an optimal choice of wage for this firm type, the third inequality will hold. We note that the inequalities in (A.1) imply that

$$\pi_i^{si}(p_i, w_i) - \pi_j^{si}(p_j, w_i) - \pi_i^{sj}(p_i, w_j) - \pi_j^{sj}(p_j, w_j) = q[n(w_i)] - q[n(w_j)] > 0 \tag{A.2}$$

This implies that $n(w_i) \geq n(w_j)$ which implies that $w_i \geq w_j$.

### A.2 | Proof of Proposition 2

Assume that $w_i$ and $w_j$ are both wages offered in equilibrium by a firm of type-*i* and a firm of type-*j*, respectively, where $p_j \geq p_i$. From Proposition 1, we know that $w_j > w_i$. We assume $w_i$ is the wage paid by the lowest wage compliant firm across all firms. Since the firm chooses to be compliant, then the value of compliance is higher than non-compliance at the optimal wage:

$$V_i^c(w_i) > V_i^d(w_i) \tag{A.3}$$

We note that for any firm of type-*g*, the value of the firm is determined by choosing the wage that will maximise the stream of profits to the manager. We also note that for firms *i* and *j*, respectively, the difference between profit in compliance and non-compliance at the optimal wage can be written as

$$\Delta_i = \pi_i^c(w_i) - \pi_i^d(w_i) = -w_i tn(w_i) + \Theta[n(w_i)]\Omega[w_i tn(w_i)] > 0 \Delta_j = \pi_j^c(w_j) - \pi_j^d(w_j) = -w_j tn(w_j) + \Theta[n(w_j)]\Omega[w_j tn(w_j)] \tag{A.4}$$

We note that if firm *j* were non-compliant, it must be that $\Delta_j < 0$. This implies that if $\Delta_j - \Delta_i \geq 0$, then firm *j* cannot be non-compliant. The difference in the two difference terms above can be written as

$$\begin{aligned} \Delta_j - \Delta_i &= \{\Theta[n(w_j)]\Omega[w_j tn(w_j)] - \Theta[n(w_i)]\Omega[w_i tn(w_i)]\} - \{[w_j n(w_j) - w_i n(w_i)]t\} \\ &= \{\text{Difference in expected penalty}\} - \{\text{Difference in tax bill}\} \end{aligned} \tag{A.5}$$

We note that if the expected penalty is increasing at least as fast as the tax bill as the wage (number of workers) increase, then firm $j$ must also be compliant. This establishes that any firm $j$ which has higher productivity to the lowest wage compliant firm must also be compliant. We note that firm $i$ is the lowest wage compliant firm by definition so that any firm with lower wage is non-compliant.

### A.3 | Proof of Proposition 3

The value of the lowest equilibrium wage offer is $E(\underline{w})$. Say this wage is offered by a type-$j$ firm in equilibrium where $j \geq i$ and where $i$ is the lowest ability type. If a type-$i$ worker preferred self-employment to this offer, then

$$V_i^h[p_i, w, n(w)] > E(\underline{w}) \text{ where } h \in (c,d) \tag{A.6}$$

Since for any other worker type $k \neq i$ it must be that $p_k > p_i$, it follows from the definition of profits and the value of the firm, that is, Equations (1) and (2), that $V_k^h[p_k, w, n(w)] > V_i^h[p_i, w, n(w)] > E(\underline{w})$.

That is, it must be that if type-$i$ workers would prefer self-employment to the lowest wage job, the same would be true for all workers. This means that no firm could offer such a contract and attract any workers and such an offer cannot be an equilibrium contract. It must be that in equilibrium the lowest wage contract is sufficiently attractive to attract at least the lowest ability worker or else it cannot attract any workers.

### A.4 | Proof of Proposition 4

As long as some firms are larger than own-account firms, the highest ability managers will prefer self-employment to any employment offer. From Proposition One, the highest ability managers (type-$g$) will manage the largest, highest wage firm. Since any manager can choose to be an own-account firm at any point in time, the profit of being the highest wage manager must be at least as high as the profit of being an own-account worker in equilibrium:

$$\pi_z^j(\overline{w}) > p_z q(n_0) \tag{A.7}$$

where $j \in (c,d)$. Since this is the largest firm and since $q_n(n) > 0$ and $q_{nn}(n) \leq 0$ by assumption and $n(\overline{w_t}) > n_0$ by assumption, the additional output generated by the last $n_0$ workers in the highest wage firm is less than or equal to the output a high-ability manager could produce as an own-account worker:

$$p_z\{q[n(\overline{w_t})] - q[n(\overline{w_t}) - n_0]\} \leq p_z q[n_0] \tag{A.8}$$

In the case where $q_{nn}(n) < 0$, even if the highest wage firm paid a wage to the marginal worker equal to the value of their marginal product and this worker was from the highest ability group, from (A.8) this would be less than this worker's earnings in self-employment (if the worker is from the highest ability group $g$). That is, it could never be profitable for even the highest wage firm to offer the highest ability worker a wage that would be attractive enough to attract this worker from self-employment. In the case of $q_{nn}(n) = 0$, offering workers their marginal product as a wage could not be an optimal strategy for any manager since they would make no surplus and could do better in self-employment. Firms must offer wages less than the marginal product of workers to make it profitable to hire them. No firm could profitably offer the highest ability worker a wage equal to their productivity in self-employment.

## APPENDIX B: THE BURDETT–MORTENSEN MODEL AS AN EXAMPLE

### B.1 | The base framework

In the example below, we solve a slightly more general version of the Burdett and Mortensen (1998) model which allows for the inclusion of firm-specific capital costs. We could also solve for a simpler version of the model without capital costs which would be more in line with the general model outlined earlier. However, as noted in Mortensen (2003), the wage offer distribution with match specific capital included is more empirically plausible. As we noted earlier, the possibility that capital is more costly in non-compliant firms is an important part of the difference between formal and informal firms. In Table C2 in Appendix C, we show using IFS data that access to capital is one of the barriers informal firms face. Interestingly, we find little difference between small and large informal firms. Regardless of their size, informal firms rely mainly on internal funds for day-to-day operations (91% of firms in sampled countries) and seldom on external funds from banks and financial institutions (11% of firms). In addition, capital is expensive for 34% of informal firms, which report not applying for loans because of high interest rates. Finally, 65% of informal firms consider better market access the main benefit of being registered.

Below, we summarise labour market flows and then derive the equilibrium labour supply curve and wage offer distribution using the equilibrium search model outlined in Burdett and Mortensen (1998) [BM from now on] and extended to incorporate investments in firm-specific capital in Mortensen (2003). This model serves as an example where a positive relationship between firm size and wages emerges endogenously in equilibrium and where we can solve the model explicitly. While equilibrium search models have been solved with heterogeneity across workers outside options and firm productivity (see Bontemps et al., 1999 or Postel-Vinay & Robin, 2002, for example), the model we develop here is complicated by the fact that a worker's outside option is defined by the profit (s)he can make in self-employment, that is the distribution of outside options is not exogenous. We adopt the simplest approach possible to solve the model in a tractable way that illustrates some of its key features. In particular, we will assume that there are only two ability groups. In equilibrium, the high (H) managerial ability will be employers, while the low-ability group ($L$) will be either employees or own-account workers in self-employment.

