Contributions

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Financing Infrastructure in the Presence of Informality

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Abstract: Public infrastructure investment plays a pivotal role in fostering economic development, yet low-income countries characterized by high informality make limited investments. The literature underscores that informality induces maintaining tax rates low, depleting the already limited funds available for public infrastructure. Within a framework that accounts for heterogeneous labor, we study the optimal labor-income taxation aimed at financing infrastructure. We develop the analysis with and without the presence of a binding legal minimum wage. Our findings reveal that the minimum wage increases the optimal tax rate, raises the income (and income share) of low-skilled workers, and induces higher infrastructure investments for a wide range of parameter settings. Furthermore, we show that in the presence of minimum wage, no clear relationship emerges between the beneficial impact of infrastructure on informal sector productivity and the share of the informal economy.

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1 Introduction

The primary aim of this paper is to examine the impact of a binding legal minimum wage on the relationship between optimal labor-income taxation and infrastructure investment in developing countries characterized by low per-capita income and high share of informal employment. We find that the presence of a minimum wage increases the optimal labor-income tax rate, facilitating infrastructure accumulation under a wide range of calibrations. The consequent wage segmentation among formal and informal workers increases the size of the informal sector but reduces income inequality. In this scenario, the accumulation of infrastructure that increases productivity in both the formal and informal sectors does not necessarily result in an expansion of the informal sector's share.

Although public infrastructure matters for GDP growth and welfare improvement, the level of infrastructure is critically low in developing countries. Lin and Doemeland (2012) report that almost one billion and a half people have no access to electricity, while Rozenberg and Fay (2019) estimate that 663 million people do not have access to clean drinking water and more than 1 billion people reside more than 2 km away from an all-season road, facing the high cost of transport services that limit employment and educational opportunities.

Infrastructure investment requires a high amount of financial resources but developing countries have low tax revenues varying between 10 % and 20 % of GDP, while the average value is close to 40 % in developed countries (Besley and Persson 2014). The low capacity of collecting financial resources is often connected to the high share of informal employment, about 70 % (Elgin et al. 2021), reported in many developing countries. Indeed, La Porta and Shleifer (2014) show that both the intensive and extensive margins of the taxable income are lower in developing countries, with many economic activities lurking in the informal sector.

Notwithstanding the relevant size of the informal economy, the proportion of low-income countries adopting minimum wage legislation has been on the rise over

Figure 1: Minimum wages, informal employment share, and tax revenues (percentage of GDP) in developing countries. Both figures consider countries classified as low income (World Bank) and that adopt minimum wage regulation (values in PPP on the *x*-axis) over the 1995–2019 period. On the *y*-axis, Figure 1a reports an estimate of the informal employment share (Elgin et al. 2021) while Figure 1b reports the tax revenue as a percentage of GDP (World Development Indicators, World Bank).

time.[1] This share moved from about 20 % in 1995, to about 50 % in 2005, to exceed 70 % in the recent years. The presence of a binding minimum wage is expected to stimulate workers to join the formal sector but, at the same time, to increase labor costs and decrease labor demand in the formal sector. Consequently, labor market segmentation and higher involuntary informal employment might emerge. Indeed, if we report the joint distribution of minimum wage and informal employment share in low-income countries, as in Figure 1a, a positive relationship emerges.[2] By reducing the number of workers in the formal sector, the minimum wage is expected to reduce the tax base, limiting the government's resources, including those for infrastructure investment. In spite of such prediction, data reported in Figure 1b do not signal the existence of a negative relationship between minimum wage and tax revenue.[3]

Starting from these considerations and empirical evidence, we build a two-sector (formal and informal) model with heterogeneous labor (low- and high-skilled labor) where labor-income taxation funds infrastructure investment. We

1 Data on minimum wages come from the International Labour Organization (ILO) spanning the years 1995–2019. To identify countries with minimum wage regulations, we consider those for which ILO provides a minimum wage value. Our focus is on countries classified as low-income countries, according to the World Bank classification, and we calculate the percentage of such countries with minimum wage regulations for each year.

2 Minimum wages are measured in PPP. Estimates of the informal employment shares are taken from Elgin et al. (2021) database. We report all the available observations for each country.

3 The tax revenue as a percentage of GDP is taken from the World Bank database.

assume that the informal sector employs only low-skilled workers and we distinguish among two types of informality regimes according to the presence or not of a binding legal minimum wage, see Loayza (2016). When the government does not enforce any minimum wage (labeled the *unregulated* regime), the size of the informal sector results from an arbitrage condition, with low-skilled workers earning the same remuneration in both sectors (after-tax for formal workers). When a sufficiently high minimum wage is introduced (labeled the *regulated* regime), low-skilled workers' net wage is higher in the formal sector, and the sensitivity of formal employment to infrastructure increases. We show that the last element is crucial in shaping the optimal tax rate.

Through analytical solutions and numerical simulations, we analyze how the optimal tax rate varies according to the informality regime and report how other aggregate variables react. We show that the optimal tax rate is higher in the regulated regime and increases with the minimum wage, as the direct effect of taxation on net wages does not drive workers away from the formal sector. By increasing the labor cost in the formal sector, the minimum wage implies a higher informal-sector share, misallocation of labor services, and lower consumption. Conversely, the minimum wage can induce an increase in infrastructure investment as the decrease in the tax base is offset by an upward adjustment of the optimal tax rate. Concerning income distribution, the introduction of a minimum wage positively affects low-skilled workers but is detrimental to high-skilled workers, who suffer from the adverse effects of higher taxation and a lower number of low-skilled workers in the formal sector (as they represent a complementary input of production).[4]

Throughout the entire analysis, we pay particular attention to the impact of infrastructure on informal sector productivity. In the unregulated regime, as highlighted in most of the literature (for example, Mitra 2017), this element defines the competitiveness of the informal (inefficient) sector with respect to the formal (efficient) sector. On the contrary, the presence of minimum wage amplifies the overall impact of infrastructure on the production frontier without decreasing the size of the formal sector. We show that such difference has particularly strong implications for the welfare analysis and the determination of the informal sector share.

The rest of the paper is organized as follows. The next section discusses the related literature. Section 3 describes the model, highlighting the difference between regulated and unregulated regimes. Section 4 describes and solves the optimal taxation problem faced by a benevolent social planner. Section 5 shows and discusses steady-state results. Section 6 describes the transition path towards the steady state when the economy starts from low levels of infrastructure and

4 Our results are in line with Gindling (2018) who suggests that minimum wage may be a useful tool for reducing poverty in developing countries.

when the economy moves from the unregulated to the regulated regime. Section 7 concludes.

2 Related Literature

Our paper ties together various areas of research. First, we relate to the literature on the role of infrastructure investments in economic development. Second, we contribute to the literature that studies optimal taxation in presence of high informality. Lastly, we explore how minimum wage regulation affects optimal tax policies in less developed countries. In this section, we briefly introduce each of these research areas, highlighting their connection to our work.

As outlined in the Introduction, developing countries invest little in public infrastructure.[5] This can significantly hinder economic development, as a substantial body of evidence demonstrates the critical role of infrastructure investments in driving economic growth. Evidence of the positive impact of infrastructure on development emerges from studies relying on both cross-country regressions (Calderon and Servén 2010; Calderón et al. 2015) and quasi-natural experiments (Duflo and Pande 2007; Wang and Wu 2015). Since Aschauer (1989), many papers have tried to assess the elasticity of aggregate output to public infrastructure. The meta-analysis of Bom and Ligthart (2014) indicates that the long-run elasticity of GDP to core infrastructure is equal to 0.17 and the average output elasticity to public capital is equal to 0.10. Chatterjee et al. (2021) contribute to the literature estimating the effect of infrastructure investments differentiating among formal and informal firms. While confirming a positive relationship between infrastructure and formal firm productivity, they find no impact on informal firms. In line with these estimates and previous contributions (for example, Loayza 1996; Mitra 2017), we assume that formal firms are *better at exploiting* infrastructure than informal firms. Our analysis shows that the magnitude of this gap has significant implications for the optimal tax rate, the welfare analysis, and the reaction of the informal sector's size to changes in the tax rate.

Concerning the financing of public infrastructure, Barro (1990) indicates that, in the absence of an informal sector, the optimal tax rate equals the elasticity of aggregate output to public services. Glomm and Ravikumar (1994) obtain a similar result but amend the "*Barro rule*" by taking into account the representative

5 Fay et al. (2019) present updated estimates of infrastructure spending, utilizing novel data sources and integrating various datasets. They calculate that spending on infrastructure in low- and middle-income countries, excluding China, amounts to 5 % of GDP. Notably, Sub-Saharan countries have the lowest estimate, with infrastructure spending accounting for 3.86 % of GDP.

agent's discount factor.[6] With respect to this line of research, we are interested in examining how the presence of a large informal sector influences tax policies. Several papers (Ihrig and Moe 2004; Amaral and Quintin 2006; Loayza 1996), suggest that high informality rates imply lower optimal tax rates, as workers may escape taxation and the informal sector share is inversely related to tax on employment (Saracoğlu 2008). Indeed, less developed countries are characterized by extremely high levels of informality that, as outlined in Turnovsky and Basher (2009), may trap developing countries in a sort of a *recursive fiscal dilemma*. This occurs when an increase in the tax rate leads to a more than proportional decrease in the tax base. As a result, the government becomes unable to raise sufficient resources to fund infrastructure projects.

Notably, there is mixed empirical evidence concerning the effect of tax rates on the informal sector. On the one hand, Schneider (2005) identifies taxation as one of the main determinants of the informal sector size, Djankov et al. (2010) find that 10 percentage point increase in the first-year effective tax rate incurred by formal firms raises the informal economy share by nearly 2 percentage points. Similarly, Dabla-Norris et al. (2008) report a positive relationship between taxation and the share of the informal economy that falls as long as the quality of the legal system improves. On the other hand, in line with the early evidence of Johnson et al. (1997), Mitra (2017) does not find any systematic relationship between the informal-sector share and income tax revenue for developing countries. Mitra (2017) explains this mixed evidence by arguing that higher taxation may result in lower (higher) informality when either the credit markets or the level of enforcement are well (less) developed.[7]

One of the factors affecting the relationship between taxation and informality is represented by the degree to which informal firms can exploit infrastructure. Both Loayza (1996) and Mitra (2017) show that the more informal firms can take advantage of public goods the larger the informal sector's size. Our contribution confirms this positive relationship, but only in the unregulated regime. Concerning

6 Analytical solutions of their model require some specific assumptions: log utility, Cobb-Douglas technology, uniform tax rate on capital and labor income, and full depreciation of private and public capital.

