Labor Market Effects of Unemployment Insurance and UBI in Developing Economies*

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Abstract

We study an unexpected reform in the UI policy in Brazil that tightened the eligibility criteria for most (but not all) formal workers. We provide evidence that unemployment benefits reduce formal employment, and this effect is amplified by informality. We then study the consequences of replacing the existing transfer and UI policies with a universal basic income using a search-and-matching model where workers and firms jointly sort between formal and informal jobs. We calibrate the general equilibrium model to match key moments concerning unemployment, wage and wealth distributions, as well as the distribution of transfers. In addition, unemployment insurance benefits are related to pre-unemployment earnings and are subject to exhaustion, after which agents can only rely on transfers and savings. We show that a universal basic income of nearly $80 for each household per month, which replaces the existing transfer programs and unemployment benefits, can lead to aggregate welfare gains. These welfare gains mainly accrue to less skilled individuals despite a sizable fall in their wages and an increase in wage inequality. Albeit costly, the UBI reform reduces unemployment and informality, which attenuates the extra burden of higher taxes. We show that the increased activity in formal hiring is a key channel through which outcomes for low-education groups improve with the reform.

Keywords: Means-tested transfers; Welfare programs; Informality; Developing economies; Labor supply; Inequality; Universal basic income; UBI; Unemployment insurance.

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1 Introduction

Universal Basic Income (UBI) programs are transfer schemes where each person receives the same pre-specified amount irrespective of a household's or aggregate economic circumstances. It has been widely hypothesized that UBI might alleviate many problems in contemporary labor markets such as declining job security, the stagnant pay of middle-class jobs and inequality.[1] This view is inspired by the notion that setting an income floor will reduce poverty, improve economic security, cushion job loss, and increase bargaining power for low-wage workers. Another common argument is that social safety net in its present form creates welfare traps and is unduly complicated and inefficient. According to its proponents, a UBI policy could tackle these issues by providing a guaranteed income in a simple system and, as it is a lump-sum transfer, provides better incentives to work. However, due to its universal nature, the cost of such a policy would be potentially very large and thus questions are raised regarding possible taxation counterparts that are likely of first-order importance in evaluating the consequences of a UBI reform.

Although the idea of universal basic income has been hotly debated, a true universal basic income has never actually been fully implemented and there is only limited evidence about its effects so far, mostly from small pilot schemes.[2] The majority of basic income pilots and experiments have elements of targeting and transfers are made for given period of time and thus they are not informative about the long-run equilibrium impact on key outcomes such as prices, savings rate, income and wealth inequality.[3] These effects are likely to be large since the prospect of broader eligibility associated with universal cash transfers. To this end, an emerging and growing literature in macroeconomics, reviewed below, has relied on general equilibrium models to study the aggregate consequences of UBI. However, all these analysis have focused on developed economies and thus little is known about the effects of these policies in developing economies where informality is widespread and tax collection is more difficult. We aim to fill this gap by studying the consequences of UBI using an equilibrium model of the labor market that takes into account how workers and firms jointly sort between formal and informal jobs.

The interaction with informality is a key aspect to bear in mind when thinking about the consequences of UBI in developing economies.[4] On the one hand, social programs — transfer and social insurance programs — require beneficiaries to not be formally employed. This feature imposes an implicit tax on formal earned income, and thus a key concern about these programs is the potential disincentive to (search for) work formally. This concern is particularly aggravated when the ready availability of informal jobs exacerbates the disincentives to work in the formal sector that are created by safety net programs. A

[1] See, for instance, Lowrey (2018) and Gentilini et al. (2020)

[2] See Hoynes and Rothstein (2019) for an overview.

[3] **?**

[4] Informality can be broadly defined as any deviation from labor regulations, such as avoiding payroll contributions and not conforming to labor law statutes.

UBI offers better incentives to formalization than more traditional welfare policies since the transfer amount will not be cut off as formal income rises.[5] Thus, unlike unemployment benefits or income support, there is no disincentive against seeking better paying employment. On the other hand, since transfers would accrue to all individuals, the budgetary concerns of UBI might be aggravated in economies with widespread informality. Tax revenue collection as a share of GDP is only 15 to 20% in lower and middle income countries as oppose to over 30% in upper income countries, and most of the tax revenue is paid by the top earners.[6] This gap is important since it implies that developing countries have less tax revenue to spend on public goods and redistribution. Thus, because of the small tax base, it is argued that a UBI reform would increase marginal tax rates substantially more for those relatively few workers inside the formal sector.[7] To the extent that these individuals are particularly productive, such a tax increase may have disproportionally larger efficiency consequences, and potentially increasing informality even more.

We take these key trade-offs into account to assess whether or not a UBI scheme, as portrayed in popular discussions, is a good idea for a developing economy using Brazil as laboratory. The Brazilian economy provides an excellent setting for our work due to its sources of data for the formal and the informal sectors. Nearly two thirds of businesses and 40 percent of GDP are informal and the labor regulations are both substantive and weakly enforced. Moreover, there is a clear definition of what constitutes informality: we define as informal workers those who do not hold a formal labor contract, clearly observable through the worker's booklet (carteira de trabalho). Informal firms are those not registered with the tax authorities, which means that they do not possess the tax identification number required for Brazilian firms (Cadastro Nacional de Pessoa Jurídica-CNPJ) and which we are able to also observe.

We begin our analysis by providing evidence on the the effects of the unemployment insurance (UI) on formal employment in Brazil. To this end, we follow Doornik et al. (2022) and study the effects of an unexpected reform in the UI policy that tightened the eligibility criteria for most (but not all) formal workers. More specifically, the reform tightened eligibility for workers with less than two previous UI spells but not for individuals with more than two. We divide Brazilian municipalities in two groups – high exposure and low exposure – according to the share of formal workers affected by the reform. Then, we exploit the geographic variation in this share of affected workers before and after the reform and in the intensity of enforcement of labor regulations in an event study framework. Our goal is to assess if, and to what extent, the presence of stricter enforcement of a costly regulatory framework shapes the labour market responses to changes in transfers. We have two important findings. First, municipalities with a higher share of formal workers affected by the

[5] A UBI has just an income effect, while the benchmark system generates both income and substitution effect.

[6] These numbers are from **?**

[7] See, for instance, Hanna and Olken (2019)

reform saw a higher growth in formal employment relative to municipalities with a lower share, suggesting that, by making it harder for formal workers to collect UI, workers' incentives to remain on the job increased. Second, our estimates indicate this effect increases as the level of labor market enforcement decreases; that is, regions where it is easier to switch to an informal job were disproportionately more affected by the policy change than regions with a higher enforcement. Taken together, these results indicate that social security programs reduce formal employment and informality amplifies this effect, increasing the cost of public policies.

Given this evidence, we develop a stochastic OLG equilibrium model to assess the labor market consequences of UBI with the following key ingredients. First, we consider a search-and-matching model along the lines of a Diamond-Mortensen-Pissarides' (D-M-P), featuring endogenous search intensity.[8] In this environment, transfers influence vacancy creation and wage bargaining between firms and workers. Firms enter by posting vacancies and match with workers bilaterally, with match probabilities given by an aggregate matching function. Employment opportunities are endogenous, depending on how hard individuals search for a job as well as the aggregate labor market conditions that determine how easy it is to locate jobs per unit of search effort. Once a match is formed, firms must choose whether or not to register the worker. Firms can avoid paying taxes by hiring the worker informally, but they are subject to inspections and may suffer fines for labor law violations.