We will assume that unemployment benefits are low enough so that the low-ability group chooses self-employment. Thus, there will be no unemployed workers in equilibrium.[18] Indeed, unemployment benefits are low in many developing countries because of the weak coverage of these benefits, that is, a small number of benefit recipients, under weak administrative capacity, large informal sector, bad governance, political risk and an environment prone to corruption (Vodopivec, 2013). Thus, unemployment is practically non-existent in many developing countries, where individuals cannot afford to be unemployed and accept any work, even if it does not match their skills. As shown in Table C3 in Appendix C for a sample of developing countries, the proportion of the population covered with unemployment benefits is extremely low overall.

As in the BM model, on-the-job search will ensure that wage dispersion will emerge in equilibrium, even though productivity in employment is the same for all workers. The assumption that workers transition directly between self-employment and being an employee may not fit every country. Narita (2020) shows that most transitions in and out of self-employment in Brazil are via a spell of unemployment between 2002 and 2007, when unemployment rates were between 8% and 9%. We report in Table C4 in Appendix C the rates of unemployment and self-employment across a range of developing countries. We show that unemployment rates are negligible for many developing countries, making the assumption that workers move directly between self-employment and employment more plausible. Fields (2019) suggests that most workers in developing countries are self-employed. The data in Table C4 show that almost 54% of workers in low- and middle-income countries are self-employed, among whom the majority are own-account workers.[19] This share reaches 80% in low-income countries. Self-employment differs considerably by region, where Sub-Saharan Africa and South Asia have self-employment rates exceeding 70%. The

highest share of self-employed of 95% is recorded for Niger with no unemployment. This suggests some variability among countries.

Interestingly, the unemployment rate is overall low. The data indicate that the unemployed constitute 5.5% of the labour force in developing countries and 4.6% among low-income countries. In this regard, unemployment is limited and unlikely the biggest challenge in most developing countries (Fields, 2019). Poschke (2019) reveals that self-employment is particularly high in the presence of labour market frictions. More precisely, he argues that '*while labor market frictions always reduce wage employment, they do so via higher unemployment when firm entry costs are high, as in rich economies, but via higher self-employment when firm entry is cheap, as in poor economies*.' Narita (2020) shows that self-employment entry opportunities '*increase as the unemployed get older regardless of their ability since the option of self-employment is always preferred to remaining unemployed*'.

We will proceed by deriving the labour supply curve in a model where there are search frictions, and workers receive on-the-job offers.[20] We define $m_i$ as the mass of type-$i$ self-employed workers (managers) who employ others and $s_i$ as the mass of type-$i$ self-employed own-account workers. This means that a mass of $m_i + s_i = S_i L_i$ type-$i$ workers is in self-employment, where $S_i$ is the self-employment rate for type-$i$ workers and $L_i$ the population of type-$i$ workers. We note from Proposition 4 that $S_H = 1$, that is, all of the high-ability workers will be self-employed managers $m_H = S_H L_H = L_H$ (we will assume that the productivity of these workers is high enough such that their profit from hiring workers is greater than from being an own-account worker). This condition will be determined in the equilibrium outlined below. Low-ability workers who fail to obtain a job are self-employed own-account workers and thus $s_L = S_L L_L$ with $S_L < 1$, and $(1 - S_L)$ is the fraction of employees. There is random matching so that any job offer is equally likely to come from any firm irrespective of the firm's size.[21] The distribution of wage offers which we will solve for is $F(w)$. The other assumptions and parameter definitions from the previous section continue to hold. In a stationary equilibrium, inflows and outflows to self-employment of each worker type are equal, implying the following relationship between inflows and outflows from self-employment and employment for low-ability workers (who are the only group who will be in employment in our model with two skill groups) where the share of wage offers which fall below the self-employment profit a low skilled worker can earn is $F(\pi_L)$:

$$\lambda S_L[1 - F(\pi_L)] = \delta(1 - S_L) \tag{B.1}$$

The outflows, on the left-hand side, are the job offer arrival rate $\lambda$ times the fraction of offers where the job offer is better than the profit worker type-$L$ expects in self-employment. The inflows to self-employment, on the right-hand side, are the fraction of type-$L$ workers (we recall that type-$H$ workers are all managers) who are employees times the job destruction rate. It follows that, since all high-ability workers are managers and since wages exceed self-employment profits for all low-ability workers, $F(\pi_L) = 0$ in any equilibrium where there are some employees from type-$L$ workers:

$$S_L = \frac{\delta}{\delta + \lambda} \tag{B.2}$$

For high-ability workers, we know from Proposition 4 that $S_H = 1$. Firms managed by high-ability managers that go out of business after being subjected to a negative shock are replaced by new firms, which will be created by the same managers in equilibrium, implying that there are no inflows or outflows from self-employment for this group.

In a steady state equilibrium, the outflows from low skill employment (the separation rate plus the flow of job offers received from higher wage firms times the stock of employment $N_L$) and inflows from low skill employment (the number of offers less than $w$ accepted by self-employed workers of type-$L$) are equal, that is

$$\dot{N}_L = \{\delta + \lambda[1 - F(w)]\}N_L(w) - \lambda F(w)S_L L_L = 0 \tag{B.3}$$

We assume that the labour supply of low-ability workers is $n_0 = 1$.

We can solve for employment of type-$L$ workers earning $w$ or less from Equation (B.3) as $N_L(w) = \frac{\lambda F(w) S_L L_L}{\delta + \lambda[1 - F(w)]}$. Low skill employment at a wage less than $w$ can also be defined as $(1 - S_L)$ times the wage distribution of this group, $G_L(w)$, times the population of workers of this type $L_L$:

$$N_L(w) = (1 - S_L)G_L(w)L_L = \frac{\lambda F(w) S_L L_L}{\delta + \lambda[1 - F(w)]} \tag{B.4}$$

Using the fact that $\frac{S_L}{1 - S_L} = \frac{\delta}{\lambda}$ and rearranging Equation (B.4), we can solve for $G_L(w)$:

$$G_L(w) = \frac{\delta F(w)}{\delta + \lambda[1 - F(w)]} \tag{B.5}$$

The probability that any worker contacted by the firm will be hired times the number of workers contacted is the firms hiring rate:

$$h_L(w) = \lambda \frac{L_L}{L_H}[S_L + (1 - S_L)G_L(w)] = \frac{L_L}{L_H}\left\{\frac{\delta\lambda}{\delta + \lambda[1 - F(w)]}\right\} \tag{B.6}$$

$S_L$ is the probability any worker contacted will be self-employed. Self-employed workers will accept all wage offers, and all wage offers will be greater than the value of self-employment since a lower offer would attract no workers and would never be made. $1 - S_L$ is the probability any worker contacted is in employment, $G_i(w)$ is the probability they earn no more than $w$ and will accept the firm's wage offer, and $\lambda \frac{L_L}{L_H}$ is the number of workers each firm expects to contact in each period given random matching.