7 Mitra (2017) assumes the tax rate as an exogenous element and primarily focuses on the role of enforcement policies, showing that the productivity of government expenditure does not affect the threshold level of enforcement, which determines the sign of the effect of taxation on informal sector share. A vast literature (for example, Ihrig and Moe 2004) suggests that more effective enforcement policies reduce the informal sector share, but our analysis leaves aside the role of this institutional element.

the impact on the optimal tax rate, Loayza (1996) finds that the ability of informal firms to benefit from public infrastructure reduces the optimal tax rate.[8]

Our analysis points out that the presence or absence of a binding minimum wage has significant descriptive and normative implications. Boeri et al. (2011) provide evidence of the varying levels of minimum wages, assessed in relation to the average wage. However, legal provisions may not always be effectively enforced in developing countries.[9]

The different levels of the minimum wage, along with differences in its enforcement, may explain why the empirical literature obtains mixed results about the existence and magnitude of a wage penalty incurred by informal workers. For example, Magnac (1991) and Maloney (1999) do not find evidence of rationing for formal jobs. On the contrary, García (2017) reports mixed evidence suggesting that voluntary and involuntary informal employment co-exist, while Tansel et al. (2020) find that informal workers incur a persistent penalty. In our analysis, in line with these heterogeneous and sometimes conflicting findings, we consider different values of the minimum wage (which determines the wage penalty for informal workers). However, we assume that, once accounted for, the minimum wage is binding and fully enforced in the formal sector.[10]

An important reference to our analysis is Loayza (2016). In both Loayza (2016) and our paper, workers consume all available resources in each period, a plausible assumption in poor developing countries. In Loayza (2016), capitalists choose the optimal accumulation of private capital, while we assume that the Social Planner determines the optimal accumulation of public infrastructure through taxation. Similarly to Loayza (2016), a binding legal minimum wage stimulates the accumulation of (private or public) capital and, through this channel, positively affects the remuneration of workers in the informal sector. However, our setting introduces a further distortion between formal and informal sectors, as the former provides the financial resources for infrastructures, which also benefits the latter. Furthermore, it is worth mentioning that our approach does not consider other two mechanisms that may affect the relationship between the minimum wage and the remuneration in the informal sector in opposite directions. On the one hand, if decreasing marginal productivity of labor is assumed in the informal sector, as in Ham (2018) and Saraçoğlu (2020), increases in the minimum wage reduce informal workers'

8 In our framework, this result does not hold because, unlike Loayza (1996), we account for the congestion effect by normalizing infrastructure with respect to the total number of workers rather than the total output.

9 See Munguía (2019), Gindling (2018).

10 In our framework, the employment effect of the minimum wage is negative for the formal sector, consistently with Jales (2018) and Arango and Rivera (2022), although we acknowledge that other studies, such as Lemos (2009), did not detect this effect.

income by shifting employment towards the informal sector. On the other hand, our model does not incorporate the *lighthouse effect* (Maloney and Mendez 2004), which posits that an increase in the minimum wage would positively affect remuneration in the informal sector.

We acknowledge that by disregarding private capital accumulation, our approach may overlook some relevant general equilibrium mechanisms (Chatterjee et al. 2022). However, it is worth noting that models without private capital are not uncommon in this literature, see Docquier et al. (2017) and Docquier and Iftikhar (2019), and that the absence of private capital significantly streamlines our analysis. Besides, in small open economies with unrestricted capital mobility, see Ortega and Peri (2014) and Groneck and Kaufmann (2017), capital naturally flows, keeping the capital/labor ratio constant.

3 Theoretical Framework

We consider an economy where two productive sectors, formal and informal, produce a homogeneous good using two different production technologies.[11] The formal sector represents the official (or recorded) economy. Following Docquier et al. (2017), we define the informal economy as the part of the production that escapes taxation and does not fulfill government regulation.[12] Although unrecorded activities exist in most of economies, the nature of informality differs between developed and developing countries. In developed countries, (almost) the same production technology characterizes informal/unreported and formal/declared activities. In developing countries, informal and formal firms are inherently different and operate according to different technologies. This view dates back to Lewis (1954) where the dual-sector model is outlined.[13] A characterizing element of the dual theory is

11 In line with Ihrig and Moe (2004) the informal sector does not include the criminal sector (which produces illegal goods, such as drugs).

12 Several definitions of the informal sector exist, see Gerxhani (2004). The definition used in this paper is similar to the one suggested in Feige (1981), "*all economic activities which because of accounting conventions, non-reporting or under-reporting, escape the social measurement apparatus, most notably the national accounts*".

13 The dual-sector model is still the dominant approach to formalize informal activities in low-income countries, see La Porta and Shleifer (2014). However, there are competing theories on the impact of informal sector activities on development. On the one hand, De Soto (1988) considers the informal sector as a reservoir of entrepreneurial energy held back by government regulations; inciting these firms to become formal would be beneficial for development. On the other hand, Farrell (2004) recommends a suppression of the informal sector, considering informal firms as those violating government regulations and unfairly competing with legal firms. Ulyssea (2018) develops a framework able to comprise different theories, showing that each one is the result of the behavior of heterogeneous firms.

that the informal sector uses a low-skill technology and serves as a subsistence sector for many individuals. The necessity to escape extreme poverty explains why a significant fraction of low-skilled workers join informal activities. A direct implication of the dual theory is that, above a certain level of development, the subsistence part of the informal sector disappears and the main motive to act informally is to elude taxes. Our framework captures both mechanisms generating informality.

3.1 Workers

As in Docquier et al. (2017), two types of working-age individuals populate our economy: (*i*) High-skilled workers (*H*), who have higher education and work only for formal firms; (*ii*) Low-skilled workers (*L*), who have lower level of education and may work either for formal or informal firms. We assume that the population is constant in its level and structure, with the skill ratio in the economy defined as $z \equiv \frac{H}{L}$.[14]

Workers distribute in the same proportion in each household and share their income. In our model, we assume that individuals do not smooth consumption across periods. Specifically, they are modeled as non-Ricardian or rule-of-thumb consumers, who spend all of their disposable income within each period. This assumption rules out individuals' intertemporal optimization and is similar to the approach used by Loayza (2016), as discussed in Section 2.[15] As there is no private saving, the entire after-tax income is used to consume the homogeneous good, *C*, and the utility function is described by a logarithmic function, an assumption that will be exploited in Section 4.

3.2 Production

Formal and informal firms produce the same homogeneous good but through different technologies. The production technology does not include private capital, featuring an economy without restriction on capital mobility and a common international interest rate. In such an economy, savings decisions are a function only of the international interest rate leaving the private capital-labor ratio constant.[16] Formal firms produce according to the following Cobb-Douglas production function:

14 The optimal taxation problems are more tractable under the assumption of a constant population. However, our main results do not depend on this assumption.

15 Studies focusing on developed countries have reported evidence of a significant proportion of non-Ricardian or rule-of-thumb consumers, see (Mankiw 2000; Menna 2016).

16 Ortega and Peri (2014) find that capital adjustments are rapid in open economies. This hypothesis is widely used in the literature (Kennan 2013; Klein and Ventura 2009; Delogu et al. 2018; Docquier and Iftikhar 2019; Carroni et al. 2023) to motivate the small open economy assumption.

$$Y_{f,t} = A_{f,t} H^{\alpha} L_{f,t}^{1-\alpha}, \tag{1}$$

where the subscript f identifies the formal sector and t defines the time period. $Y_{f,t}$ is the output of formal sector firms, $A_{f,t}$ is the Total Factor Productivity (TFP), $L_{f,t}$ is the number of low-skilled workers in the formal sector, while α and $1 - \alpha$ (with $0 < \alpha < 1$) represent the elasticity of formal sector output to high-skilled and low-skilled labor. The TFP in the formal sector is a function of the stock of infrastructure, k_t:

$$A_{f,t} = A k_t^{\epsilon}, \tag{2}$$

where the parameter A captures the productivity level and ε is the elasticity of formal sector TFP (and formal sector output) to infrastructure.

As Docquier et al. (2017) and Loayza (1996), the informal sector, i, uses the following production function:[17]

$$Y_{i,t} = A_{i,t} L_{i,t}, \tag{3}$$

where $Y_{i,t}$ is the output, $L_{i,t} = L - L_{f,t}$ is the level of employment in the informal sector, and the TFP, $A_{i,t}$, is given by:

$$A_{i,t} = B k_t^{\eta} \tag{4}$$

is the informal sector TFP. In line with the literature, informal firms are less productive than formal ones. In our framework, we capture this stylized fact in two ways. First, we assume that the exogenous productivity factor, B, is lower than A, as in Docquier and Iftikhar (2019). Second, we assume that informal sector firms have lower capacity to benefit from infrastructure, thus $\eta < \varepsilon$.[18]

Formal firms operate in a competitive market and aim to maximize profits, $\Pi_{f,t}$, defined as:

$$\Pi_{f,t} = Y_{f,t} - w_{h,t}^{g} H - w_{l,f,t}^{g} L_{f,t}, \tag{5}$$

where $w_{h,t}^{g}$ is the gross (before taxes) high-skilled workers' wage while $w_{l,f,t}^{g}$ is the gross wage paid to low-skilled workers. Assuming competitive labor markets, gross wages equal labor productivity for each type of worker, in each sector. Therefore, high-skilled workers receive the following net wage:

$$w_{h,t} \equiv (1 - \tau_t) w_{h,t}^{g} = (1 - \tau_t) \alpha A_{f,t} z_{f,t}^{\alpha - 1}, \tag{6}$$

17 As low-skilled workers are the only factor of production chosen by the firms, the linearity assumption in labor services grants constant returns to scale, consistent with a perfect market competition framework.