Second, we depart from the standard DMP setting with risk neutrality by combining the search-and-matching framework with incomplete markets as in Krusell et al. (2010), and introduce endogenous job separations as in Bils et al. (2011). Our motivation for doing this is to study the welfare effects of transfers when workers care about consumption smoothing. In addition, by allowing for diminishing marginal utility in consumption and imperfect insurance, wealth affects workers' reservation wages and thus the cross-sectional distributions of wealth play a critical role in determining the aggregate labor response to changes in the transfer system.

Third, working and earning a wage does not only have implications for the cross-sectional distribution of income and wealth, but also for life-cycle profiles through human-capital accumulation on the job. In particular, labor productivity is determined by two components. First, agents are ex-ante heterogeneous concerning their ability, which can be interpreted as pre-market skills such as innate ability or obtained through education. The second component reflects human capital or experience, and accumulates in a learning-by-doing fashion. We build on the work of Ljungqvist and Sargent (1998) and Kehoe et al. (2019) in assuming that worker's productivity changes over time according to laws of motion that depend on her employment status. Employed agents can experience productivity increases during their employment spell, which is influenced by the formality status of the

[8] Diamond (1982), Mortensen (1982) and Pissarides (1985)

job in line with the evidence in Bobba et al. (2021). On the contrary, idle workers have less opportunities to practice his skills and may even lose previously accumulated knowledge, leading to a depreciation of his human capital.

We use microdata from Brazil to inform the model and proceed with a quantitative analysis. The model matches key facts concerning unemployment, and the wage and wealth distributions, as well as the distribution of transfers and UI. Unemployment insurance (UI) benefits are related to pre-unemployment earnings and subject to exhaustion, after which agents rely on transfers and their own savings. The calibrated model allows us to conduct several counterfactual experiments to shed light on the impacts of existing and new transfer regimes on labor market outcomes, inequality, and welfare.

We consider two sets of counterfactual simulations in which each person receives a predetermined amount, irrespective of their income and asset levels or employment status. In the first set, we only remove the current transfers system. In the second set, we additionally remove unemployment benefits. Within each case, we consider three levels of universal basic income: 15%, 20%, and 25% of the benchmark average income. The costs of the scheme are financed by adjusting the level of labor income taxation.

We find ...

This paper contributes to several strands of the literature. First, we contribute to the literature that studies the welfare and aggregate effects of taxes and transfer programs using general-equilibrium models with heterogeneous agents. Lopez-Daneri (2016) studies a revenue-neutral reform of the U.S. income tax and welfare system that involves the adoption of a negative income tax. Wellschmied (2021) studies the savings effects of the asset means-test in US income support programs. Ortigueira and Siassi (2021) study the effects of the U.S. anti-poverty system on savings, labor supply, and marital decisions of non-college-educated workers with children. Guner et al. (2020) study the effects of conditional transfers on households' labor supply with children.[9]

We also contribute to the emerging literature focusing on the impact of UBI using quantitative models in the Bewley-Huggett-Aiyagari tradition. Conesa et al. (2021) and Luduvice (2021) find that it is hard to justify a UBI policy reform on welfare grounds. Guner et al. (2021) find similar conclusions in a model that incorporates heterogeneity in gender and marital status. Daruich and Fernández (2020) study the impact of UBI on parental skill investments during early childhood and education decisions and find that UBI is not a good idea when the welfare of future generations is taken into account. Ferriere et al. (2021) build on the work in Heathcote et al. (2017b) to study the optimal negative relation between transfers and income-tax progressivity using a Ramsey approach. They show that most of the welfare gains in the benchmark plan can be attained by a UBI of $26,000 per

[9]Our work also relates to the literature that studies optimal tax progressivity (e.g., Conesa and Krueger 2006; Kindermann and Krueger 2020; Guner et al. 2016; Heathcote et al. 2017b), capital taxation (Golosov et al. 2003; Conesa et al. 2009; Boar and Midrigan 2021) or age-dependent taxation (da Costa and Santos 2018; Ndiaye 2017; Heathcote et al. 2017a).

household.

We add to this literature by evaluating a UBI policy reform in a framework that combines job search as well as formal and informal job creation with incomplete markets. This is important because the efficiency-equity trade-off associated with transfers depends on the endogenous relationship between formal vacancy creation, incentives to work, and savings behavior. In addition, unlike the papers above in which the wage level is competitively determined, in our model wages are determined by Nash bargaining and thus more generous transfers affect workers' outside options and firms' incentives to create formal vacancies.

We also add to the large body of reduced-form evidence on the effects of means-tested transfers on informality. De Brauw et al. (2015) find that beneficiaries of the Bolsa Familia program in Brazil report working 8.0 fewer hours per week in the formal sector and 7.8 more hours in the informal sector, on average, relative to individuals who did not receive transfers. Bergolo and Cruces (2021) study the impact of a conditional cash transfer program in Uruguay on the employment of adult members in beneficiary households in a context of high informality. They rely on the sharp discontinuity introduced by program eligibility rules around a poverty score threshold combined with longitudinal administrative data and find reductions of about 6 percentage points (a 13% drop) in formal employment among all beneficiaries. Garganta and Gasparini (2015) study the effects of the Asignacion Universal por Hijo in Argentina and find large disincentive to the labor market formalization of beneficiaries.

We contribute to this literature by relying on unique data on enforcement of labour regulation in Brazil to document how the presence of stricter enforcement of a costly regulatory framework shapes the labour market responses to changes in the bolsa família program.

The paper is organized as follows. In section 2, we provide reduced form evidence on the effects of the Bolsa Família programa on informality. In section 3, we present the model economy. In section 4 we describe the estimation and calibration of the benchmark economy. Section 5 discusses the properties of the benchmark economy. In section 6, we present the main findings of our quantitative experiments, and section 7 concludes.

2 Empirical Analysis

2.1 Unemployment Insurance and Labor Enforcement

We follow Doornik et al. (2022) and Van Doornik et al. (2023) and evaluate a reform in the Unemployment Insurance program that took place in 2015 in Brazil. Prior to the reform, in order to be eligible to receive the compensation, a formal employee must had worked for at least 6 straight months prior to the dismissal. However, in December 2014, a new executive order (*Medida provisória*) was announced to take place from March 2015 onward.

According to the new rule, first-time applicants must had worked for at least eighteen of the twenty four months prior to the layoff, and second time applicants at least twelve of the last sixteen months. Importantly, the rule did not change the necessary tenure for individuals with at least 2 prior spells, this way the reform affected some individuals, but not all formal workers. In June/2015, the executive order became law and changed again; the tenure conditions were then reduce to twelve and nine months for first-time and second-time applicants, respectively. Thus, the new set of rules made stricter the conditions to receive UI benefits for workers with less than two prior spells,but not for employees with two or more. Importantly, no changes were made that directly affected firms. Another important topic is that,in Brazil, a worker has to be fired in order to receive the UI benefit, that is, if an employee asks to leave the firm,he won't receive UI benefits. Nevertheless, workers have incentives do manage to get fired in order to receive UI.