The separation rate $d(w)$ at any firm is the sum of the job destruction rate $\delta$ plus the arrival rate of offers to each worker times the probability the offer comes from a higher wage firm $\lambda[1 - F(w)]$:

$$d(w) = \delta + \lambda[1 - F(w)] \tag{B.7}$$

The separation rate times employment equals inflows per firm in a stationary equilibrium, so that the labour supply of type-$L$ workers is

$$n_L(w) = \frac{h_L(w)}{d(w)} = \frac{L_L}{L_H}\frac{\delta\lambda}{\{\delta + \lambda[1 - F(w)]\}^2} \tag{B.8}$$

Equation (B.8) gives the labour supply of type-$L$ workers to a firm paying a wage $w$ in terms of the equilibrium wage offer distribution.

We can assume all managers are highly skilled when writing the profit function from Proposition 4. The profit functions are the same as presented earlier in Equation (1) except for the additional assumption that the marginal productivity of workers is constant and the introduction of the capital cost. Since in equilibrium in our example with two ability types, there can be no job offers that a manager will receive which will be more attractive than being a manager, the value of self-employment given in Equation (2) can be written as follows:

$$V_H^d(w_*)=\frac{\pi_i^d(w_*)}{r+\delta}=\frac{(p_H-w)n(w)-\mathrm{n}(w)^\sigma zwt-\gamma^d k_H^d h_H(w)}{r+\delta}V_H^c(w_*)=\frac{\pi_i^c(w_*)}{r+\delta}=\frac{[p_H-w(1+t)]n(w)-\gamma^c k_H^c h_H(w)}{r+\delta} \quad \text{(B.9)}$$

Since we assume $n_0=1$, the production function for an own-account worker with low managerial ability is

$$q_L[p_L,n_0]=p_L \quad \text{(B.10)}$$

Equation (B.10) is also the profit function of own-account low-ability workers since the only tax is a payroll tax and type-$L$ self-employed non-compliant workers do not hire others. From Equation (3), the value of unemployment is increasing in benefits $b$. We assume that $p_L n_0 > b$. Since unemployed workers and own-account workers draw from the same wage offer distribution and have the same arrival rate of job offers, if the flow of income in unemployment $b$ is less than the flow of profit of a low-ability worker $p_L n_0$, which we assume it is, then the value of own-account self-employment is better than unemployment for low-ability workers. We also see immediately that it could never be profitable for a low-ability worker to hire another worker since any other worker will be at least as productive as an own-account worker.

### B.2 | The equilibrium wage distribution

The lowest wage a low-ability worker will consider working for is $\pi_L$ since this is the wage that they can earn in self-employment. We can solve for the profit of the lowest informal firm by solving for the level of profit of a firm that pays this wage, where we know from Proposition 2 that this will be a defaulting firm. We also know that in equilibrium, all wage strategies must have the same level of profit since any firm can choose any wage. We note that the labour supply of the lowest wage firm (where any offer is accepted by the workers so that $F(w)=0$) can be written as $n_L(\pi_L)=\frac{L_L}{L_H}\frac{\delta\lambda}{(\delta+\lambda)^2}$.

The profit function of any non-compliant firm is

$$\pi_H^d=[p_H-w]n(w)-n(w)^\sigma zwt \quad \text{(B.11)}$$

We solve for the level of profit ($\pi_H^d$) the manager of the firm paying the lowest wage earns, where the lowest wage equals the profit ($\pi_L$) a worker with low managerial ability would earn as an own-account worker, that is, their outside option. By plugging this wage into Equation (B.11), we can solve for the equilibrium level of profit, which must be the same for firms offering any wage:

$$\pi_H^d=[p_H-\pi_L]n(\pi_L)-n(\pi_L)^\sigma z\pi_L t=[p_H-\pi_L]\frac{L_L}{L_H}\frac{\delta\lambda}{(\delta+\lambda)^2}-\left[\frac{L_L}{L_H}\frac{\delta\lambda}{(\delta+\lambda)^2}\right]^\sigma z\pi_L t \quad \text{(B.12)}$$

We see that Equation (B.12) gives the level of profit of a high-skilled manager in terms of the exogenous parameters. Plugging this value for the level of profit into the profit function in Equation (B.11), we can solve for the wage in terms of the equilibrium wage offer distribution facing any non-compliant firm:

$$w^d=\frac{p_H n(w)-\pi_H}{n(w)+n(w)^\sigma zt}=\frac{p_H\left\{\frac{L_L}{L_H}\frac{\delta\lambda}{\{\delta+\lambda[1-F(w)]\}^2}\right\}-\pi_H}{\frac{L_L}{L_H}\frac{\delta\lambda}{\{\delta+\lambda[1-F(w)]\}^2}+\left\{\frac{L_L}{L_H}\frac{\delta\lambda}{\{\delta+\lambda[1-F(w)]\}^2}\right\}^\sigma zt} \quad \text{(B.13)}$$

Similarly, compliant firms will make the same profit as defaulting firms, which is given in Equation (B.12). By equalising this with the profit function of a compliant firm with a higher wage,

$$\pi_H^c = [p_H - w(1+t)]n(w) \tag{B.14}$$

Next, we solve for the relationship between the wage and the wage offer distribution for compliant firms by substituting the labour supply function into Equation (B.14):

$$w^c = \frac{1}{(1+t)}\left[p_H - \frac{\pi_H}{n(w)}\right] = \frac{1}{(1+t)}\left\{p_H - \frac{\pi_H}{\frac{L_L}{L_H}\frac{\delta\lambda}{\{\delta+\lambda[1-F(w)]\}^2}}\right\} \tag{B.15}$$

We note that for $n(w) > \left(\frac{1}{z}\right)^{\frac{1}{\sigma-1}}$, the firm will be compliant and for any employment level below this, the firm will maximise the stream of profit by defaulting. Using the labour supply curve in Equation (B.8), this inequality can be written as

$$\frac{L_L}{L_H}\frac{\delta\lambda}{\{\delta+\lambda[1-F(w)]\}^2} > z^{\frac{1}{1-\sigma}} \tag{B.16}$$

This inequality can be used to solve for the value of the wage distribution below which the firm will default:

$$F(w^*) > \frac{\delta+\lambda}{\lambda} - \left[z^{\frac{1}{\sigma-1}}\frac{L_L}{L_H}\frac{\delta}{\lambda}\right]^{0.5} \tag{B.17}$$

BM shows some interesting comparative static results from this inequality which continue to hold in the framework with self-employment.