18 Alternatively, rather than assuming lower elasticity of output to infrastructure, informal firms might use only a fraction of infrastructure, as in Loayza (1996).

where $z_{f,t} \equiv \frac{H_t}{L_{f,t}}$ is the skill ratio in the formal sector and τ_t is the tax rate on formal-sector workers' wage. In the unregulated regime, a similar condition defines the low-skilled workers' net wage:[19]

$$w_{l,f,t} \equiv (1-\tau_t) w^g_{l,f,t} = (1-\tau_t)(1-\alpha) A_{f,t} z^{\alpha}_{f,t}. \tag{7}$$

In the regulated regime, the gross wage of formal low-skilled workers is enforced to be equal to the minimum wage, which we label $w_{\min}$.[20] The formalization of the informal sector aligns with either the assumption of a competitive labor market or the assumption of informal workers operating as self-employed individuals. It follows that their remuneration is:

$$w_{l,i,t} = B k_t^{\eta}. \tag{8}$$

Finally, the government funds public infrastructure by taxing formal workers at the rate τ_t. Eq. (9) defines the accumulation of the infrastructure stock:

$$k_{t+1} = \frac{\tau_t Y_{f,t}}{(L+H)} + (1-\delta) k_t. \tag{9}$$

To account for congestion, see Loayza (1996) and Glomm and Ravikumar (1994), infrastructure is normalized to the labor force.[21] We assume that infrastructure depreciates at a constant rate, δ, and, in line with Futagami et al. (1993) and Glomm and Ravikumar (1994), infrastructure investments are not immediately productive. From now on, we restrict our analysis to the case that a positive level of informality is always present. As outlined in Section A.2 of the Appendix, this requires the share of skilled workers to be sufficiently low. In our framework, when the skill ratio is larger than a certain threshold, the informal technology becomes not sufficiently productive, and all workers join the formal economy.[22]

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19 Our analysis focuses on the case when the high-skilled workers' wage is always greater than the low-skilled one. In the Appendix, see Section A.2, we determine the conditions for having $w_{h,t} > w_{l,f,t}$.

20 From now on, we assume that the minimum wage is binding. This assumption is in line with Gindling (2018) who shows that minimum wages are way above the national poverty line in many developing countries.

21 Differently from Loayza (1996), we assume that congestion is a feature of the overall economy, not only of the informal sector.

22 Docquier et al. (2017), analyses the interplay between education choices and informality, while in our paper, we focus on infrastructure-enhancing policies disregarding human capital accumulation.

3.3 Informality Regimes: *Unregulated* versus *Regulated*

Low-skilled workers join the informal sector either if formal firms cannot offer a salary higher than the one paid by informal firms, unregulated regime, or if enforcing a minimum wage in the formal sector induces a shortage of formal jobs, regulated regime. In the unregulated regime, $L_{f,t}$ adjusts until the net wage paid in the formal sector equals the remuneration in the informal sector. It follows that the number of low-skilled formal workers is:

$$L_{f,t} = H\left(\frac{A(1-\tau_t)(1-\alpha)k_t^{\varepsilon-\eta}}{B}\right)^{\frac{1}{\alpha}}. \tag{10}$$

Eq. (10) shows that the tax rate has a direct negative effect on the number of formal workers. However, a higher tax rate incentivizes infrastructure investment, potentially leading to a larger number of low-skilled formal workers in the long run. Indeed, the higher the elasticity of infrastructure to the tax rate and the higher the difference in the impact of infrastructure on sectoral TFPs, the stronger the push toward an increase (decrease) in formal (informal) employment after an increase in the tax rate.

In the regulated regime, the number of low-skilled workers joining formal firms is the one that equalizes the marginal productivity of low-skilled labor in the formal sector to $w_{\min}$. Exploiting this condition, we obtain the number of low-skilled formal workers as follows:

$$L_{f,t} = H\left(\frac{(1-\alpha)Ak_t^{\varepsilon}}{w_{\min}}\right)^{\frac{1}{\alpha}}. \tag{11}$$

Although low-skilled workers are perfectly mobile across sectors, the level of employment in the formal sector is not influenced by the labor supply in the regulated regime, as the presence of a binding minimum wage induces a shortage of jobs in the formal sector, leaving informal workers willing to work in the formal sector if they had the opportunity. Accordingly, the elements determining the remuneration in the informal sector (B and η) and the tax rate (which introduces a gap between firm labor cost and workers' net income in the formal sector) do not directly enter Eq. (11). As long as the minimum wage is binding, only the marginal productivity of low-skilled labor in the formal sector matters in determining the share of informal workers. Therefore, a direct effect of taxation is absent in the regulated regime, and the tax rate impacts the number of formal/informal workers only indirectly through its impact on infrastructure accumulation.

Finally, it is worth noticing that in both regimes informality arises when either the skill ratio or the stock of infrastructure is low, which are both distinctive characteristics of low-income countries, as documented in Calderón and Servén (2014) and

Docquier et al. (2017). As illustrated in the Appendix (Section A.2), the conditions to have a positive level of informality differ depending on the informality regime. Accordingly, we calibrate the parameters to meet these conditions.

4 Fiscal Policy

The government chooses the tax rate to maximize the representative household's welfare, subject to the technological and resource constraints as well as the conditions governing the allocation of low-skilled workers in the different regimes. Accordingly, the intertemporal optimization problem can be represented recursively as a value function problem,

$$V(k_t) = \max_{\tau_t} \ln(C_t) + \beta V(k_{t+1}) \tag{12}$$

s.t.

$$C_t = (1-\tau_t)Y_{f,t} + Y_{i,t}, \tag{13}$$

$$\left((1-\tau_t)(1-\alpha)\frac{Y_{f,t}}{L_{f,t}} - \frac{Y_{i,t}}{L_{i,t}}\right)\Gamma_{\{1,0\}} = 0, \tag{14}$$

$$\left((1-\alpha)\frac{Y_{f,t}}{L_{f,t}} - w_{\min}\right)(1-\Gamma_{\{1,0\}}) = 0 \tag{15}$$

$$\lim_{t\to\infty}\beta^t \frac{k_{t+1}}{C_t} = 0 \tag{16}$$

and the law of accumulation of infrastructure, Eq. (9). $V(.)$ is the value function, where τ_t is the control variable while k_t is the state variable and β is a parameter capturing the time discounting factor. Eq. (13) reports the overall consumption in our economy at period t. $\Gamma_{\{1,0\}}$ is an indicator function that takes value one when the economy is in the unregulated regime and zero in the regulated regime. The solution to the above problem yields distinct sequences of optimal tax rates, contingent upon the value of the indicator function. Finally, Eq. (16) is the relevant transversality condition of our dynamic problem. This problem, in its general form, has no analytical solution.[23] Leaving the numerical analysis of the general problem to the

23 Interestingly, under the regulated regime, the Euler equation characterizing the solution of the dynamic problem (available upon request) is almost identical to that of the typical Ramsey problem. The marginal utility of consumption at period t must equal the discounted marginal utility of consumption at period $t+1$ capitalized by the marginal productivity of capital. However, under the regulated regime, this equation also accounts for the change in the sectoral composition of workers implied by the accumulation of infrastructure. As a higher tax rate moves people towards the formal sector, where infrastructure is more productive, the optimal tax rate will be higher than in the standard Ramsey case.

next sections, in the rest of this one, we focus on the steady solution with $\eta = 0$; in this case, analytical solutions are available and provide interesting economic intuitions.

First, we provide the equation defining the optimal tax rate in the unregulated regime, $\tau_{C,u}$:

$$\tau_{C,u} = \varepsilon \frac{\delta}{D}, \tag{17}$$

where $D \equiv \frac{1}{\beta} - (1 - \delta)$ is a combination of parameters capturing the intertemporal trade-off that the central planner accounts for when setting the optimal tax rate.

In the regulated regime the optimal tax rate, $\tau_{C,r}$, is:

$$\tau_{C,r} = \frac{\varepsilon}{\alpha} \frac{\delta}{D} \left(1 - (1 - \alpha) \frac{B}{w_{\min}} \right). \tag{18}$$

The comparison between Eq. (17) and Eq. (18) allows us to highlight a key difference between the two regimes. In the unregulated regime, the optimal tax rate depends on the elasticity of formal sector TFP to infrastructure (in line with the "*Barro rule*"). On the contrary, in the regulated regime, the optimal tax rate depends on the ratio $\frac{\varepsilon}{\alpha}$, which is greater than ε. This difference derives from the fact that, in the regulated regime, there is a shortage of low-skilled formal jobs. The tax rate affects labor productivity through infrastructure accumulation but it does not impact the cost of labor services, as the option to work in the informal sector is not appealing. The labor supply in the formal sector exhibits infinite elasticity when the minimum wage is binding. As a result, the elasticity of low-skilled employment in the formal sector with respect to infrastructure is equivalent to the elasticity of formal sector demand for low-skilled workers, represented by $\frac{\varepsilon}{\alpha}$.

This difference among regimes induces the optimal tax rate to be higher in the regulated regime than in the unregulated regime. This gap is increasing in the ratio between the minimum wage and the productivity in the informal sector.[24]

The definition of the intertemporal equilibrium follows.

Definition 1. Given a stock of high-skilled workers $(\bar{H})$, low-skilled workers $(\bar{L})$ and an initial level of infrastructure, k_0 the intertemporal equilibrium consists in a sequence of wages $w_{h,t}, w_{i,l,t}, w_{l,f,t}$, a sequence of tax rates τ_t, a sequence of infrastructure levels k_t, and a sequence of formal and informal workers $L_{f,t}, L_{i,t}$ such that

1. Wages are determined by Eqs. (6), (7) and (8) in the unregulated regime and by Eqs. (6), (8), and $w_{\min}$ in the regulated regime.

24 Subtracting Eq. (17) to Eq. (18) emerges $\tau_{C,r} - \tau_{C,u} = \frac{\varepsilon\delta}{D} \frac{(1-\alpha)}{\alpha} \left(1 - \frac{B}{w_{\min}} \right) > 0$.

2. The labor market clears, $H = \bar{H}$ and $L_{f,t} + L_{i,t} = \bar{L}$.
3. The government balances its budget, Eq. (9) holds.
4. The size of informal employment is determined by Eq. (11) in the regulated regime, and by Eq. (10) in the unregulated regime.
5. The sequence $\{\tau_t\}_0^\infty$ is the solution of the problem outlined by Eqs. (12)–(16).
6. The good market clears, i.e., consumption equals the output net of tax revenues.

In the next section, we provide a quantitative analysis of the model using the optimality conditions and allowing η to be greater than zero.[25]

5 Quantitative Assessment

In this section, we define the calibration strategy to represent a low-income country at the steady state and we assess the implication of the informality regime in terms of optimal taxation, infrastructure, consumption, income distribution, and informality shares. We run the analysis for different values of minimum wage and elasticity of the informal sector productivity to infrastructure.