In addition to the change in UI eligibility criteria, we also study a metric of labor market enforcement. Enforcement of labor laws is a responsibility of the Ministry of Labor and it is done by inspectors on the premises of firms. These inspectors are allocated to Labor Offices (LOs) throughout the country, however, not all municipalities have LOs; so in order to a firm to be inspected, an inspector must drive, by car, from the nearest LO (that can be in other municipality) to the firm (Almeida and Carneiro (2012)). Hence, the further a municipality is from a LO, the costlier it is to enforce labor regulations in that municipality. Thus, we use as a metric of enforcement the driving distance (by car) from a municipality to the nearest Labor Office, like in Almeida and Carneiro (2012) and Ponczek and Ulyssea (2021), measured in hundreds of kilometers. It is worth noting that the focus of inspections are formal firms, and inspectors should enforce labor laws as a whole, and not only verify if a formal firm is hiring an informal worker.

2.2 Data

Our data comes from three main databases.The first one is *Base de Gestaão do Seguro Desemprego* (BGSD), a database with information on every request for an UI benefit. Since BGSD is identified at the individual level, we can observe how many times each employee had received UI benefits prior to December 2014, the month when the reform was announced; if an individual had less than two prior spells, then we consider him an affected person. We then proceed to merge it with our second main database, *Relação Anual de Informações Sociais* (RAIS). This data set contains detailed and identified information on formal labor employment, with data both for workers (like age, race, gender, wages and employment tenure) and firms (like location and age). Focusing on private non-temporary employment only, since public and temporary employees do not receive UI, we are able to construct a panel of affected workers by municipality along time. Throughout the Empirical Analysis section, the terms "formal employment" and "private non-temporary formal employment" will be used interchangeably. It is worth noting that we exclude from the sample municipalities that could be seen as outliers; more specifically, we exclude municipalities with less than 5 formal employees in any month from January 2012 to December 2017. In addition, we also exclude very small and large municipalities as given by the bottom and top 1% of the employment distribution.

The final main dataset contains information from the Ministry of Labor on labor enforcement, gathered by Ponczek and Ulyssea (2021), with the driving distance form each municipality to each LO. With this, we can define the nearest LO to each municipality, as well as the driving distance in hundreds of kilometers.

Our goal is to compare the heterogeneous effects of the change in UI eligibility criteria across municipalities given the level of labor market enforcement. Hence, we need a metric to compare the exposure each municipalities had to the change in UI rules; we define this measure as the share of formal employees in December/2014 (at the announcement of the reform) in each municipality that were affected by the changes in UI criteria. That is, we our exposure metric is the ratio of affected formal employees over the total formal employees in a given municipality. We proceed to split our sample of municipalities in two halves according to this metric of exposure. Municipalities on the top half of exposure are assigned as Treated regions, while the bottom half are assigned as Control, in a process similar to the one adopted by Gerard (2021).

Our analysis will take place quarterly, from 2012Q1 to 2017Q4 at the municipality level. Summary statistics are given in Table 1 below. It is important to note that there are some base differences between our Treated and our Control Group, more specifically, our control group is composed of larger municipalities, as can be seen by the population and formal employment lines. Nevertheless, as we will see in the results of our event study, there seams to be no difference between the municipalities prior to the change in UI rules after controlling for some fixed effects and covariates.

Table 1: Summary Statistics For Municipalities by Treatment Group

	All	Control	Treated
Population	25673	33368	17981
Formal non-temporary private-sector employees	3623	5840	1406
Affected	1016	1516	516
Exposure (Affected/Formal employees)	0.34	0.25	0.42
Share of White	0.58	0.59	0.54
Share over 40 years old	0.32	0.32	0.31
Share with High School or Less	0.87	0.87	0.87
Distance (100 kms)	0.95	0.86	1.05
Number of municipalities	5371	2685	2686

Notes: This table display average characteristics across municipalities, both for all and splited by treatment group. Values are from December 2014 and Shares are with respect to formal non-temporary private-sector employees.

2.3 Empirical Specification

Our main empirical specification takes the following Difference in Differences Event Study format:

$$Y_{mts} = Treatment_{ms} \cdot \sum_{p \neq 20142} \beta_p \cdot 1\{t = p\} + \gamma \cdot X_{mts} + \alpha_m + \alpha_t + \alpha_{ps} + \varepsilon_{mts} \tag{1}$$

In equation 1, m denotes municipalities, t denotes time (quarters from 2012 to 2017) and s denotes states. Since we want to understand the effect of the reform on labor supplye, our dependent variable, Y_{mts} is the log of formal employment. We group time in 12 periods, one for each semester from 2012 to 2017, that is $p = \{20121, 20122, ..., 20171, 20172\}$. $Treatment_m$ is a dummy variable that takes the value of 1 if municipality m was treated and 0 otherwise, that is, if the municipality's exposure to the shock (Affected/Employed in December 2014) was above the median. This way, we can estimate the effect of being in the treated group both before and after the tightening in UI rules. In addition to that, we also include a set of control variables X_{mts} that are the share of white workers, share of men, share of workers above 40 years old, and shares of each of these educational levels: incomplete elementary, complete elementary, incomplete high school and complete high school. Note that these shares are with respect to the whole of the formally employed population. We also add municipality α_m and time fixed α_t effects to control for time invariant characteristics in the municipalities and common shocks across municipalities, respectively. On top of that, we also add state by period fixed effects α_{ps} to control for time varying characteristics that affect all municipalities within a state, such as a change in state government. Finally, we cluster our error term ε_{mts} at the microrregion level. Microrregions are a a subdivision of Brazil, defined by *Instituto Brasileiro de Geografia e Estatística* (IBGE), with a regional identity and similar structure of production, a concept that resembles local economies (Ponczek and Ulyssea, 2021).

Our main coefficients of interest is β_p. It will give information on the heterogeneous effect of changes in UI rules on regions more exposed ($Treatment_i = 1$) in relation to regions less exposed. A positive β_p from 2015 onwards means that the change in UI had a relative positive effect on employment for regions more exposed. In the context of the model we will show below, stricter rules for UI can be associated with a decrease in the Value of Unemployment, and thus, a greater incentive for workers to remain in a formal employment. Results can be seen in the figure 1 above.