While the analysis so far has concentrated on the case where some compliant and non-compliant firms exist, we must allow for the possibility that, if the tax rate were too high, high-ability managers may be indifferent between own-account work and being a manager. That is, if the tax rate is high enough, the profit of being an own-account worker will dominate that of being a worker in a compliant firm. To check this, we calculate the profit of the highest wage compliant firm (where $F(w) = 1$ and so from Equation (B.8) the labour supplied to the highest wage firm is $n_L(w)\frac{L_L}{L_H}\frac{\lambda}{\delta}$). We need to ensure that own-account profit $p_H$ is higher than the profit of the highest wage compliant firm $\pi_H^c$ (which is the same as the profit of all other firms in equilibrium):

$$p_H > \pi_H^c = \left[p_H^c - w(1+t)\right]n(w) = [p_H - w(1+t)]\frac{L_L}{L_H}\frac{\lambda}{\delta} \tag{B.18}$$

Solving for the wage,

$$\overline{w} > \frac{p_H\left(\frac{L_L}{L_H}\frac{\lambda}{\delta} - 1\right)}{(1+t)\frac{L_L}{L_H}\frac{\lambda}{\delta}} \tag{B.19}$$

This implies that if the wage of the highest wage compliant firm $\overline{w}$ exceeds the right-hand side of inequality (B.19), then the manager would earn more profit in own-account self-employment than as manager of the highest wage compliant firm. If we replace the wage in inequality (B.19) with the wage the lowest wage firm could ever pay (which is $p_L$ since a firm offering a lower wage would attract no employees), the inequality becomes $\frac{p_L}{p_H} > \frac{1}{(1+t)}\frac{\frac{L_L}{L_H}\frac{\lambda}{\delta}-1}{\frac{L_L}{L_H}\frac{\lambda}{\delta}}$. Solving for the tax rate, we establish a sufficient condition that if the tax rate is above this threshold, there is no

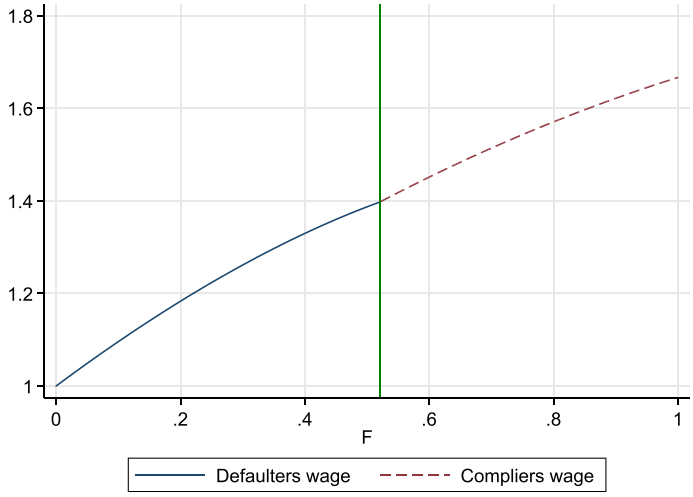


**FIGURE B1** Simulated wage offer distribution, compliant and non-compliant firms.

**TABLE B1** Parameter assumptions for simulations in Figures B1 and B2.

| | |
|---|---|
| $L_H = 10$ | $L_L = 100$ |
| $z = 0.2$ | $t = 0.1$ |
| $p_L = 1$ | $p_H = 2$ |
| $\delta = 0.207$ | $\lambda = 0.287$ |
| $\sigma = 2$ | $\eta = 0.5$ |
| $\gamma^C = 0.8$ | $\gamma^d = 1$ |
| $T = 5$ | |

wage at which high-skilled managers could attract workers and make more profit than they would as an own-account worker:

$$t > \frac{p_H}{p_L}\left(1 - \frac{L_H}{L_L}\frac{\delta}{\lambda}\right) - 1 \tag{B.20}$$

Figure B1 graphs the wage offer distribution for the parameter values given in Table B1. The lowest wage defaulting firm pays workers their outside option (its own-account profit of $p_L = 1$).

There is a vertical line at $F^*$ where any firm offering a wage that puts them at a higher value than this in the wage offer distribution will find it more profitable to be compliant.

### B.3 | The case with higher capital costs in the informal sector

While we recognise that discount rates in developing countries may be higher than in more developed countries, in the interest of tractability, we follow BM and assume $r = 0$ in the derivation of the explicit solution for the labour supply curve. It would be important to account for this in any empirical analysis or simulation based on the model.[22] The per period cost of the match specific capital is $\gamma^d k$ and $\gamma^c k$ for a non-compliant and compliant firm, respectively.

As we discussed earlier, a prominent explanation for informality in the literature is that informal firms may be restricted to informal capital markets where poorer enforcement implies higher risk and higher interest rates, as in the models of Amaral and Quintin (2006) and Straub (2005), for example.[23] We capture this feature by assuming that the price of firm-specific investments in new hires is higher for an informal manager than that for a formal manager: $\gamma^d > \gamma^c$.[24]

In what follows, we change the tax from a percentage of the wage bill to a fixed cost of formalising $T$, which the firm pays in each period. In the interests of tractability, we ignore any potential penalties for not paying tax other than that the firm faces higher capital costs. We can think of this example as a framework to analyse a firm's decision on whether to formalise, where there is a fixed cost involved in registering, but where registered firms have other benefits such as access to cheaper capital. To incorporate the match specific capital, we note the firms' production function as $p_H k^{\eta} n(w)$. The productivity parameter of the manager $p_H$ is multiplied by the number of workers $n(w)$ and the amount of capital per worker $k$ that the firm chooses when a worker is hired to the power of $\eta < 1$. As in the previous example, we assume output is fixed at $p_J$ where $J \in (H,L)$ indicates ability. We assume that own-account workers do not invest in job specific training and so have no reason to pay $t$ implying that output equals their profit. We will proceed taking it as given that only high-ability managers find it profitable to hire workers and will outline the parameter restrictions that ensure that this is true after we have solved for the equilibrium level of profit. The value of a firm for a high-ability manager who is defaulting or compliant, respectively, is

$$V_H^d(w) = \frac{\pi_H^d(w)}{\delta} = \frac{\left[p_H\left(k_H^d\right)^{\eta} - w\right]n(w) - \gamma^d k_H^d h_H(w)}{\delta} V_H^c(w) = \frac{\pi_H^c(w)}{\delta} = \frac{\left[p_H\left(k_H^c\right)^{\eta} - w\right]n(w) - \gamma^c k_H^c h_H(w) - T}{\delta} \quad \text{(B.21)}$$

Using the fact that $n_H(w) = \frac{h_H(w)}{d(w)}$, this can be written as

$$V_H^d(w) = \frac{\pi_H^d(w)}{\delta} = \frac{\left\{\frac{\left(p_H k_H^{d\,\eta} - w\right)}{d(w)} - \gamma^d k_H^d\right\}h_H(w)}{\delta} V_H^c(w) = \frac{\pi_H^c(w)}{\delta} = \frac{\left\{\frac{p_H k_H^{c\,\eta} - w}{d(w)} - \gamma^c k_H^c\right\}h_H(w) - \gamma^c T}{\delta} \quad \text{(B.22)}$$

The firm's optimal choice of capital implies $\frac{\eta p_H \left(k_H^j\right)^{\eta-1}}{d(w)} = \gamma^j$, so that

$$k_H^j = \left[\frac{\eta p_H}{\gamma^j d(w)}\right]^{\frac{1}{1-\eta}} = \left[\frac{\eta p_H}{\gamma^j\{\delta + \lambda[1 - F(w)]\}}\right]^{\frac{1}{1-\eta}} \text{where } j \in (c,d) \quad \text{(B.23)}$$