5.1 Calibration Strategy

We calibrate our model to replicate the features of Sub-Saharan African (SSA) countries where the informal sector is large and characterized by low productivity firms. The calibration is conducted according to three distinct approaches. The values of certain parameters are derived directly from extant literature, in accordance with prevailing values and empirical estimations. With regard to skill composition of the labor force, we use available datasets to determine the average value in SSA countries. The calibration process is concluded by setting two technological parameters in order to establish equilibrium conditions consistent with specific macroeconomic aggregates. Given the calibration setting, we allow the minimum wage to vary in order to examine its effect on the optimal tax rate, infrastructure accumulation, income distribution and informal sector shares.

Starting from the parameters whose values are derived from the literature, the discount factor, β, is equal to 0.96, implying an annual discount rate of about 4 percent as in the RBC literature, see Kydland and Prescott (1982). With regard to the value of the depreciation rate of infrastructure, we set $\delta = 0.085$ as in Gibson and

25 Section A.1 of the Appendix shows the stability of the steady-state, for both regimes, exploiting the calibration strategy defined in Section 5.

Rioja (2019).[26] It is worth noting, as outlined in Krusell and Smith Jr (2015), that there is no consensus estimate for the depreciation rate, and this absence of a commonly accepted benchmark makes calibrating this parameter particularly challenging for low-income countries. We assess the robustness of our analysis to the value of this parameter in Appendix A.3 by using a higher value, $\delta = 0.1$, which is typical in the RBC literature (Kydland and Prescott 1982), and a lower value, $\delta = 0.032$, indicated as the minimum bound in Krusell and Smith Jr (2015). The elasticities of TFP (or output) to infrastructure are ε and η. Bom and Ligthart (2014) suggest ε equal to 0.1. In line with Chatterjee et al. (2021), see Section 2, it is reasonable to assume that informal firms face hurdles when trying to take advantage of some types of infrastructure, hence $\eta < \varepsilon$. Accordingly, we let η range from 0 to 0.08 and the figures in the next sections show the results for five values of η, $\eta\{0, 0.02, 0.04, 0.06, 0.08\}$.

To calibrate the share of high-skilled workers, we rely on the latest version of the dataset from Barro and Lee (2013), from which we determine the share of high-skilled individuals defined as those with at least one year of higher education, following Docquier et al. (2017). The latest information refers to 2015, with the average value of $\frac{H}{L+H} = 4.31\%$ for SSA countries. In Appendix A.3, we assess the robustness of our results by considering the value reported in the same dataset for year 2010. Furthermore, we repeat the same analysis using the ratio that characterizes South Asia Region (SAR) countries for both 2010 and 2015. Accordingly, our calibrations consider values ranging between 2.7 % (2010, SSA) and 7.4 % (2015, SAR). Our main findings are robust to these variations, see discussion in Appendix A.3.

To match the data on informality, we calibrate two parameters: the ratio between the exogenous TFP parameters, $\frac{A}{B}$, and the elasticity of formal output to high-skilled workers, α. The calibration targets are informal sector shares for SSA in terms of both GDP ($\frac{Y_i}{Y_i+Y_f} = 36.4\%$) and employment ($\frac{L_i}{H+L} = 61.7\%$).[27] Following this procedure, we obtain $\frac{A}{B} = 10.7$ and $\alpha = 0.66$. This substantial productivity difference between the formal and informal sectors reflects an important characteristic of SSA economies, where the average informal employment share exceeds the average informal GDP share by 25.3 percentage points. In Appendix A.3, we evaluate the robustness of our results by calibrating the model for SAR countries, where informal sector shares are lower ($\frac{Y_i}{Y_i+Y_f} = 28.8\%$ and $\frac{L_i}{H+L} = 58.7\%$), but the difference is even higher (almost 30 percentage points).

26 We choose to take the value of δ from Gibson and Rioja (2019) as the authors study the impact of infrastructure investment in a similar context.

27 We compute these values by averaging the data across SSA countries reported in Ohnsorge and Yu (2022).

Table 1: Benchmark calibration.

Parameter/Statistics	Value	Source/Moment matched
ε	0.10	Bom and Ligthart (2014)
η	$0 \leq \eta \leq 0.08$	$\eta < \varepsilon$ Chatterjee et al. (2021)
α	0.66	$\frac{L_i}{H+L} = 61.7\%$ Ohnsorge and Yu (2022)
$\frac{A}{B}$	10.7	$\frac{Y_i}{Y_i+Y_f} = 36.4\%$ Ohnsorge and Yu (2022)
$\frac{H}{H+L}$	4.31 %	Barro and Lee (2013)
δ	0.085	Gibson and Rioja (2019)
β	0.96	4 % discount rate, Kydland and Prescott (1982)

The benchmark calibration, labeled with the subscript$_{\text{ben}}$, refers to the unregulated regime with $\eta = 0.04$. When we analyze the regulated regime, we need to fix a value for $w_{\min}$. We consider several scenarios, with $w_{\min}$ ranging between 1.4 and 2 times the value of the low-skilled workers' wage that emerges in the benchmark scenario (w_{ben}).[28] Our choice concerning w_{ben} implies the Kaitz ratio, i.e. the ratio between the minimum wage and the average wage, to range between 0.54 and 0.77 (increasing in $w_{\min}$), in line with the values reported in Bhorat et al. (2015).

Table 1 summarizes the benchmark calibration.

This table describes the benchmark calibration. The TFP ratio $\frac{A}{B}$ and elasticity α are jointly calibrated to match the informal sector shares in SSA countries.

5.2 Quantitative Results

This section reports and discusses the results of our numerical experiments. We emphasize the role of the informality regime, the value of the minimum wage, and the value of the elasticity of informal sector productivity to infrastructure. We partition our discussion into three blocks. First, we determine the optimal tax rate and the resulting infrastructure accumulation. Then, we show the implications for income distribution between low-skilled and high-skilled workers and total consumption. Finally, we analyze the changes in the informal economy's share of both employment and output across the various scenarios considered.

28 We run the analysis for several values of the minimum wage. As we notice that the effects are monotone in the value of $w_{\min}$, we report the results for only the lowest and the highest value of $w_{\min}$.

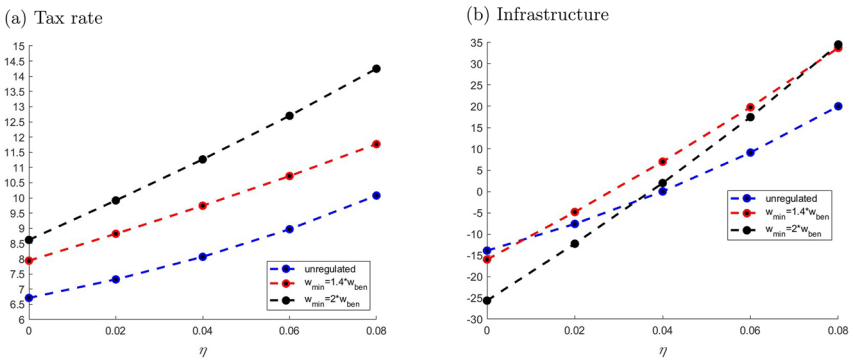


Figure 2: Optimal tax rates and infrastructure. The graph on the left reports the tax rate in percentage values. The graph on the right reports percentage variations of infrastructure from the benchmark case.

5.2.1 Optimal Tax Rates and Infrastructure

We start from the behavior of the optimal tax rate. Figure 2a shows that τ_C is increasing in both η and $w_{\min}$. Higher values of η induce an increase in τ_C as the incentive to finance infrastructure rises when its overall impact on total output, which includes informal production, is higher. τ_C is increasing in $w_{\min}$ because the minimum wage increases the labor cost incurred by formal firms, generating rationing of low-skilled labor in the formal sector. Indeed, as long as the minimum wage exceeds informal sector remuneration, higher tax rates do not increase labor costs. However, they lead to higher tax revenue, more infrastructure, increased productivity, and greater demand for low-skilled workers in the formal sector.

In the unregulated regime, the optimal tax rate ranges between 6.7 %, for $\eta = 0$, and 10 %, for $\eta = 0.08$. We observe that as η increases, the tax rate differential between the two regimes widens. For example, for $w_{\min} = 2 * w_{\text{ben}}$, the optimal tax rate is equal to 8.6 % when $\eta = 0$ (almost 2 percentage points higher than in the unregulated regime) and equal to 14.3 % when $\eta = 0.08$ (4.3 percentage points higher than in the unregulated regime).[29] These results can be explained as follows. In the unregulated regime, infrastructure accumulation leads to higher low-skilled labor costs in the formal sector, as the net wage of low-skilled workers matches informal sector productivity, which is a positive function of η. In contrast, in the regulated regime, this relationship does not hold as long as the minimum wage is high enough. Accordingly, the difference between the optimal tax rates, regulated

29 It is worth noticing that our tax rates are in line with the one in Ihrig and Moe (2004), 9.3 %, retrieved from Easterly and Rebelo (1993).

versus unregulated, becomes larger for higher values of η, as the central planner in the regulated regime does not have to take into account the negative impact of a higher tax rate on the tax base.

The path of the optimal tax rate determines infrastructure accumulation. In fact, Figure 2b shows that, in both regimes, infrastructure is increasing in η. More articulated is the effect of the minimum wage. The presence of a minimum wage induces higher taxation but it also reduces the tax base with ambiguous effects on tax revenues and infrastructure. Based on our model calibration, a positive relationship between minimum wage and infrastructure emerges for sufficiently high values of η as the increases in the tax-rate difference between the two regimes compensate for the shrink in the tax base.

5.2.2 Income Distribution and Consumption

Figure 3a and b illustrate the impact of the minimum wage and the elasticity of informal sector production to infrastructure on the net incomes of the two types of workers. For convenience, the figures show the percentage deviation from the benchmark scenario. Our analysis highlights the key distributional effects of introducing a minimum wage: it benefits low-skilled workers, while reducing the net income of high-skilled workers.