As we can see, prior to the reform announcement (December/2014), there was no effect of being in the treatment group on formal employment. With the tightening of UI rules, employment in treated municipalities became higher than in control municipalities starting in the first half of 2015. Our estimates point to a employment 9.1% larger in treated municipalities in comparisson to control municipalities in the end of 2017. This could be due to the decline in incentives for formal employees to go unemployed (to remain unem-

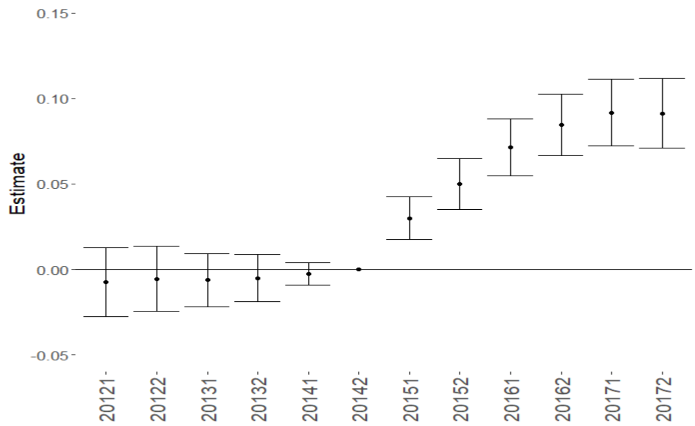


Figure 1: The figure displays the estimated coefficients, $\hat{\beta}_p$, of equation 1 and their 95% confidence interval. The dependent variable is the log of non-temporary formal employment.

ployed or go informal) after the reform, since for some it would be necessary more time working to get access to the unemployment insurance.

We can go further now and understand the heterogeneous effect for regions with distinct levels of labor enforcement. We run regression 1 above but with restricted samples. We split our sample based on the distance of the municipality to the nearest LO, first we run only for municipalities below the the 25% of the distance distribution , and then we run the regression for municipalities above the 75% of the distance distribution. This way we split municipalities between high enforcement (low distance) and low enforcement (large distance). We expect the effects to be driven mostly by low enforcement municipalities. An easy way to understand this is to think that, if some municipality had perfect enforcement, its formal employees already had low incentives to go unemployed in order to receive UI, even prior to the UI reform, since they could not have an informal job. Hence, the effects of the change in UI rules should be higher for lower enforcement locations.

Results for the estimation split by distance group can be seen in Figure 2 below. The figrure on the left shows the results for estimating equation 1 only for municipalities below the 25% of the distance distribution, and the one on the right shows for municipalities above the 75% of the distance distribution. As expected, our estimates points to a stronger effect for regions with a higher distance (low enforcement) than for regions with a lower distance (higher enforcement). More specifically, the estimated effect in the second half of 2017 is a formal employment increase of 5,7% for municipalities in the treated group in relation to ones in the control group, for municipalities with a low distance to LOs. In constrast, our estimate for municipalities with a high distance is 14.2% higher employment in the treated group relative to the control group in the second half of 2017. This result goes in line with the literature indicating the distortionary effects of informality.

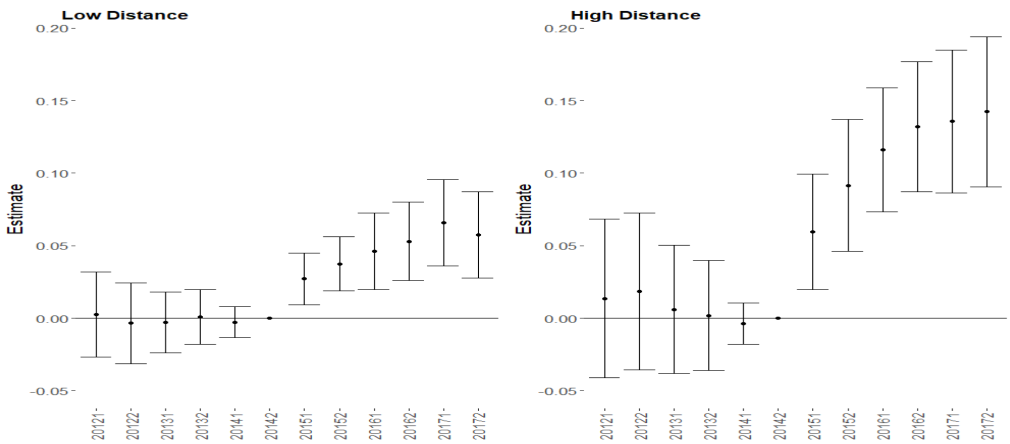


Figure 2: This figure presents the estimated coefficients, $\hat{\beta}_p$, of equation 1 and their 95% confidence interval. The dependent variable is the log of non-temporary formal employment. "Low Distance" corresponds to municipalities in the bottom 25% of the distance distribution, while "High Distance" corresponds to municipalities in the top 25%.

3 Model

3.1 Demography and preferences

Time is discrete and runs eternally. The economy is populated by overlapping generations of individuals who face an exogenous probability, ν, of surviving to the next period. At each period, $1-\nu$ new agents are born, and $1-\nu$ die, so that the population remains constant at the normalized unit level. Individuals' labor productivity is determined by two components. The first one, denoted by e, is realized at birth and retained throughout one's life. It can be interpreted as innate ability and pre-market skills obtained through education. The second one, z, is a stochastic component and its law of motion is explained below.

Agents have preferences over random streams of consumption, c_t, according to

$$\mathbb{E}\left[\sum_{t=0}^{\infty}\beta_e^t\left(\prod_{s=0}^{t}\nu\right)u(c_t,\ell_t,s_t)\right], \tag{2}$$

where $\mathbb{E}$ is the expectation operator conditional on information at birth and the intra-period utility takes the following separable functional form:

$$u(c_t,\ell_t,s_t)=\frac{c_t^{1-\gamma}}{1-\gamma}+\ell_t\left(d-\chi\frac{s_t^{1+\phi}}{1+\phi}\right). \tag{3}$$

The parameter d captures the utility from leisure when unemployed, while ℓ_t is an indicator function which assumes value 1 when unemployed and zero otherwise. The valuation of leisure in (3) entails that the marginal rate of substitution between leisure and consumption is decreasing in c, and thus the worker's reservation match quality is increasing in savings as in Bils et al. (2011). In addition, an unemployed worker looks for a job by exertingchoosing search intensity s. The cost of searching for a job depends on how intensively the worker searches. The parameter χ determines the cost of search effort, while ϕ is an elasticity parameter that governs how search effort responds to a change in transfers.

We allow the discount factor β_e to depend on individual's ability as a way to generate an empirically plausible cross-sectional wealth distribution, which has been already explored in Krusell and Smith (1998) and more recently in Krueger et al. (2016), among others.[10]

3.2 Human capital accumulation

In line with Ljungqvist and Sargent (1998) and Kehoe et al. (2019), we think of z as representing the individual's human capital, which is accumulated on the job in a leaning-by-doing fashion. It captures the fact that while working, agents can practice their skills and learn, thereby increasing productivity. While off the job, the worker has less opportunities to practice his skills and may even lose previously accumulated knowledge, potentially leading to a depreciation of his human capital. The dynamics of z are stochastic and are characterized by shocks moving agents up and down the job ladder. In particular, the human capital of an employed worker evolves according to the following sector-specific law of motion, with $j = f, i$:

$$\log z' = (1 - \varphi_j)\bar{z}_j + \varphi_j \log z + \sigma_j \varepsilon' \tag{4}$$

where φ_j determines the persistence, σ_j the volatility and $\bar{z}_j$ the mean of the process, while ε is a Gaussian disturbance with zero mean and unit variance.

We allow for the volatility of the shock, σ_j, the persistence, φ_j, and the mean, $\bar{z}_j$ to be different across sectors. This is in line with the empirical evidence in Bobba et al. (2021) who show that the formality status of the job significantly affects the dynamic of worker's human capital. Notice that neither process results from explicit investment decisions but is a result of the worker's labor market state. In addition, adding idiosyncratic shocks, ε, to human capital accumulation allows the model to reproduce the dispersion in wage growth rates observed in the data.