We see that in equilibrium, the optimal level of investment depends on the firm's choice of wage and whether the firm is compliant. We can substitute the optimal value of capital back into the profit function for defaulting and compliant firms, respectively:

$$\pi_H^d(w) = \left[p_H\left(k_H^d\right)^{\eta} - w\right]n(w) - \gamma^d k_H^d h_H(w)$$

$$= \left\{\left(\eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}}\right)\gamma^{d^{-\frac{\eta}{1-\eta}}} p_H^{\frac{1}{1-\eta}}\{\delta + \lambda[1 - F(w)]\}^{-\frac{\eta}{1-\eta}} - w\right\}\frac{L_L}{L_H}\frac{\delta\lambda}{\{\delta + \lambda[1 - F(w)]\}^2} \quad \text{(B.24)}$$

$$\pi_H^c(w) = \left[p_H\left(k_H^c\right)^{\eta} - w\right]n(w) - \gamma^c k_H^c h_H(w) - T$$

$$= \left\{ \left( \eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}} \right) \gamma^{c^{-\frac{\eta}{1-\eta}}} p_H^{\frac{1}{1-\eta}} \{\delta + \lambda[1 - F(w)]\}^{-\frac{\eta}{1-\eta}} - w \right\} \frac{L_L}{L_H} \frac{\delta\lambda}{\{\delta + \lambda[1 - F(w)]\}^2} - T \tag{B.25}$$

A firm will default if

$$\pi_H^d(w) = p_H \left( k_H^d \right)^\eta n(w) - \gamma^d k_H^d h(w) > \pi_H^c(w) = p_H \left( k_H^c \right)^\eta n(w) - \gamma^c k_H^c h(w) - T \tag{B.26}$$

This condition can be reorganized as follows:

$$T > \Delta\pi^G = \left[ p_H \left( k_H^c \right)^\eta - p_H \left( k_H^d \right)^\eta \right] n(w) - \left[ \gamma^c k_H^c - \gamma^d k_H^d \right] h(w) \tag{B.27}$$

This just says that the tax liability of the firm is greater than the difference in gross (i.e. before tax) profits between compliant and defaulting firms so that the benefit of the lower capital costs associated with compliance is outweighed by the tax. The difference in gross profit on the right-hand side can be decomposed into the difference in revenue between compliant and defaulting firms, $\Delta Revenue$, and the difference in capital costs, $\Delta Capital$ costs (there is no difference in labour costs at a given wage). Using the solution for capital in Equation (B.23), we see that revenue for either defaulting or compliant firms can be written as follows:

$$p_H k_H^{j,\eta} n(w) = p_H^{\frac{1}{1-\eta}} \left( \frac{\eta}{\gamma^j} \right)^{\frac{\eta}{1-\eta}} \frac{L_L}{L_H} \frac{\delta\lambda}{\{\delta + \lambda[1 - F(w)]\}^{\frac{2-\eta}{1-\eta}}} k_H^j = \left[ \frac{\eta p_H}{\gamma^j \{\delta + \lambda[1 - F(w)]\}} \right]^{\frac{1}{1-\eta}} \text{where } j \in (c,d) n_L(w) = \frac{h_L(w)}{d(w)}$$
$$= \frac{L_L}{L_H} \frac{\delta\lambda}{\{\delta + \lambda[1 - F(w)]\}^2}.$$

We also see that capital costs can be written:

$$\gamma^j k_H^j h(w) = \gamma^{j^{-\frac{\eta}{1-\eta}}} (\eta p_H)^{\frac{1}{1-\eta}} \frac{L_L}{L_H} \left\{ \frac{\delta\lambda}{\delta + \lambda[1 - F(w)]^{\frac{2-\eta}{1-\eta}}} \right\}.$$

Using these equations where $j \in (c,d)$, inequality (B.27) can be rewritten as follows:

$$T > \Delta\pi^G = \left[ p_H \left( k_H^c \right)^\eta - p_H \left( k_H^d \right)^\eta \right] n(w) - \left[ \gamma^c k_H^c - \gamma^d k_H^d \right] h(w) = \left( \gamma^{c^{\frac{-\eta}{1-\eta}}} - \gamma^{d^{\frac{-\eta}{1-\eta}}} \right) \left( \eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}} \right) p_H^{\frac{1}{1-\eta}} \frac{L_L}{L_H} \frac{\delta\lambda}{\{\delta + \lambda[1 - F(w)]\}^{\frac{2-\eta}{1-\eta}}} \tag{B.28}$$

Since $\eta < 1$ by assumption, then $\eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}} > 0$. Also, since $\gamma^c < \gamma^d$, we can see that $\left( \gamma^{c^{-\frac{\eta}{1-\eta}}} - \gamma^{d^{-\frac{\eta}{1-\eta}}} \right) > 0$, so the right-hand side of inequality (B.28) is positive and is also increasing in the difference in the cost of capital between defaulting and compliant firms. We also note that a higher separation rate lowers $\Delta\pi^G$. Since the separation rate $d(w) = \delta + \lambda[1 - F(w)]$ is decreasing in the wage as we expect, this implies that, other things equal, a higher wage firm will have a lower separation rate and increase the profit of compliance relative to defaulting. It follows from this that Proposition 2 will continue to hold for this example.[25]

The equilibrium wage distribution can be solved as before by noting that the lowest wage firm will offer a wage of $p_L$ (that corresponds to the reservation wage of a low-ability worker) and solving for the profit of this firm. In equilibrium, all firms must make this level of profit:

$$\pi_H = \left\{ \left( \eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}} \right) \left[ \gamma^d (\delta + \lambda) \right]^{-\frac{\eta}{1-\eta}} p_H^{\frac{1}{1-\eta}} - p_L \right\} \frac{L_L}{L_H} \frac{\delta \lambda}{(\delta + \lambda)^2} > p_H \tag{B.29}$$

We must ensure that this level of profit is higher than the high-ability workers' outside option to ensure that high-ability workers choose to be managers in equilibrium. Similarly, we can use this condition to check that a low-productivity worker could never make more profit as a manager than as an own-account worker by replacing $p_H$ with $p_L$:

$$\pi_L = \left( \eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}} \right) \left[ \gamma^d (\delta + \lambda) \right]^{-\frac{\eta}{1-\eta}} p_L^{\frac{1}{1-\eta}} - p_L \frac{L_L}{L_H} \frac{\delta \lambda}{(\delta + \lambda)^2} < p_L \tag{B.30}$$

This condition can be re-arranged as

$$\left\{ \left( \eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}} \right) \left[ \frac{p_L}{\gamma^d (\delta + \lambda)} \right]^{\frac{\eta}{1-\eta}} - 1 \right\} \frac{L_L}{L_H} \frac{\delta \lambda}{(\delta + \lambda)^2} < 1 \tag{B.31}$$

We can check that this condition holds in equilibrium. We note that since all firms must make an equal profit, we can set this level of profit equal to that of any higher wage defaulting firm:

$$\pi_H = \left\{ \left( \eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}} \right) \gamma^{d - \frac{\eta}{1-\eta}} p_H^{\frac{1}{1-\eta}} \{ \delta + \lambda [1 - F(w)] \}^{-\frac{\eta}{1-\eta}} - w \right\} \frac{L_L}{L_H} \frac{\delta \lambda}{\{ \delta + \lambda [1 - F(w)] \}^2} \tag{B.32}$$