The introduction of a minimum wage impacts the income of low-skilled workers through three main channels. First, it generates income gains for the low-skilled workers who remain in the formal sector, where wages, by assumption, exceed what would prevail under competitive conditions. Second, it affects the income of workers in the informal sector through its impact on infrastructure accumulation. As

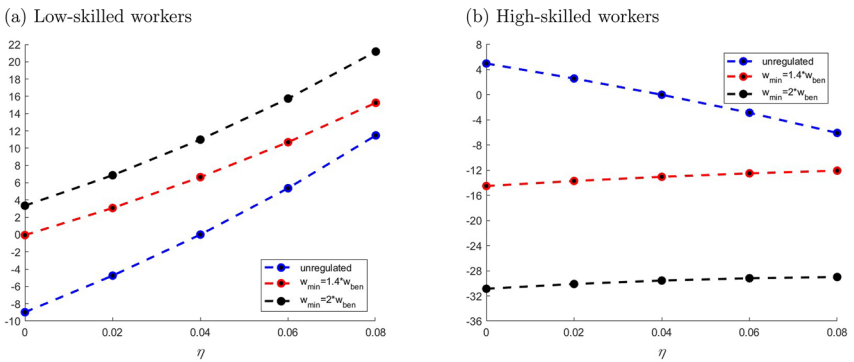


Figure 3: Net income by skill. Both graphs report percentage variations from the benchmark case.

shown in Figure 2b, under most of the parameterizations, infrastructure increases with the introduction of a minimum wage, raising the productivity and wages of informal workers. Third, with the introduction of the minimum wage a higher number of low-skilled workers are employed in the informal sector, see Figure 5a and the following discussion. In summary, considering the effects induced by the mechanisms described above, the overall impact of a minimum wage on the income of low-skilled workers is positive.

Figure 3b reports a negative impact of the minimum wage on high-skilled workers, driven by two distinct mechanisms. The introduction of the minimum wage causes an outflow of low-skilled workers toward the informal sector. This leaves fewer low-skilled workers in the formal sector to work alongside high-skilled workers, lowering their productivity / gross remuneration (see Figure 5a and the following discussion). Additionally, higher minimum wages lead to higher optimal tax rates (see Figure 2a). This directly reduces the net income of high-skilled workers.

The combined effect on the net income of the two types of workers results in overall wage compression. This theoretical prediction is consistent with empirical evidence from Brazil. For example, Engbom and Moser (2022) and Haanwinckel (2023) identify minimum wage increases as a primary driver of Brazil's significant decline in inequality during the 2000s.[30]

The elasticity of informal sector productivity to infrastructure, η, has different effects depending on workers' skill type and informality regime. An increase in η results in a higher net income for low-skilled workers (see Figure 3a). The effect is stronger in the unregulated regime, where the arbitrage condition ensures that η directly determines their earnings in both sectors. The impact of η on the income of high-skilled workers depends on the informality regime (see Figure 3b). In the regulated regime, an increase in η has a non-negative impact on their net income, whereas it induces a significant decline in the unregulated regime (moving from $\eta = 0$ to $\eta = 0.08$ results in a fall of 11 percentage points). This difference occurs despite the fact that higher η increases the optimal tax rate in both regimes (see Figure 2a), reducing high-skilled workers' net income through taxation. In the regulated regime, however, this tax burden is offset by an increase in the marginal productivity of high-skilled workers, which can be explained by two mechanisms. First, as shown in Figure 2b the sensitivity of infrastructure to η is higher in the

30 The relationship between minimum wage and inequality has been extensively investigated using detailed Brazilian data. Lemos (2009) document that minimum wages compressed wage distributions in both the formal and informal sectors. More recently, Parente (2024), confirms a significant reduction in inequality in the formal sector but reports a rise in the informal sector. However, our theoretical framework assumes just two types of workers and therefore does not provide insights into the heterogeneous effects of the minimum wage among specific groups of workers. More research is necessary for SSA countries, as discussed in Bhorat et al. (2017).

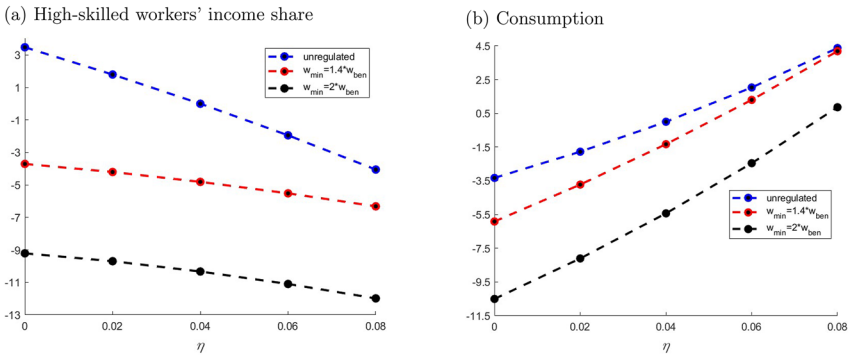


Figure 4: High-skilled workers' income share and Consumption. The graph on the left reports the variation of high-skilled workers' income share. The graph on the right reports percentage variations of consumption from the benchmark case.

regulated regime. Second, as detailed later, when discussing Figure 5a, contrary to the unregulated regime, increases in η do not lead to a decrease in the share of low-skilled workers employed in the formal sector.

The previous analysis has straightforward consequences in terms of income distribution, as reported in Figure 4a. The high-skilled workers' share of the net income is decreasing in both η and $\omega_{\min}$ as both elements support low-skilled workers' income. Notably, moving η from 0 to 0.08 implies a reduction of the income share of the high-skilled workers close to 7.5 percentage points in the unregulated regime, compared to about 2.7 percentage points in the regulated regime.

Finally, Figure 4b reports the percentage deviations of consumption (i.e. the net income of all workers) with respect to the benchmark scenario. Two main facts stand out. First, overall consumption is increasing in η, as higher values of η shift the production frontier. Second, consumption is decreasing in $\omega_{\min}$, as higher minimum wages imply a less efficient distribution of low-skilled workers across sectors and higher tax rates. However, the higher the value of η, the lower the consumption loss induced by $\omega_{\min}$, because the impact of the misallocation of labor services falls. In fact, for $\eta = 0$, $\omega_{\min} = 2 * \omega_{\text{ben}}$ implies a 7.2 % reduction in consumption compared to the unregulated regime. The loss decreases to 3.5 % when $\eta = 0.08$.[31]

31 If we consider $\omega_{\min} = 1.4 * \omega_{\text{ben}}$ the corresponding values become 2.6 % (for $\eta = 0$) and 0.2 % (for $\eta = 0.08$).

5.2.3 Informal Economy Share

The last aspect that we want to analyze concerns the path of the informal economy share. Figure 5a and b report the informal economy share in terms of both employment and output. The role of $\omega_{\min}$ is intuitive: Increases in the minimum wage directly increase the labor cost, reducing the number of low-skilled workers in the formal sector, and inflating the informal sector size.

On the contrary, the role of η is more articulated. In the unregulated regime, both informality shares are increasing in η as, *ceteris paribus*, the higher η the higher the remuneration for low-skilled workers. This result is in line with Mitra (2017) who highlights that the more informal firms can benefit from public services, the higher the informality share. Differently, in the regulated regime, higher values of η do not make low-skilled services more expensive for the formal sector. The endogenous relationship between η and τ_C, along with the positive impact of infrastructure on productivity in the formal sector, explain why the demand for low-skilled workers in the formal sector is increasing in η, reducing the share of workers in the informal sector, see Figure 5a. Nevertheless, shifts in the informal sector share of employment may not align with similar variations in the informal sector share of output, as shown in Figure 5b. When the value of η increases, the productivity in the informal sector rises, and this might counterbalance the fall in informal employment.

In the presence of wage segmentation, two key features of the unregulated regime disappear: first, the monotonic positive relationship between the beneficial effects of infrastructure on informal sector productivity and informality shares; and second, the positive association between employment and output informality

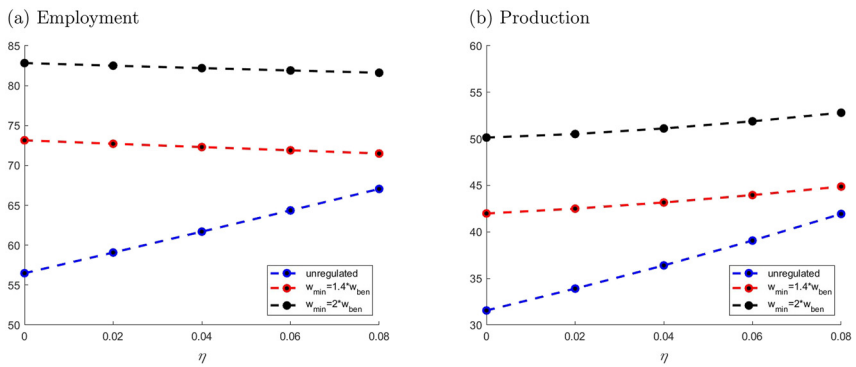


Figure 5: Informality share. Both graphs report percentage shares.

shares. Our results suggest that minimum wages along with differences in the capacity of informal firms to capture the benefits of infrastructure might explain the absence of a clear relationship among tax rates and informality shares. In the regulated regime, countries with higher values of η can implement higher tax rates experiencing a modest decrease in the informal share of employment and a mild increase in the informal share of GDP.

6 Dynamic Insights and Regime Switching

In addition to the comparative statics in the steady state, we present dynamic analyses for both regimes, focusing on an economy with $\eta = 0.04$ and with an initial endowment of infrastructure equal to 80 % of its corresponding steady-state value. We conduct numerical simulations to determine the time-varying optimal tax rate and examine its impact on various macroeconomic variables.[32] Furthermore, we explore the scenario of regime switching from the unregulated to the regulated regime, analyzing the corresponding trajectories of both the optimal tax rate and the infrastructure.

In both regimes, when the economy starts with a low infrastructure endowment, it is optimal to set the tax rate higher than the steady-state value to induce infrastructure accumulation. Figure 6 shows that the convergence towards the steady states of both the optimal tax rate and infrastructure requires a similar number of periods in both regimes. However, in the presence of the minimum wage, the initial deviation of the tax rate is significantly higher (6.9 vs 4 percentage points). This discrepancy arises as in the regulated regime raising the tax rate does not compress the tax base and the elasticity of labor demand to infrastructure is higher. The difference in the paths of the tax rates explains the slightly faster convergence of infrastructure in the regulated regime.

Concerning the transition path of consumption, Figure 7a in line with the results of Figure 6, shows that a drop in consumption is necessary to facilitate infrastructure accumulation in both regimes albeit through different mechanisms. In the regulated regime, consumption fall is mainly driven by a substantial increase in the tax rate, whereas in the unregulated regime, it is also induced by the decline in formal employment with a consequent fall in production. Indeed, the low infrastructure (and the consequent low productivity) induces temporary increases in

32 We conducted additional analyses solving for a fixed optimal tax rate. Although the induced dynamics take generally longer to converge to the new steady state, the results remain largely unchanged. For this reason, this set of results is not included in the paper and is available upon request.