A non-employed worker's human capital evolves according to a similar AR(1) process with the same volatility but with a different mean (which we normalize to 0) and persistence φ_u:

$$\log z' = \varphi_u \log z + \sigma_u \epsilon'. \tag{5}$$

We represent below the Markov processes in 4 and 5 as $F_j(z, z')$ and $F_u(z, z')$. Finally, newborn workers enter the economy endowed with a draw of z from a log-normal distribution with mean zero and variance equal to the unconditional variance of productivity

[10]See Falk et al. (2018) for experimental evidence on heterogeneity in discount rates.

process for the unemployed $\log(z) \sim N(0, \sigma_u^2/(1-\varphi_u^2))$.

These laws of motion imply that a newborn worker's productivity increases on average over time since its productivity converges to $\exp(\bar{z}_j)$ from below. The speed at which productivity and, as a consequence, the wage grow over the employment spell is determined by the persistent parameter φ_j. For instance, the slope of the life-cycle earnings profile will be steeper, the lower the value of φ. Similarly, if φ_u is relatively low, non-employed workers experience a faster reduction in their human capital since their productivity converges to $\exp(0)$ from above more rapidly. This also entails that the higher the human capital of a worker who loses her job, the higher the likelihood of her falling down the ladder.

3.3 Labor market frictions

Workers and firms come together via random search. We assume that a worker's type is observable and that firms can direct their search by posting vacancies for individuals of a given level of education e. Let u_e be the measure of nonemployed agents of type e, S_e be the aggregate search effort in market e, and v_e the corresponding measure of vacancies posted by firms for agents in submarket e. The flow of successful matches within a period are given by the following matching function:

$$M(S_e, v_e) = \frac{(S_e u_e) v_e}{[(S_e u_e)^\eta + v_e^\eta]^{\frac{1}{\eta}}} \tag{6}$$

where η determines the interaction between the measure of job searches $S_e u_e$ and vacancies v_e.

We use this matching function, which was proposed by Haan et al. (2000), to ensure that job finding rates are between 0 and 1. Specifically, dividing (6) by S_e, the probability per search effort that a nonemployed individual of type e matches with a vacancy in submarket e is then

$$m(\theta_e) = \frac{\theta_e}{(1+\theta_e^\eta)^{\frac{1}{\eta}}}$$

where $\theta_e = \frac{v_e}{S_e u_e}$ is labor market tightness in the submarket e. A worker supplying search effort s then finds a job with probability $sm(\theta_e)$. The job filing rate in the submarket e can similarly be obtained dividing (6) by v_e:

$$q(\theta_e) = \frac{1}{(1+\theta_e^\eta)^{\frac{1}{\eta}}}.$$

Note that formality status is endogenous and chosen by the firm period by period, based on the worker's type and human capital. We describe below the formalization choice in detail.

3.4 Asset markets

Consumers face idiosyncratic income shocks. Because markets are incomplete, they cannot perfectly smooth consumption. Thus, savings may be precautionary and allow partial insurance against shocks. Agents can accumulate two kinds of tangible assets: physical capital, k, which is used as an input for production, and equity x, which is a claim for the aggregate profit. Let r be the return to capital and div be the dividend paid to the holders of equity. The total amount of equities is normalized to one. As there is no aggregate risk, the equity price remains constant in equilibrium. The equity price p has to satisfy a standard no-arbitrage condition, which implies that the returns on holding capital and equity are equal:

$$p = \frac{div + p}{1 + r - \delta} \tag{7}$$

where δ is the depreciation rate of capital.

Since capital and equity both are riskless and provide the same return and therefore are the same from the consumer's viewpoint, we do not have to keep track of the asset composition of the consumers. In the following, we define total financial resources as:

$$(1 + r - \delta)(k + px) = (1 + r - \delta)a \tag{8}$$

and use a as the state variable for a consumer.

Asset holdings are subject to an exogenous lower bound. More precisely, for our main exercise, we assume that agents are not allowed to contract debt, so that the amount of assets carried over from one period to the next is such that $a' \geq 0$.

3.5 Government

The government levies taxes on capital income, consumption, and labor income. We assume that consumption is taxed at a flat rate τ_c and capital income at a flat rate τ_k. In addition, the government collects a non-linear and progressive tax schedule on formal labor income according to the tax function suggested by Benabou (2002) and more recently used by Heathcote, Storesletten, and Violante (2017):

$$T(w_f) = \max\{w_f - \tau_w w_f^{1-\xi}, 0\} \tag{9}$$

where w_f is the wage for an individual employed in the formal sector, and $T(w_f)$ is tax paid. Parameters τ_w and ξ regulate the level and progressivity of taxation, respectively. For instance, if $\xi = 0$ then the tax rate is flat at $1 - \tau_w$, and the system is progressive if $\xi > 0$.

Government revenue is used to finance a stream of exogenously given government consumption, G. In addition, there are two government-run programs in the economy. Newly unemployed workers are eligible to receive unemployment insurance (UI) benefits if they were formally employed in the previous period. The benefit amount, $b(w_f)$, depends on the worker's wage in the last job, w_f, and is given by a piecewise linear function specified in accordance with Brazilian legislation.

$$b(w_f) = \begin{cases} \vartheta_1 w_f, & w_f \leq w_1 \\ \vartheta_1 w_1 + \vartheta_2(w_f - w_1), & w_1 < w_f \leq w_2 \\ \bar{b}, & w_f > w_2 \end{cases} \tag{10}$$

where $0 < \vartheta_2 < \vartheta_1$, and (w_1, w_2) are the bend points of the function.

The function implies that up to a wage in the previous job of w_1, individuals are entitled to $\vartheta_1 w_f$, so that ϑ_1 corresponds to the replacement rate in this case. If the wage in the previous job is greater than w_1 but smaller than w_2, the worker will receive $\vartheta_1 w_1 + \vartheta_2(w_f - w_1)$, and finally, for wages greater than w_2, unemployed workers will receive $\bar{b}$, which corresponds to the maximum benefit amount.

Hereafter, we use ι as an indicator function that takes value 1 if the unemployed worker is collecting unemployment insurance and 0 otherwise. To economize on the state space, we assume that the exhaustion of UI benefits are stochastic events, which is governed by the following transition matrix:

$$\Pi_{\iota,\iota'} = \begin{pmatrix} 1 & 0 \\ 1 - \pi & \pi \end{pmatrix}. \tag{11}$$

Thus, for example, if an unemployed worker is not currently receiving UI benefits, $\iota = 0$, then she will not receive it next period, i.e. $\iota' = 0$ with probability one. On the contrary, if $\iota = 1$, the parameter π denotes the probability of UI benefits not being exhausted next period.