Using Equation (B.32), we can solve for the value of the wage in terms of the wage offer distribution for a defaulting firm:

$$w = \left\{ \left( \eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}} \right) \gamma^{d - \frac{\eta}{1-\eta}} p_H^{\frac{1}{1-\eta}} \{ \delta + \lambda [1 - F(w)] \} \right\}^{-\frac{\eta}{1-\eta}} - \pi_H \frac{\{ \delta + \lambda [1 - F(w)] \}^2}{\delta \lambda} \frac{L_H}{L_L} \tag{B.33}$$

Similarly, since all firms must make the same profit in equilibrium, we can also solve for the relationship between the wage offer distribution and the wage of a compliant firm by using the level of profit given in Equation (B.29) in the profit function of a compliant firm provided in Equation (B.25) and solving

$$w = \left\{ \left( \eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}} \right) \gamma^{c - \frac{\eta}{1-\eta}} p_H^{\frac{1}{1-\eta}} \{ \delta + \lambda [1 - F(w)] \} \right\}^{-\frac{\eta}{1-\eta}} - (\pi_H + T) \frac{\{ \delta + \lambda [1 - F(w)] \}^2}{\delta \lambda} \frac{L_H}{L_L} \tag{B.34}$$

Next, we need to ensure that some defaulting and non-compliant firms exist in equilibrium. We see that if inequality (B.28) is satisfied for the lowest wage firm, then there will be some defaulting firms. If it is violated for the highest wage firm, these firms will be compliant and there will be some other defaulting and compliant firms. We set $F(w) = 0$ for the lowest wage firm in inequality (B.28) and $F(w) = 1$ for the highest wage firm to get the following condition for the tax rate such that it is high enough so that some firms will default, but not too high so that there will be some compliant firms:

$$\left( \gamma^{c \frac{-\eta}{1-\eta}} - \gamma^{d \frac{-\eta}{1-\eta}} \right) \left( \eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}} \right) p_H^{\frac{1}{1-\eta}} \frac{L_L}{L_H} \frac{\delta \lambda}{(\delta + \lambda)^{\frac{2-\eta}{1-\eta}}} < T < \left( \gamma^{c \frac{-\eta}{1-\eta}} - \gamma^{d \frac{-\eta}{1-\eta}} \right) \left( \eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}} \right) p_H^{\frac{1}{1-\eta}} \frac{L_L}{L_H} \frac{\delta \lambda}{\delta^{\frac{2-\eta}{1-\eta}}} \tag{B.35}$$

Before plotting the equilibrium wage distribution, we can use inequality (B.28) to solve for the threshold value of the wage offer distribution $F(w) = F^*$ such that for values of the wage offer distribution that are higher/lower than the threshold level, the firm prefers complying/defaulting to defaulting/complying:

$$F^* = \frac{\delta+\lambda}{\lambda} - \frac{1}{\lambda}\left[\left(\eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}}\right) p_H^{\frac{1}{1-\eta}} \frac{L_L}{L_H} \delta\lambda\right]^{\frac{1-\eta}{2-\eta}} T^{-\frac{1-\eta}{2-\eta}} \left(\gamma^{c\frac{-\eta}{1-\eta}} - \gamma^{d\frac{-\eta}{1-\eta}}\right)^{\frac{1-\eta}{2-\eta}} \tag{B.36}$$

Figure B2 below graphs out the wage distribution and shows the cut-off above which firms are compliant for the parameter values assumed in Table B1.

We proceed by differentiating Equation (B.36) to calculate comparative static effects where

$$\frac{dF^*}{dT} = \frac{1-\eta}{2-\eta}\frac{1}{\lambda}\left[\left(\eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}}\right) p_H^{\frac{1}{1-\eta}} \frac{L_L}{L_H} \delta\lambda\right]^{\frac{1-\eta}{2-\eta}} \left(\gamma^{c\frac{-\eta}{1-\eta}} - \gamma^{d\frac{-\eta}{1-\eta}}\right)^{\frac{1-\eta}{2-\eta}} T^{\frac{-3+2\eta}{2-\eta}} > 0 \tag{B.37}$$

The comparative static result in Equation (B.37) shows that the fraction of wage offers and workers in non-compliant firms will increase with the tax rate. The comparative static result with respect to the cost of capital is given below:

$$\frac{dF^*}{d\gamma^d} = -\frac{1-\eta}{2-\eta}\frac{1}{\lambda}\left[\left(\eta^{\frac{\eta}{1-\eta}} - \eta^{\frac{1}{1-\eta}}\right) p_H^{\frac{1}{1-\eta}} \frac{L_L}{L_H} \delta\lambda\right]^{\frac{1-\eta}{2-\eta}} T^{-\frac{1-\eta}{2-\eta}} \left(\gamma^{c\frac{-\eta}{1-\eta}} - \gamma^{d\frac{-\eta}{1-\eta}}\right)^{\frac{-1}{2-\eta}} \frac{\eta}{1-\eta} \gamma^{d\frac{-1}{1-\eta}} < 0 \tag{B.38}$$

As we expect, an increase in the cost of capital in the defaulting firms reduces the share of offers from and workers in defaulting firms. The empirical results from the literature are mixed in terms of efforts to increase the share of formal firms. Floridi et al. (2020) present evidence from a meta-analysis that interventions encouraging firms to become formal have had little or no impact. Benhassine et al. (2018) present evidence from Benin that while providing information on how to become formal process had no impact, a wider range of policies aimed at enhancing the benefits of becoming formal did lead to a rise in the share of formal firms. However, there were no clear ex-post benefits to these firms from being formal. There are similar findings in de Mel et al. (2013) in that information on its own had little impact on the share of formal firms, while other incentives did lead to an increase in firms becoming

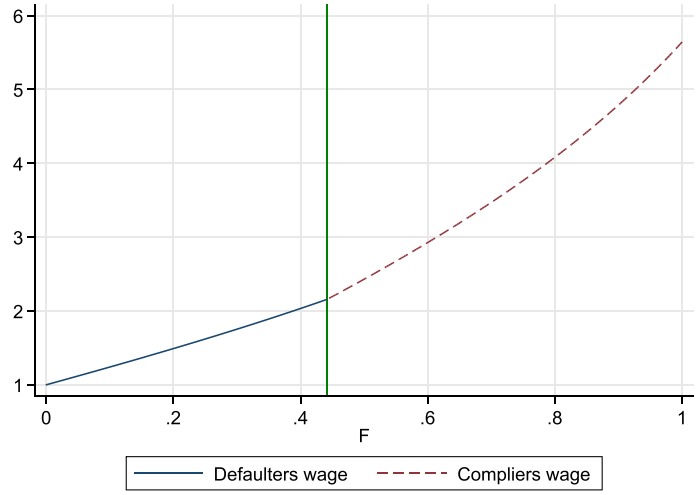


**FIGURE B2** Simulated wage offer distribution, compliant and non-compliant firms.

formal. The benefits of being formal were shown to be concentrated in a small number of high productivity firms. The results from de Andrade et al. (2014) also show that providing information support to firms to encourage them to become formal had little effect, while increasing inspection had a modest effect.