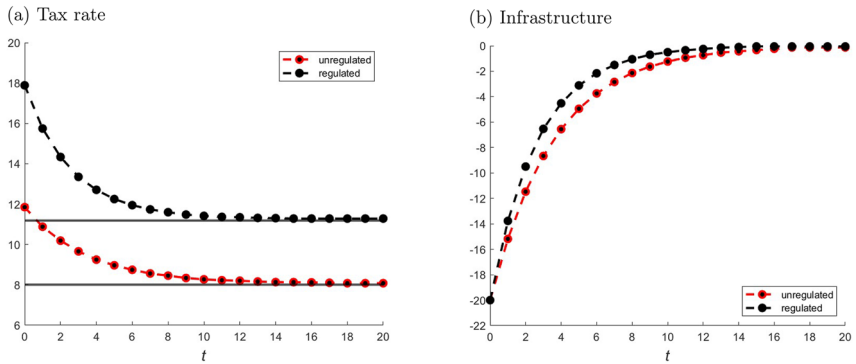


Figure 6: Optimal tax rate and infrastructure – convergence path. The graph on the left reports the tax rate in percentage values. The graph on the right reports percentage variations of infrastructure from the corresponding benchmark case.

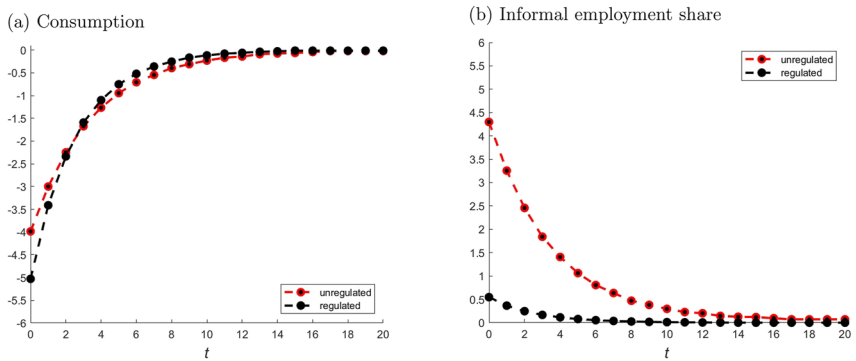


Figure 7: Consumption and informal employment share – convergence path. The graph on the left reports the percentage variations of consumption from the corresponding steady-state values. The graph on the right reports the variations of informal employment share from the corresponding steady-state values.

the number of informal workers in both regimes. However, Figure 7b shows that the percentage deviation is much higher in the unregulated regime, as low-skilled workers react to higher tax rates by joining the informal sector till the arbitrage condition is restored. On the contrary, in the regulated regime, the fall in the net wage does not induce an outflow of workers from the formal to the informal sector. Informality is sustained only by the low levels of infrastructure, which reduce labor demand in the formal sector.

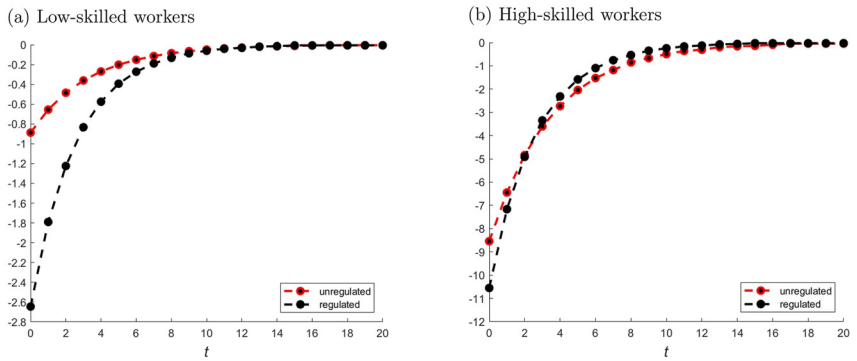
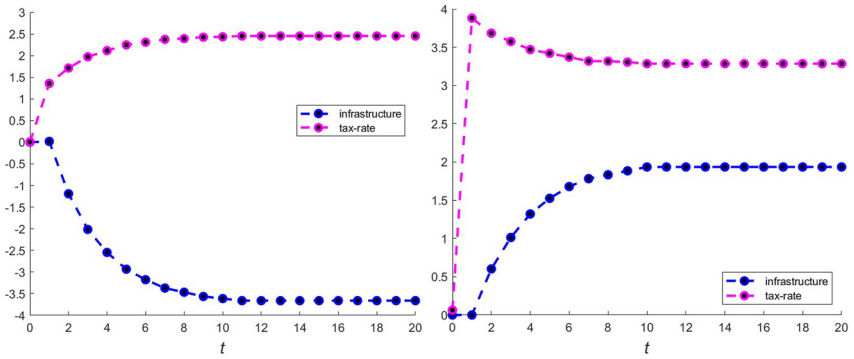


Figure 8: Net income by skill – convergence path. Both graphs report the percentage variations of net income from the corresponding steady-state values.

Moving to the path characterizing the net income of the different types of workers, Figure 8 provides clear evidence that high-skilled workers are the most affected along the convergence path. As they work only in the formal sector, they all suffer from the low infrastructure, the increase in the tax rate, and the lower presence of low-skilled workers in the formal sector. With regard to low-skilled workers, it emerges that the net income loss is higher in the regulated regime as workers in the formal sector are hit by the significant increase in the tax rate with no incentive to shift sector (the formal sector still grants a better remuneration than the informal sector).

We need to point out that our analysis does not take into account frictions in the inter-sectoral movement of low-skilled workers. Specifically, our framework does not include search and reallocation costs. Under this perspective, we differ from Turnovsky and Basher (2009) and Chatterjee et al. (2022) who consider that moving from the informal to the formal sector absorbs personal time. They introduce an incentive to smooth the intersectoral transition, discouraging significant changes, by assuming that the loss function is quadratic in the additional time workers decide to spend in the formal sector. Although the inclusion in our framework of such costs would not alter the outcomes of our steady-state analysis or the direction of the transition dynamics (provided the cost structure remains symmetric), it would have a noticeable impact on the variations along the transition path.[33] In the presence of such costs, workers tend to prefer gradual adjustments. Consequently, the transition towards the steady state last longer.

33 Furthermore, Aleksynska et al. (2023) find that the transition between formal and informal employment generates heterogeneous effects according to workers' characteristics.



(a) $\eta = 0.02$ (b) $\eta = 0.04$

Figure 9: Optimal tax rate and infrastructure – transition dynamics. Both graphs report the transition dynamics induced by the introduction of the minimum wage. Tax rate paths are reported in percentage points while infrastructure paths are reported in percentage variations.

As a final experiment, we analyze the implications of introducing a minimum wage in an economy that is in steady-state equilibrium under the unregulated regime.[34] We analyze two scenarios, which differ in the value of η, with the purpose of showing the adjustment path according to the sign in the difference between the new and the old steady-state value of infrastructure. Both Figure 9a and b show the evolution of the tax rate, measured in percentage points relative to the steady-state value of the unregulated regime, as well as the percentage change in the stock of infrastructure compared to its initial level. In Figure 9a, $\eta = 0.02$ and the steady-state value of infrastructure in the regulated regime is lower than in the unregulated regime. Upon introducing the minimum wage, the optimal tax rate rises smoothly, as the economy converges to a lower value of infrastructure. The increase in the tax rate is induced only by the reduction in the tax base. Figure 9b reports the results for $\eta = 0.04$, which implies an increase in the steady-state value of infrastructure. In this case, the tax rate is set above the new steady-state optimal value and then decreases towards the new steady state.

7 Conclusions

This paper studied the optimal financing of public infrastructure for low-income countries where the informal economy employs a large share of the labor force. We

34 We assume that individuals do not anticipate the regime change.

built a two-sector model accounting for heterogeneous labor along the skill dimension where infrastructure investment is financed through labor-income taxation. Our primary purpose was to analyze how a binding minimum wage, which defines the informality regime (regulated *vs* unregulated), affects infrastructure financing in poor-income countries.

We found that the minimum wage increases the optimal tax rate, resulting in increased infrastructure accumulation and reduced income inequality. Simultaneously, the economy witnesses decreased aggregate consumption and a higher share of the informal economy. Furthermore, unlike most of the literature, we highlighted that when infrastructure investments benefit also the informal sector and the tax rate changes accordingly, the economy does not always witness an increase in the informal share of employment.

Overall, the introduction of a minimum wage generates a wage gap among workers in different sectors. Once the minimum wage is binding, neither a rise in the tax rate nor enhanced productivity in the informal sector lead to a shift of workers towards informal employment. The absence of these effects markedly alters the optimal tax rate under the regulated regime, as higher tax rate does not imply a lower tax base.

Our analysis of the transition paths highlights interesting differences between the regulated and the unregulated regimes. It emerged that under the regulated regime the economy adjusts more swiftly in terms of infrastructure investments, as it is optimal to implement a higher increase in the tax rate. The analysis of the policy experiment of introducing a minimum wage uncovered that, contingent on the extent to which the informal economy seizes infrastructure investments, the new infrastructure steady state can be either lower or higher. In the latter scenario, the economy experiences a sudden increase in the tax rate simultaneous to the introduction of the minimum wage. In the former scenario, the tax rate rises smoothly along the transition path.

This contribution represents a starting point for future research. For example, it would be interesting to further examine the effects of introducing a minimum wage on workers' endogenous choices, such as migration, as these choices may affect model results. In our framework, the introduction of a minimum wage significantly reduces the income of high-skilled workers, thereby increasing their incentive to migrate abroad (Beine et al. 2008). However, accounting for this option introduces at least two mechanisms that could counteract the decline in income of the high-skilled workers and mitigate the magnitude of our results. First, the exodus of high-skilled workers would make them scarcer domestically, increasing the marginal productivity and wage of those who remain. Second, the central planner would need to internalize migration flows and set a lower tax rate. Another topic

that would be worth deepening is the inter-generational welfare analysis in countries far away from the optimal level of infrastructure, as there could be a significant time lag between the financing and the availability of infrastructure. Finally, the interaction between infrastructure and private capital accumulation may also affect model results. However, a more comprehensive analysis would necessitate considering additional forms of taxation and household heterogeneity, given that only a small portion of individuals living in low-income countries engage in savings.