The government also runs a welfare system designed to mimic the social programs in the Brazilian economy. The function $Tr(y_v)$ corresponds to the transfer amount received by a household. We assume that the amount of transfers is given by a Ricker function:

$$Tr(y_v) = \begin{cases} e^{\rho_1} e^{\rho_2 y_v} y_v^{\rho_3} & \textit{if } y_v > 0 \\ \rho_0 & \textit{if } y_v = 0. \end{cases} \tag{12}$$

It depends on individual's total verifiable income, consisting of formal wages or unemployment benefits, interest, and dividend income and thus does not take into account informal wages. In particular, y_v is defined as follows:

$$y_v = \begin{cases} ra + w_f, & \text{if formal} \\ ra + b, & \text{if informal with } \iota = 1 \\ ra, & \text{if informal with } \iota = 0 \\ ra + b, & \text{if unemployed with } \iota = 1 \\ ra, & \text{if unemployed with } \iota = 0. \end{cases} \tag{13}$$

Note that the transfer amount of an individual with no income are given by ρ_0, while the transfers of a household with positive income are determined by the three parameters (ρ_1, ρ_2, ρ_3), where ρ_1 governs that level, and (ρ_2, ρ_3) govern the curvature of the function.

3.6 Workers' maximization problem

Let $V_f(a, e, z)$ denote the value function of a formally employed worker with individual productivity (e, z) who owns a assets. Similarly, $V_i(a, e, z, b, \iota)$ and $V_u(a, e, z, b, \iota)$ denote the value functions of informally employed and unemployed workers, respectively, where b denotes the UI benefit amount and ι indicates the UI eligibility status as explained above.

We can write the recursive problem of a formally employed agent as

$$\begin{aligned} V_f(a, e, z) = \max_{a' \geq 0, c} &: u(c, 0, 0) \\ &+ \beta_e \nu \Big[(1 - \varsigma_e) \sum_{z\prime} F_f(z, z') \max\{\tilde{V}(a', e, z'), V_u(a', e, z', b', \iota = 1)\} \\ &\qquad + \varsigma_e \sum_{z\prime} F_f(z, z') V_u(a', e, z', b', \iota = 1) \Big] \end{aligned} \tag{14}$$

subject to the following budget constraint:

$$(1 + \tau_c)c + a' = [1 + (1 - \tau_k) r] a + w_f(a, e, z) - T(w_f(a, e, z)) + Tr(y_v). \tag{15}$$

where $\tilde{V}(a', e, z')$ corresponds to the value of being employed (formally or informally) next period and is given by:

$$\tilde{V}(a', e, z') = \tilde{\mathbb{I}}(a', e, z') V_f(a', e, z') + (1 - \tilde{\mathbb{I}}(a', e, z')) V_i(a', e, z', b', \iota = 1) \tag{16}$$

The function $\tilde{\mathbb{I}}(a', e, z')$ captures the firm's formalization choice, which is taken as given by the worker. It takes value 1 if the firm chooses to keep the worker registered and 0 otherwise. Notice that if the worker is deregistered next period, she will be entitled to UI benefits b' as given by 10. Thus, informal labor provides workers with the opportunity to receive UI benefits while being employed informally.[11] In addition, the continuation value in (14)

[11] These formal-to-informal employment transitions within the firm are consistent with the empirical evi-

also reflects the consumer's survival probability, ν, the type and sector-specific exogenous separation probability $\varsigma_{e,f}$, the decision of whether to continue a relationship. Equation (18) is the household's budget constraint. The worker's wage, w_f, is determined through Nash bargaining between the firm and the worker every period as explained below, and thus depends on her individual state (a, e, z).

The recursive problem of an unregistered worker is given by

$$\begin{aligned} V_i(a,e,z,b,\iota) = \max_{a'\geq 0,c} &: u(c,0,0) \\ &+ \beta_e \nu \sum_{\iota'} \Pi_{\iota,\iota'} \Big[(1-\varsigma_{e,i}) \sum_{z\prime} F_i(z,z') \max\{\hat{V}(a',e,z',b,\iota'), V_u(a',e,z',b,\iota')\} \\ &+ \varsigma_{e,i} \sum_{z\prime} F_i(z,z') V_u(a',e,z',b,\iota')\Big] \end{aligned} \tag{17}$$

subject to the following budget constraint:

$$(1+\tau_c)c + a' = [1+(1-\tau_k)\, r]\, a + w_i(a,e,z,b,\iota) + \iota b + Tr(y_v). \tag{18}$$

where $\hat{V}(a', e, z', b, \iota')$ is the value of being employed next period and is given by:

$$\hat{V}(a',e,z',b,\iota') = \hat{\mathbb{I}}(a',e,z',b,\iota') V_f(a',e,z') + (1-\hat{\mathbb{I}}(a',e,z',b,\iota')) V_i(a',e,z',b,\iota') \tag{19}$$

As before, $\hat{\mathbb{I}}(a', e, z', b, \iota')$ describes the firm's formalization choice and takes value 1 if the firm chooses to register the worker next period and 0 otherwise. Note that it depends on the UI eligibility status next period and on the amount of benefits that the worker might be collecting.

Finally, workers move from unemployment to employment according to the endogenous job-finding rate $sm(\theta_e)$. The recursive problem of an unemployed worker is given by

$$\begin{aligned} V_u(a,e,z,b,\iota) = \max_{a'\geq 0,c,s} &: u(c,1,s) \\ &+ \beta_e \nu \sum_{\iota'} \Pi_{\iota,\iota'} \Big[sm(\theta_e) \sum_{z'} F_u(z,z') \max\{\hat{V}_e(a',e,z',b,\iota'), V_u(a',e,z',b,\iota')\} \\ &+ (1-sm(\theta_e)) \sum_{z'} F_u(z,z') V_u(a',e,z',b,\iota')\Big] \end{aligned} \tag{20}$$

subject to

$$(1+\tau_c)c + a' = [1+(1-\tau_k)\, r]\, a + \iota b + Tr(y_v). \tag{21}$$

where $\hat{V}_e(a', e, z', b, \iota')$ is given by 19.

dence in Doornik et al. (2022).

3.7 Firms

On the other side of the market, there is a continuum of risk-neutral, infinitely-lived firms. They maximize the expected value of the sum of profit streams and use the net real interest rate r to discount the future. Firms use both capital and labor inputs to produce according to a standard Cobb-Douglas production function $f(k,n) = k^{\alpha}n^{1-\alpha}$. Production can take place only in a worker-job match and each match consists of one job and one worker. Labor efficiency units, n, are thus given by ez.

Once a match is formed, the firm must choose the formalization status of the worker and the amount of capital employed in the job, which is rented from the households. The value of a formal job filled by a type's e worker with asset level a and productivity shock z is given by

$$J_f(a,e,z) = \max_k \Bigg\{ (1-\tau_f)\psi k^{\alpha}n^{1-\alpha} - (r+\delta)k - (1+\tau_w)w_f(a,e,z) + \frac{(1-\varsigma_{e,f})(1-\nu)}{1+r}\sum_{z'} F_f(z,z')\max\left\{J_f(a',e,z'), J_i(a',e,z',b',\iota=1), 0\right\}\Bigg\} \tag{22}$$

where $a' = a_f(a,e,z)$, meaning that the firm internalizes the worker's next period asset decision. The continuation value takes into account that a worker-firm pair is dissolved exogenously with the worker's death or with a per-period probability $\varsigma_{e,f}$, which depends on the worker's type. It also captures the formalization choice next period as well as the possibility that the match no longer yields a positive value to the firm and is thus destroyed. Note that the formality status decision involves comparing the value of filling the vacancy hiring formally or informally. This decision is taken by the firm after the realization of the worker's state and upon observing her outside option.