The evidence suggests that for many firms, not becoming formal was a deliberate choice and that they only became formal when inducements to do so were offered and often gained little from this. Arguably, these results show the importance of accounting for heterogeneity across firm productivity, as emphasised in the model we outlined earlier. This can also be seen in the comparative static results in Equations (B.37) and (B.38), where managerial productivity is a key determinant of the comparative static effect.

## APPENDIX C: STATISTICS FROM DEVELOPING COUNTRIES

**TABLE C1** Percentage of informal employment by firm size and by country.

| Country | Year | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|---|
| Afghanistan | 2021 | 86.9 | 90.1 | 69.3 | 52.5 | 50.2 | 43.7 | 86.4 |
| Angola | 2021 | 98.4 | 97.6 | 76.5 | 51.5 | 29.9 | 20 | 90.3 |
| Burkina Faso | 2018 | 99.2 | 97.7 | 94.7 | 92.3 | 85.5 | 79.8 | 95.7 |
| Bolivia | 2019 | 89.8 | 92.5 | 85.7 | 55.1 | 33.9 | 44.9 | 81.5 |
| Botswana | 2020 | 99.1 | 88.7 | 80.4 | 80.2 | 66.4 | 57.7 | 74 |
| Côte d'Ivoire | 2017 | 92.5 | 91.9 | 87.3 | 74.9 | 65.1 | 68 | 86.7 |
| Colombia | 2021 | 94.7 | 81.5 | 54.5 | 35.7 | 22.5 | 9.8 | 63.2 |
| Costa Rica | 2021 | 78.6 | 65.5 | 33.2 | 16 | 7.6 | 4.4 | 40.8 |
| Dominican Republic | 2021 | 95.5 | 77.5 | 43.5 | 15.6 | 5.6 | 2.2 | 57.3 |
| Ecuador | 2021 | 79.4 | 88.1 | 84.1 | 58.4 | 39.3 | 7.7 | 68.6 |
| Egypt | 2019 | 61.7 | 72.5 | 68.5 | 39.7 | 19 | 15.8 | 67 |
| Guatemala | 2019 | 99.3 | 97.3 | 80.5 | 61.7 | 49.1 | 29 | 79 |
| Guyana | 2019 | 78.4 | 73.3 | 57.5 | 34.3 | 17 | 10.8 | 50 |
| Honduras | 2017 | 98.8 | 90.2 | 72.9 | 57 | 62 | 38 | 82.6 |
| Jordan | 2021 | 89.6 | 77.3 | 72.4 | 43.3 | 20.8 | 30.7 | 51.6 |
| Kenya | 2019 | 97.3 | 94.1 | 74.5 | 53.3 | 43.1 | 23.9 | 86.5 |
| Cambodia | 2019 | 96 | 95.8 | 92.3 | 87.4 | 73 | 59 | 89.4 |
| Lebanon | 2019 | 83.1 | 73.6 | 57.4 | 39.3 | 31.4 | 18.5 | 55.4 |
| Liberia | 2017 | 93.7 | 88 | 81.6 | 77.9 | 70 | 55.5 | 89.6 |
| Mexico | 2021 | 96.6 | 90.7 | 57.2 | 32.8 | 18.9 | 7.8 | 57.1 |
| Mali | 2020 | 92.1 | 95.7 | 98.2 | 97.1 | 85.7 | 62 | 94 |
| Mongolia | 2021 | 79.2 | 85.8 | 31.6 | 10.7 | 6.4 | 2.9 | 43.2 |
| Mauritania | 2017 | 98.4 | 98 | 97.5 | 94.6 | 87.4 | 74.9 | 94.5 |
| Niger | 2017 | 89.3 | 75.5 | 36.6 | 20.1 | 3.7 | 10.7 | 73.6 |
| Pakistan | 2021 | 89.5 | 86.1 | 87 | 80.4 | 82.1 | 81.7 | 84.3 |
| Panama | 2021 | 95.8 | 89.2 | 63.5 | 31 | 24.6 | 8.1 | 55.7 |
| Peru | 2021 | 87.5 | 86.5 | 75.5 | 47.7 | 32.2 | 13.2 | 68.4 |
| Paraguay | 2021 | 87.7 | 83.7 | 60.4 | 42.8 | 30.5 | 19.4 | 69.3 |
| Palestine | 2021 | 63 | 80.1 | 65.7 | 44.7 | 19.8 | 11 | 51 |

**TABLE C1** (Continued)

| Country | Year | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|---|
| Rwanda | 2020 | 81.9 | 91.8 | 91.3 | 68.1 | 58.4 | 51.1 | 85.8 |
| Senegal | 2019 | 99.6 | 98.8 | 96.3 | 77.2 | 49.1 | 46.1 | 90.2 |
| El Salvador | 2021 | 97.1 | 94.7 | 78.5 | 62.3 | 48.9 | 43.9 | 69 |
| Somalia | 2019 | 87.6 | 81.2 | 77 | 72.9 | 74.1 | 70.1 | 82.5 |
| Seychelles | 2020 | 34.2 | 24.9 | 19.1 | 7.9 | 14.1 | 5.4 | 17 |
| Togo | 2017 | 98.6 | 95.3 | 91 | 65.6 | 81.7 | 66.7 | 90.1 |
| Tonga | 2018 | 94.9 | 86.7 | 75.5 | 63.6 | 54.6 | 43.3 | 81 |
| Uruguay | 2020 | 60.8 | 33.6 | 11 | 4.4 | 2 | 0.4 | 21.9 |
| Venezuela | 2017 | 94.1 | 76.6 | 50.7 | 37.3 | 21 | 25.4 | 58.3 |
| Vietnam | 2020 | 91.2 | 93.1 | 87.9 | 56.2 | 23.7 | 10.6 | 69.2 |
| Samoa | 2017 | 60.2 | 45.3 | 22.6 | 16.2 | 7.4 | 2.5 | 52.4 |
| South Africa | 2021 | 83.9 | 58.9 | 32.6 | 16.9 | 12.7 | 8.1 | 41.6 |
| Zambia | 2017 | 91.8 | 89.8 | 68 | 39.3 | 29.3 | 18.3 | 76.9 |
| Zimbabwe | 2019 | 95.3 | 92.5 | 85.2 | 71.5 | 69.4 | 51 | 88.2 |

*Notes*: (i) Columns 1–6 show the percentage of informal employment in firms composed of 1 worker, 2–4 workers, 5–9 workers, 10–19 workers, 20–49 workers, and 50 or more workers, respectively. (ii) Column (7) shows the percentage of informal employment across all firm sizes. (iii) The data considered are the most recent ones (2017 onwards) and correspond to the countries with no missing values for the seven columns; (iv) Source: ILO Statistics (period 2017–2021).