A Appendix

The appendix provides additional material that complements the analysis of the paper. Section A.1 shows the stability of the steady states in both regimes. Section A.2 provides the derivation of the mathematical conditions outlined in Section 3 of the paper. Section A.3 reports the sensitivity analysis.

A.1 Steady-state Stability

Figure A.1 reports the transition function of k_t and k_{t+1} along with a 45-degree line. The figure clarifies that our model, under both regimes, has a unique and stable steady state.[35] Similar graphical representations are obtained for different parameterizations and steady states.

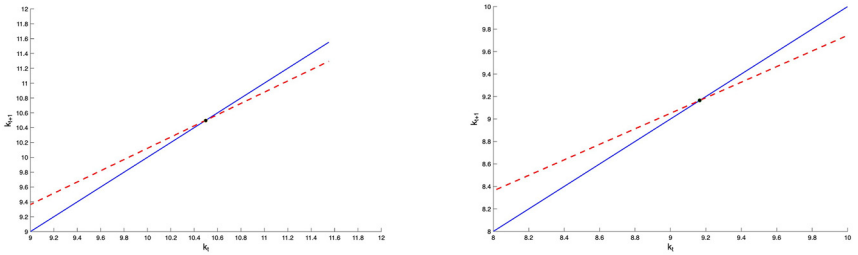
A.2 Assumptions

This appendix reports conditions granting the presence of informality with the high-skilled workers' wage always higher than low-skilled workers' wage. Informality arises in the unregulated regime if $\left(w_{l,f,t}\left(z_{f,t} = z_t\right)\right) < w_{l,i,t}$ which implies that the level the skill ratio in the economy, z, is small enough:

$$z < \bar{z}_u = \left(\frac{Bk^{\eta-\epsilon}}{(1-\tau_t)(1-\alpha)A} \right)^{\frac{1}{\alpha}}, \tag{A.1}$$

where $\bar{z}_u$ decreases with the stock of infrastructure, as the low-skilled wage in the formal sector increases with H (due to complementarity of labor services) and with k_t (as infrastructure positively affects the formal sector TFP). A similar condition

35 To conduct this set of simulations we use the benchmark calibration, see Section 5.1. For the regulated regime we set the minimum wage equal to two times the benchmark low-skilled wage under the unregulated regime.



(a) Unregulated Regime (b) Regulated Regime

Figure A.1: Transition function. Both graphs report the transition functions. Panel (a) reports the transition function for the unregulated regime, Panel (b) reports the transition function for the regulated regime.

holds for the regulated regime. Under this case, informality arises if the enforcement of the minimum wage would induce unemployment in the formal sector, $\left(w^g_{l,f,t}\left(z_{f,t}=z\right)\right) < w_{\min}$, which is equivalent to:

$$z < \overline{z}_r = \left(\frac{w_{\min}}{(1-\alpha)Ak_t^{\epsilon}}\right)^{\frac{1}{\alpha}}. \tag{A.2}$$

For the regulated regime, we also assume that the minimum wage is high enough, meaning that the minimum wage (after tax) is higher than the wage paid by informal firms:

$$w_{\min} > \frac{Bk_t^{\eta}}{1-\tau_t}.$$

Finally, we assume that the high-skilled workers' wage is always larger than the low-skilled workers' wage. For both regimes, this requires assuming:

$$z < \frac{\alpha}{1-\alpha}. \tag{A.3}$$

It is important to note that for $\alpha = \frac{1}{2}$, the RHS of the above equation equals 1 and tends to infinite for α approaching to 1. Given that we assume $\alpha < 1$ and that z is low in low-income countries, the above condition is easily met in low-income countries. It is also apparent that, as long as assumptions A.1 and A.2 hold, that the economy approaches to a steady-state with a positive level of informality.

A.3 Sensitivity Analysis

This section evaluates the robustness of our main findings to changes in the calibration strategy. We consider three main variants of our benchmark calibration described in Section 5.1:

1. Different values of the share of high-skilled workers in the economy, calculated from Barro and Lee (2013) and referring to 2010.
2. Different values of the depreciation rate, one higher $\delta = 0.1$ (Kydland and Prescott 1982) and one lower $\delta = 0.032$, see Krusell and Smith Jr (2015).
3. A different reference group of countries, matching data from SAR countries. This implies changes in the informal sector shares ($\frac{Y_i}{Y_i+Y_f} = 28.8\%$, $\frac{L_i}{L_i+L_f} = 58.7\%$) and in the share of high-skilled workers, equal to 7.4 % in 2015. In line with what done for SSA countries, we consider an additional calibration setting with the share of high-skilled workers equal to its 2010 value, 6.6 %.

Table A.1 summarizes all these sensitivity analyses, reporting the new calibrated values of α and the TFP ratio $\frac{A}{B}$ in the first and second rows. The third and fourth rows report the optimal tax rates for the unregulated $(\tau_{C,u})$ and regulated $(\tau_{C,r})$ regimes. In all these experiments we keep $\eta = 0.04$, and the minimum wage equal to 1.4 times the value of the low-skilled workers' wage that emerges in the benchmark scenario.[36]

Considering a lower share of the high-skilled workers affects the parametrization of the TFP ratio, $\frac{A}{B}$, which increases in both SSA and SAR countries. This occurs because a reduction in the ratio $\frac{H}{H+L}$ requires a higher TFP gap between sectors to maintain the same productivity gap between formal and informal sectors. The value of α and of the optimal tax rates are only slightly affected.

Compared to SSA countries, SAR countries are on average characterized by a higher proportion of high-skilled workers, a lower informal sector share and a higher gap between the informal sector shares in terms of employment and GDP (almost 30 percentage points of difference in SAR countries *vs* 25.3 in SSA countries). These differences translate into higher calibrated values of α in SAR countries. Furthermore, optimal tax rates are lower in SAR countries under both regimes – 7.7 % versus 8.1 % in the unregulated regime and 8.6 % versus 11.3 % in the regulated regime.

The sensitivity analysis concerning different values of the depreciation rate δ confirms the theoretical predictions from the analytical solutions (Equations 17 and 18). We observe a positive relationship between the depreciation rate and optimal

36 Graphs in line with the ones reported in Section 5.2 are available upon request.

Table A.1: Sensitivity analysis.

	SSA				SAR			
	Bench	$h = 2.7\,\%$	$\delta = 0.1$	$\delta = 0.032$	$h = 7.4\,\%$	$h = 6.6\,\%$	$\delta = 0.1$	$\delta = 0.032$
α	0.66	0.64	0.66	0.67	0.75	0.74	0.75	0.75
$\frac{A}{B}$	10.69	13.72	10.7	10.5	11.5	12.3	11.5	11.2
$\tau_{C,u}$	0.081	0.081	0.085	0.053	0.077	0.077	0.081	0.050
$\tau_{C,r}$	0.113	0.115	0.119	0.073	0.086	0.097	0.101	0.062

This table reports the calibrated values of α, the TFP ratio $\frac{A}{B}$, and the optimal tax rates at steady state implied by the model: $\tau_{C,u}$ for the unregulated regime and $\tau_{C,r}$ for the regulated regime. For compactness, we use $h = \frac{H}{H+L}$ to denote the proportion of high-skilled workers. **SSA Countries:** *Bench* represents the benchmark calibration used in the main text of the paper with $h = 4.31\,\%$, informal employment share equal to 61.7 %, and informal GDP share equal to 36.4 %. The second column considers a lower share of high-skilled workers ($h = 2.7\,\%$ from 2010 data), while the third and fourth columns examine different depreciation rates ($\delta = 0.1$ and $\delta = 0.032$, respectively). **SAR Countries:** The calibration targets informal employment share equal to 58.7 % and informal GDP share equal to 28.8 %. As for SSA countries, the calibration considers the share of high-skilled workers observed in 2015 ($h = 7.4\,\%$) and in 2010 ($h = 6.6\,\%$), and two alternative values of the depreciation rate.

tax rates in both regimes across both geographical areas. When the depreciation rate increases from 0.032 to 0.1, optimal tax rates rise substantially – for example, in SSA countries, the regulated regime tax rate increases from 7.3 % to 11.9 %. This pattern reflects the need for higher taxation to maintain adequate infrastructure investment when capital depreciates more rapidly.

References

Aleksynska, M., J. La, and T. Manfredi. 2023. "Transitions to and from Formal Employment and Income Dynamics: Evidence from Developing Economies." OECD Development Centre Working Papers 349, OECD Publishing.

Amaral, P. S., and E. Quintin. 2006. "A Competitive Model of the Informal Sector." *Journal of Monetary Economics* 53 (7): 1541–53.

Arango, L. E., and S. A. Rivera. 2022. "Moderate Wage Increases and Flexible Labour Contracts to Protect Employment in Colombian Manufacturing." *Journal of Policy Modeling* 44 (3): 578–98.

Aschauer, D. A. 1989. "Is Public Expenditure Productive?" *Journal of Monetary Economics* 23 (2): 177–200.

Barro, R. J. 1990. "Government Spending in a Simple Model of Endogeneous Growth." *Journal of Political Economy* 98 (5): 103–25.

Barro, R. J., and J. W. Lee. 2013. "A New Data Set of Educational Attainment in the World, 1950–2010." *Journal of Development Economics* 104 (C): 184–98.

Beine, M., F. Docquier, and H. Rapoport. 2008. "Brain Drain and Human Capital Formation in Developing Countries: Winners and Losers." *The Economic Journal* 118 (528): 631–52.

Besley, T., and T. Persson. 2014. "Why Do Developing Countries Tax So Little?" *The Journal of Economic Perspectives* 28 (4): 99—120.

Bhorat, H., R. Kanbur, and B. Stanwix. 2015. Minimum Wages in Sub-Saharan Africa: A Primer. CEPR Discussion Papers 10760, C.E.P.R. Discussion Papers.

Bhorat, H., R. Kanbur, and B. Stanwix. 2017. "Minimum Wages in Sub-Saharan Africa: A Primer." *The World Bank Research Observer* 32 (1): 21—74.

Boeri, T., P. Garibaldi, and M. Ribeiro. 2011. "The Lighthouse Effect and Beyond." *Review of Income and Wealth* 57: S54—S78.