Given the assumption of frictionless capital market, all formal firms pay the same rental rate r, implying equal marginal products across firms. Thus, the same capital to labor ratio, k/n, is employed at each filled job. In fact, the first order condition implies that

$$\bar{k} = \frac{k}{n} = \left(\frac{\alpha}{r+\delta}\right)^{\frac{1}{1-\alpha}} \tag{23}$$

and plugging (23) into (22), the flow profit can be written as $\pi_f(a,e,z) = (1-\alpha)\left(\frac{\alpha}{r+\delta}\right)^{\frac{\alpha}{1-\alpha}} n - w_f(a,e,z)$.

The firm can avoid paying taxes by hiring the worker informally. However, this is not free of cost. Informal firms are subject to inspections and may suffer fines for labor law violations. A well-documented fact in the literature is that informality declines with firm size.[12] This is an important fact, as it indicates that the costs of operating in the informal

[12] See, for instance, De Paula and Scheinkman (2011)

sector are increasing in firm size. Therefore, the cost of hiring informally, $\chi(k,n)$, is modeled as a convex and increasing function of capital, k, and labor, n. In our one firm-one worker framework, this function entails that the higher the worker's productivity, the larger the cost of informality and it will be more likely that the firm chooses to register the worker. The value of an informal job filled by a type's e worker with asset level a and productivity shock z is given by

$$J_i(a,e,z,b,\iota) = \max_k \Bigg\{ \psi k^{\alpha} n^{1-\alpha} - (r+\delta)k - w_i(a,e,z,b,\iota) - \chi(k,n) \\ + \frac{(1-\varsigma_{e,i})(1-\nu)}{1+r} \sum_{\iota'} \Pi_{\iota,\iota'} \sum_{z'} F_i(z,z') \max\left\{J(a',e,z'), J_i(a',e,z',b,\iota'), 0\right\} \Bigg\} \quad (24)$$

where $a' = a_i(a,e,z,b,\iota)$.

Note that the informality cost increases the cost of capital for informal firms, reducing their capital usage and their capital to labor ratio. In addition, the continuation value considers the possible change in the UI eligibility status as well as the formalization choice next period. This generates an interesting dynamic usually ignored in the literature as the formality status may interact with UI eligibility status within the same employer.

To create a job, a firm first posts a vacancy. The flow cost of posting a vacancy is denoted by κ_e. There is free entry of firms, so that the asset value of holding a vacant position is always zero in equilibrium, which implies the following job creation condition:

$$\kappa_e = \frac{q(\theta_e)}{1+r} \sum_{\iota} \Pi_{\iota,\iota'} \sum_{z'} F_u(z,z') \max\left\{J_f(a',e,z'), J_i(a',e,z',b,\iota'), 0\right\} \frac{\lambda_u(a,e,z,b,\iota)}{u_e} \quad (25)$$

where $a' = a_u(a,e,z,b,\iota)$.

The right hand side of (25) corresponds to the present discounted value of future benefits from creation a vacancy. A firm with a vacancy does not know what worker type it will meet next period. The firm does know, however, the distribution of worker types among the unemployed. The population of unemployed workers at state (a,e,z,b,ι) is given by $\lambda_u(a,e,z,b,\iota)$, so that $\lambda_u(a,e,z,b,\iota)/u_e$ is the conditional density function. Since the matching process is random, the firm can be matched with any worker of type e in the current period unemployment pool.

The free entry condition (25) pins down the vacancy-unemployment ratio in each submarket e, θ_e. Clearly, no vacancies are created in submarket e if the value of expected profits conditional on matching is sufficiently low in that submarket. This may occur for all values of e such that even if a vacancy leads to a match for a firm with probability one, expected profits are lower than the vacancy posting cost.

3.8 Wage setting

Wages are determined, period by period and without commitment, using Nash bargaining within each worker-firm pair in both sectors. For formal workers, we assume that the outside option is the value function of an unemployed worker collecting UI benefits, $V_u(a, e, z, b, \iota = 1)$. We think this is relevant for a number of reasons. First, in standard search-and-matching models, UI benefits are supposed to exert a push effect on wages throughout the duration of employment. In order to generate this outcome, one should let the incumbent worker use $V_u(a, e, z, b, \iota = 1)$ as her threat point to bargain with the firm. An empirical justification for this is that fair and unfair dismissals cannot be distinguished, but generally the burden of the proof that a dismissal was fair lies with the employer. Thus, in the case of registered workers, the Nash bargaining solution solves the following problem:

$$\max_{w_f} \left[V_f(a, e, z) - V_u(u, e, z, b, \iota = 1)\right]^{\zeta} J_f(a, e, z)^{1-\zeta} \tag{26}$$

where $\zeta \in (0, 1)$ is a parameter that represents the bargaining power of the worker.

For informal workers, the outside option depends on the UI eligibility status.

$$\max_{w_i} \left[V_i(a, e, z, b, \iota) - V_u(u, e, z, b, \iota)\right]^{\zeta} J_i(a, e, z, b, \iota)^{1-\zeta} \tag{27}$$

Note that, in line with Krusell et al. (2010), the Nash solution in 26 and 27 generate wage functions that are increasing in the worker's assets, reflecting that being unemployed is less painful for a worker with greater assets. In turn, as can be seen in equation (25), this makes the vacancy creation decision to depend on the unemployed asset holdings. To the extent that social insurance affects the individual's savings behavior, it establishes an additional channel through which transfers affect wage, vacancy creation and informality in the model.

Moreover, it should be noticed that marginal taxes and transfers affect wages and profits not only through their influence on net payoffs, but also through the sharing rules. In fact, as has been highlighted by Pissarides (1985), marginal taxes and transfers strengthen the firm's hand in the wage bargain since its share of the surplus from the job increases. Intuitively, a small increment in the negotiated wage benefits the worker less since she attains a smaller part of it. Since informal workers do not pay taxes, this effect is in place only for formal jobs. Thus, since higher marginal taxes reduce the effective bargaining power of the formal worker, it can have a beneficial effect not only on the rate of unemployment — as has been pointed out, for instance, by ... — but also on formalization. In contrast, unemployment benefits strengthen the formal worker's hand in bargaining since a small increment in the bargained wage would give her an extra benefit in case of separation. These effects are important for one to bear in mind when thinking about the consequences of the UBI reforms considered below.

3.9 Equilibrium

A stationary equilibrium is a list of value functions $(V_f, V_i, V_u, J_f, J_i)$, decision rules for asset holdings (a_f, a_i, a_u), search intensity $s(a, e, z, b, \iota)$, and formalization status $(\tilde{\mathbb{I}}, \hat{\mathbb{I}})$, wage functions (w_f, w_i), a population distribution across possible individuals' states $\lambda_f(a, e, z)$, $\lambda_f(a, e, b, z, \iota)$ and $\lambda_u(a, e, z, b, \iota)$, a value of type-specific labor-market tightness, θ_e, and a tax rate τ_w such that:

1. Given the aggregate variable θ_e, the wage functions (w_f, w_i), the formalization status $(\tilde{\mathbb{I}}, \hat{\mathbb{I}})$, and the policy parameters, households solve the maximization problem in (14), (17) and (20).