**TABLE C2** Access to capital for informal firms, by country and firm size.

| | (a) Internal funds | (b) External funds | (c) High interest rates | (d) Registering benefit |
|---|---|---|---|---|
| Total sample | 0.912 | 0.106 | 0.337 | 0.654 |
| By country | | | | |
| Angola | 0.946 | 0.027 | 0.270 | 0.703 |
| Argentina | 0.821 | 0.009 | 0.208 | 0.708 |
| Botswana | 1 | 0.037 | 0.148 | 0.815 |
| Burkina Faso | 0.981 | 0.056 | 0.204 | 0.907 |
| Cameroon | 0.879 | 0.052 | 0.259 | 0.707 |
| Congo | 0.976 | 0.004 | 0.372 | 0.560 |
| Ghana | 0.965 | 0.035 | 0.557 | 0.652 |
| Guatemala | 0.859 | 0.047 | 0.531 | 0.609 |
| Kenya | 0.896 | 0.203 | 0.426 | 0.805 |
| Lao | 1 | 0 | 0.818 | 0.591 |
| Mali | 0.925 | 0.025 | 0.275 | 0.725 |
| Mozambique | 0.775 | 0.306 | 0.425 | 0.381 |
| Nepal | 0.976 | 0.167 | 0.190 | 0.476 |
| Peru | 0.926 | 0.018 | 0.411 | 0.748 |
| Rwanda | 0.938 | 0.008 | 0.038 | 0.938 |
| Zambia | 0.910 | 0.428 | 0.198 | 0.455 |

(Continues)

**TABLE C2** (Continued)

| | (a) Internal funds | (b) External funds | (c) High interest rates | (d) Registering benefit |
|---|---|---|---|---|
| Zimbabwe | 0.895 | 0.017 | 0.280 | 0.657 |
| By firm size | | | | |
| 1 worker | 0.904 | 0.112 | 0.348 | 0.639 |
| 2–4 workers | 0.914 | 0.102 | 0.333 | 0.655 |
| 5–9 workers | 0.951 | 0.104 | 0.293 | 0.713 |
| 10–19 workers | 0.879 | 0.061 | 0.333 | 0.758 |
| 20–49 workers | 0.875 | 0.000 | 0.250 | 0.625 |

*Notes*: (i) The sample with non-missing information on firm's access to capital is composed of 2209 firms in 17 countries. (ii) There are no firms with 50 workers or more. (iii) Columns refer, respectively, to (a) firms financing the day-to-day operations by using internal funds, (b) firms financing the day-to-day operations by using external funds, (c) firms not applying for loans because of high interest rates, and (d) firms considering better access to markets as the main benefit of being registered.

**TABLE C3** Coverage of unemployment benefits (% of population).

| Country | Year | Unemployment coverage |
|---|---|---|
| Angola | 2018 | 3.22 |
| Argentina | 2019 | 1.41 |
| Bolivia | 2019 | 0.77 |
| Botswana | 2015 | 6.23 |
| Burkina Faso | 2018 | 1.14 |
| Chile | 2017 | 22.32 |
| Costa Rica | 2019 | 21.70 |
| Ecuador | 2019 | 1.49 |
| El Salvador | 2019 | 1.78 |
| Eswatini | 2016 | 2.80 |
| Gabon | 2017 | 3.35 |
| Indonesia | 2019 | 9.13 |
| Jamaica | 2017 | 3.14 |
| Lesotho | 2017 | 1.58 |
| Liberia | 2016 | 1.63 |
| Mauritius | 2017 | 5.57 |
| Namibia | 2015 | 2.83 |
| Nigeria | 2018 | 0.78 |
| Pakistan | 2018 | 6.93 |
| Panama | 2019 | 1.65 |
| Turkey | 2019 | 1.83 |
| Uruguay | 2019 | 2.71 |
| Zimbabwe | 2019 | 1.54 |

*Source*: World Development Indicators. We report data on a sample of countries with available information since 2016 and for the most recent available year.

**TABLE C4** Share of self-employed and unemployed in a range of countries.

| Region/country | (1) | (2) | Region/country | (1) | (2) |
|---|---|---|---|---|---|
| Niger | 95.06 | 0.46 | Ghana | 72.25 | 4.12 |
| Central African Republic | 93.16 | 4.04 | Bhutan | 72.11 | 2.27 |
| Chad | 92.61 | 1.91 | Gambia | 72.01 | 8.94 |
| Guinea | 91.89 | 4.14 | Cote d'Ivoire | 70.93 | 3.17 |
| Somalia | 91.67 | 12.79 | Timor-Leste | 69.12 | 4.42 |
| South Sudan | 91.57 | 12.01 | Zimbabwe | 68.75 | 5.02 |
| Sierra Leone | 90.35 | 4.36 | Bolivia | 68.25 | 3.46 |
| Equatorial Guinea | 88.41 | 7.95 | Rwanda | 66.29 | 0.99 |
| Benin | 88.10 | 2.32 | Myanmar | 64.92 | 0.50 |
| Madagascar | 87.84 | 1.67 | Senegal | 63.67 | 6.47 |
| Eritrea | 86.20 | 6.34 | Malawi | 62.10 | 5.56 |
| Burundi | 85.80 | 1.42 | Bangladesh | 59.27 | 4.22 |
| Burkina Faso | 85.69 | 4.62 | Pakistan | 56.32 | 3.98 |
| Mozambique | 84.28 | 3.19 | Peru | 55.46 | 3.03 |
| Ethiopia | 84.15 | 2.04 | Yemen | 55.03 | 12.9 |
| Tanzania | 83.68 | 1.96 | Sudan | 54.35 | 16.76 |
| Afghanistan | 82.19 | 10.98 | Vietnam | 54.30 | 2.04 |
| Guinea-Bissau | 81.31 | 2.79 | Indonesia | 51.75 | 3.62 |
| Mali | 80.38 | 7.24 | Ecuador | 51.23 | 3.81 |
| Nigeria | 79.87 | 8.53 | Thailand | 50.28 | 0.72 |
| Congo | 79.48 | 4.13 | Honduras | 50.18 | 5.57 |
| Liberia | 78.75 | 2.89 | Colombia | 49.57 | 9.96 |
| Angola | 78.51 | 6.93 | Kenya | 49.27 | 2.60 |
| Congo, Rep. | 78.36 | 9.60 | Morocco | 48.56 | 9.01 |
| Nepal | 77.34 | 2.85 | Mongolia | 48.53 | 5.31 |
| Uganda | 77.32 | 1.72 | Tonga | 47.52 | 3.01 |
| Togo | 76.43 | 3.60 | Iran | 47.22 | 11.14 |
| India | 75.83 | 5.27 | Lesotho | 47.06 | 23.86 |
| Papua New Guinea | 74.80 | 2.37 | Cambodia | 47.05 | 0.13 |
| Lao PDR | 74.72 | 0.62 | China | 44.66 | 4.60 |
| Cameroon | 74.39 | 3.32 | Venezuela | 43.63 | 7.16 |
| Haiti | 73.51 | 13.48 | Paraguay | 43.01 | 6.60 |
| Zambia | 73.45 | 11.91 | Nicaragua | 42.70 | 5.14 |
| East Asia and Pacific | 43.51 | 3.86 | High income | 12.16 | 4.80 |
| South Asia | 71.60 | 5.04 | Low and middle income | 53.97 | 5.50 |
| Sub-Saharan Africa | 74.99 | 6.28 | Low income | 80.33 | 4.61 |
| Latin America and Caribbean | 37.86 | 7.99 | OECD members | 16.34 | 5.39 |
| World | 46.49 | 5.37 | | | |

*Note*: We report, in column (1), the share of self-employed (% of total employment) and, in column (2), the share of unemployed (% of total labour force) in 2019. Source: World Development Indicators.