Bom, P. R., and J. E. Ligthart. 2014. "What Have We Learned from Three Decades of Research on the Productivity of Public Capital?" *Journal of Economic Surveys* 28 (5): 889—916.

Calderón, C., E. Moral-Benito, and L. Servén. 2015. "Is Infrastructure Capital Productive? A Dynamic Heterogeneous Approach." *Journal of Applied Econometrics* 30 (2): 177—98.

Calderon, C., and L. Servén. 2010. "Infrastructure in Latin America." Policy Research Working Paper Series 5317, The World Bank.

Calderón, C., and L. Servén. 2014. "Infrastructure, Growth, and Inequality: An Overview." *The World Bank, Policy Research Working Paper Series*, (7034).

Carroni, E., M. Delogu, and G. Pulina. 2023. "Technology Adoption and Specialized Labor." *International Economics* 173 (C): 249—59.

Chatterjee, S., M. C. Kelly, and S. J. Turnovsky. 2022. "Foreign Aid, Public Investment, and the Informal Economy." *Economic Inquiry* 60 (1): 174—201.

Chatterjee, S., T. Lebesmuehlbacher, and A. Narayanan. 2021. "How Productive is Public Investment? Evidence from Formal and Informal Production in India." *Journal of Development Economics* 151 (C). https://doi.org/10.1016/j.jdeveco.2021.102625.

Dabla-Norris, E., M. Gradstein, and G. Inchauste. 2008. "What Causes Firms to Hide Output? The Determinants of Informality." *Journal of Development Economics* 85 (1-2): 1—27.

De Soto, H. 1988. *The Other Path: The Invisible Revolution in the Third World*. New York: Harper and Row Publishers.

Delogu, M., F. Docquier, and J. Machado. 2018. "Globalizing Labor and the World Economy: The Role of Human Capital." *Journal of Economic Growth* 23 (2): 223—58.

Djankov, S., T. Ganser, C. McLiesh, R. Ramalho, and A. Shleifer. 2010. "The Effect of Corporate Taxes on Investment and Entrepreneurship." *American Economic Journal: Macroeconomics* 2 (3): 31—64.

Docquier, F., and Z. Iftikhar. 2019. "Brain Drain, Informality and Inequality: A Search-and-Matching Model for Sub-Saharan Africa." *Journal of International Economics* 120 (C): 109—25.

Docquier, F., T. Müller, and J. Naval. 2017. "Informality and Long-Run Growth." *The Scandinavian Journal of Economics* 119 (4): 1040—85.

Duflo, E., and R. Pande. 2007. "Dams." *Quarterly Journal of Economics* 122: 601—46.

Easterly, W., and S. Rebelo. 1993. "Marginal Income Tax Rates and Economic Growth in Developing Countries." *European Economic Review* 37 (2-3): 409—17.

Elgin, C., M. A. Kose, F. Ohnsorge, and S. Yu. 2021. Understanding Informality. CEPR Discussion Papers 16497, C.E.P.R. Discussion Papers.

Engbom, N., and C. Moser. 2022. "Earnings Inequality and the Minimum Wage: Evidence from Brazil." *American Economic Review* 112 (12): 3803—47.

Farrell, D. 2004. "The Hidden Dangers of the Informal Economy." *McKinsey Quarterly* 3: 26—37.

Fay, M., S. Han, H. I. Lee, M. Mastruzzi, and M. Cho. 2019. "Hitting the Trillion Mark—A Look at How Much Countries are Spending on Infrastructure." *World Bank Policy Research Working Paper*, (8730).

Feige, E. L. 1981. "The UK's Unobserved Economy: A Preliminary Assessment." *Economic Affairs* 1 (4): 205—12.
Futagami, K., Y. Morita, and A. Shibata. 1993. "Dynamic Analysis of an Endogenous Growth Model with Public Capital." *The Scandinavian Journal of Economics* 95 (4): 607—25.
García, G. A. 2017. "Labor Informality: Choice or Sign of Segmentation? A Quantile Regression Approach at the Regional Level for Colombia." *Review of Development Economics* 21 (4): 985—1017.
Gerxhani, K. 2004. "The Informal Sector in Developed and Less Developed Countries: A Literature Survey." *Public Choice* 120 (3): 267—300. https://doi.org/10.1023/b:puch.0000044287.88147.5e.
Gibson, J., and F. Rioja. 2019. "The Welfare Effects of Infrastructure Investment in a Heterogeneous Agents Economy." *The BE Journal of Macroeconomics* 20 (1): 20190095.
Gindling, T. H. 2018. "Does Increasing the Minimum Wage Reduce Poverty in Developing Countries?" *IZA World of Labor* 30: 1—10.
Glomm, G., and B. Ravikumar. 1994. "Public Investment in Infrastructure in a Simple Growth Model." *Journal of Economic Dynamics and Control* 18 (6): 1173—87.
Groneck, M., and C. Kaufmann. 2017. "Determinants of Relative Sectoral Prices: The Role of Demographic Change." *Oxford Bulletin of Economics and Statistics* 79 (3): 319—47.
Haanwinckel, D. 2023. "Supply, Demand, Institutions, and Firms: A Theory of Labor Market Sorting and the Wage Distribution." Technical Report, National Bureau of Economic Research.
Ham, A. 2018. "The Consequences of Legal Minimum Wages in Honduras." *World Development* 102 (C): 135—57.
Ihrig, J., and K. S. Moe. 2004. "Lurking in the Shadows: The Informal Sector and Government Policy." *Journal of Development Economics* 73 (2): 541—57.
Jales, H. 2018. "Estimating the Effects of the Minimum Wage in a Developing Country: A Density Discontinuity Design Approach." *Journal of Applied Econometrics* 33 (1): 29—51.
Johnson, S., D. Kaufman, and A. Shleifer. 1997. "The Unofficial Economy in Transition." *Brookings Papers on Economic Activity* 28 (2): 159—240.
Kennan, J. 2013. "Open Borders." *Review of Economic Dynamics* 16 (2): 1—13.
Klein, P., and G. Ventura. 2009. "Productivity Differences and the Dynamic Effects of Labor Movements." *Journal of Monetary Economics* 56 (8): 1059—73.
Krusell, P., and A. A. Smith Jr. 2015. "Is Piketty's "Second Law of Capitalism" Fundamental?" *Journal of Political Economy* 123 (4): 725—48.
Kydland, F. E., and E. C. Prescott. 1982. "Time to Build and Aggregate Fluctuations." *Econometrica* 50 (6): 1345—70.
La Porta, R., and A. Shleifer. 2014. "Informality and Development." *Journal of Economic Perspectives* 28 (3): 109—26.
Lemos, S. 2009. "Minimum Wage Effects in a Developing Country." *Labour Economics* 16 (2): 224—37.
Lewis, W. A. 1954. "Economic Development with Unlimited Supplies of Labor." *Manchester School of Economic and Social Studies* 22 (2): 139—91.
Lin, J. Y., and D. Doemeland. 2012. "Beyond Keynesianism: Global Infrastructure Investments in Times of Crisis." *Journal of International Commerce, Economics and Policy* 3 (03).
Loayza, N. V. 1996. "The Economics of the Informal Sector: A Simple Model and Some Empirical Evidence from Latin America." In *Carnegie-Rochester Conference Series on Public Policy*, Vol. 45, 129—62. Elsevier.
Loayza, N. V. 2016. "Informality in the Process of Development and Growth." Policy Research Working Paper Series 7858, The World Bank.
Maloney, W. F. 1999. "Does Informality Imply Segmentation in Urban Labor Markets? Evidence from Sectoral Transitions in Mexico." *World Bank Economic Review* 13 (2): 275—302.

Magnac, T. 1991. “Segmented or Competitive Labor Markets.” *Econometrica* 59 (1): 165—87.
Maloney, W., and J. Mendez. 2004. “Measuring the Impact of Minimum Wages. Evidence from Latin America.” In *Law and Employment: Lessons from Latin America and the Caribbean*, 109—30. University of Chicago Press.
Mankiw, N. G. 2000. “The Savers—Spenders Theory of Fiscal Policy.” *American economic review* 90 (2): 120—5.
Menna, L. 2016. “Optimal Fiscal and Monetary Policies Under Limited Asset Market Participation.” *Italian Economic Journal* 2 (3): 363—83.
Mitra, S. 2017. “To Tax or Not to Tax? When Does it Matter for Informality?” *Economic Modelling* 64 (C): 117—27.
Munguía, L. F. 2019. “Minimum Wages and Enforcement Effects on Employment in Developing Countries.” *Available at SSRN 3442352*.
Ohnsorge, F., and S. Yu. 2022. *The Long Shadow of Informality: Challenges and Policies*. World Bank Publications.
Ortega, F., and G. Peri. 2014. “Openness and Income: The Roles of Trade and Migration.” *Journal of International Economics* 92 (2): 231—51.
Parente, R. M. 2024. *Minimum Wages, Inequality, and the Informal Sector*. International Monetary Fund.
Rozenberg, J., and M. Fay. 2019. *Beyond the Gap: How Countries Can Afford the Infrastructure they Need While Protecting the Planet*. World Bank Publications.
Saracoğlu, D. Ş. 2008. “The Informal Sector and Tax on Employment: A Dynamic General Equilibrium Investigation.” *Journal of Economic Dynamics and Control* 32 (2): 529—49.
Saraçoğlu, D. Ş. 2020. “Do Labour Market Policies Reduce the Informal Economy More Effectively than Enforcement and Deterrence?” *Journal of Policy Modeling* 42 (3): 679—98.
Schneider, F. 2005. “Shadow Economies Around the World: What do we Really Know?” *European Journal of Political Economy* 21 (3): 598—642.
Tansel, A., H. I. Keskin, and Z. A. Ozdemir. 2020. “Is There an Informal Employment Wage Penalty in Egypt? Evidence from Quantile Regression on Panel Data.” *Empirical Economics* 58 (6): 2949—79.
Turnovsky, S. J., and M. Basher. 2009. “Fiscal Policy and the Structure of Production in a Two-Sector Developing Economy.” *Journal of Development Economics* 88 (2): 205—16.
Ulyssea, G. 2018. “Firms, Informality, and Development: Theory and Evidence from Brazil.” *American Economic Review* 108 (8): 2015—47.
Wang, Y., and B. Wu. 2015. “Railways and the Local Economy: Evidence from Qingzang Railway.” *Economic Development and Cultural Change* 63 (3): 551—88.