2. Given the wage schedules (w_f, w_i) and the workers asset-holding decision rule, (a_f, a_i), the values of a filled vacancy (J_f, J_i) satisfy equations (22) and (24).

3. Given the asset values (J_f, J_i), the asset-holding decision $a_u(a, e, z, b, \iota)$, and the measure of unemployed workers $\lambda_u(a, e, z, b, \iota)$, the number of vacancies posted in each submarket e is consistent with equation (25).

4. The wage functions (w_f, w_i) are determined through Nash bargaining between the firms and the workers according to (26) and (27).

5. Equilibrium distributions, $\lambda_f(a, e, z)$, $\lambda_i(a, e, z, b, \iota)$ and $\lambda_u(a, e, z, b, \iota)$, satisfy the equilibrium stock-flow equations across the different states of the economy implied by the sets of decision rules as well as the idiosyncratic shocks described above.

6. The tax parameter τ_w is such that the aggregate government's budget constraint

$$T_w + \tau_c C + \tau_k r A = G + B_{UI} + B_{Tr} \tag{28}$$

   is satisfied every period, where B_{UI} and B_{Tr} are the aggregate UI benefits and transfers that are due, and T_w is the aggregate revenue from labor income tax.

7. The dividend paid to equity owners every period is the sum of flow profits from formal matches, net of the expenditure on formal vacancies

$$div = \sum_e \int [\pi_f(a, e, z) - \kappa_e v_{e,f}] \, d\lambda_f(a, e, z)$$

   and p can be computed from (7).

8. Aggregate capital satisfies the asset market clearing condition:

$$k = \frac{1}{1 + (1 - \tau_k) r} A - p.$$

In addition, we assume that that newborn agents start off their lives in unemployment without UI benefits, and with zero asset holding.

3.10 Welfare measure

The government is a benevolent Ramsey planner that fully commits to fiscal policy. The planner maximizes social welfare by choosing a budget feasible level of transfers subject to allocations being an equilibrium. We consider an Utilitarian social welfare criterion that evaluates the ex-ante expected utility across all agents in the economy as in

$$\mathbb{E}\sum_{t=0}^{\infty}\beta^t\left(\prod_{s=1}^{t}\nu\right)u(c_t,\ell_t,s_t) \tag{29}$$

where $\mathbb{E}$ denotes the unconditional expectation operator with respect to all possible permanent types and histories. This welfare criterion takes into account the concern of the policy maker for redistribution and insurance against idiosyncratic shocks, as well as the distortions the transfer system imposes on labor supply, job creation, and capital accumulation decisions.

We compute the welfare change, Δ, as the amount of consumption that one would have to remove or add in order to make the utilitarian welfare criterion equal between a benchmark transfer system and some alternative policy. The welfare variation (CEV) is calculated as follows: Let $V(\omega)$ denote the expected utility of an agent who enters the economy with state ω under the transfer system we aim at evaluating. Then, define

$$V^0(\omega)=\mathbb{E}\left[\prod_{s=1}^{t}\nu U_{t,0}((1+\Delta)c_t,\ell_t,s_t)\right]$$

where $U_{t,0}(c_t,\ell_t,s_t)$ is the flow utility attained by the agent under the benchmark at period t. Our relevant measure of welfare variation is

$$CEV=\min_{\Delta}\left[\mathbb{E}_\omega V^0(\omega)-\mathbb{E}_\omega V^1(\omega)\right]. \tag{30}$$

4 Parameterization and calibration

A model period is 1.5 months. We separate the parameters into two groups: the exogenously given and parameters calibrated through the simulated method of moments. As is customary, we associate the parameters with the target that provides the most intuition for its value, but all parameters are determined jointly. The value of the parameters, their sources, and targets are shown in Table 2.

Agents in our model represent household heads and we divide the labor force into three productivity types according to levels of education: basic education or less (at most 8 years of shooling); high school (9-11 years of schooling) and more than high school. The population share of each group is denoted by μ_e and, according to PNADC data, corresponds to $\mu_1 = 0.49$, $\mu_2 = 0.32$ and $\mu_3 = 0.19$, respectively.

Preference parameters: We set risk aversion to 2 and the survival rate ν to $1 - 1/320$, implying that workers stay in the market for an average of 40 years. We introduce heterogeneity in discount factors across education groups in order to match the actual wealth inequality observed in Brazil. The data we use is from the World Wealth and Income Database (WID.world), which reports the wealth share by quintile from 1995 to 2019. In our baseline calibration, we use information for the year of 2018. The dispersion of wealth informs the dispersion of β_e. In addition, we use as a target an annual interest rate of 6.0% to inform the mean level of β_e. This procedure yields the three discount factors reported in the lower panel of Table 2.

The parameter d captures the utility from leisure when unemployed. Since d governs the marginal rate of substitution between leisure and consumption, it also directly affects the extent to which the worker's reservation match quality is increasing in savings. Thus, we calibrate d to approximate the correlation between wages and asset holdings observed in the data. Figure A.1 shows the model replicates well the actual pattern of average wages by wealth deciles.

The parameters of the search cost function, (χ, ϕ), are calibrated as follows. The value of χ is chosen in such a way that the average time spent on job search is 3.8 percent of the disposable time in line with Krueger and Mueller (2010), which reports that an unemployed worker spends on average 32 minutes per day in job search activities. Since the parameter ϕ governs how search effort responds to a change in benefits of unemployment, we choose its value to match the average elasticity of unemployment duration with respect to unemployment benefit generosity. The model counterpart of this moment is computed by holding fixed the value of θ_e and thus it captures the response that would be observed if only search intensity responds to UI. We use as a target the estimate obtained by Chetty (2008), which indicates that a 10% increase in unemployment benefit level is associated with a 3-5% increase in unemployment duration. Table 2 reports the calibrated parameters.

Labor productivity shocks: To calibrate the ex-ante productivity, e, we use data on hourly wages from the Continuous National Household Sample Survey conducted by the Brazilian Institute of Geography and Statistics (PNADC) for 2018. First, we normalize the weighted average of ex-ante productivity to one. Then, we choose the dispersion of e to match the Gini coefficient of hourly wages for workers at the beginning of the life-cycle. In particular, we restrict attention to household heads who are 25 years who have no missing data on wages or hours of work. The values for e are reported in the upper panel of Table 2.

The parameters that characterize the human capital dynamics are $(\bar{z}_j, \varphi_j, \sigma_j)$ with $j = f, i$ for the employed and (φ_u, σ_u) for the unemployed. We do not have direct information about events that may change human capital on the job, such as training or specific knowledge acquisition. Since $(\bar{z}_j, \varphi_j)$ are directly linked to life-cycle wage growth, we use information on age-earnings profiles to identify these parameters. In particular, we choose $(\bar{z}_j, \varphi_j)$ to approximate the simulated mean earnings profile for both sectors with the one computed from a Mincer regression of log hourly wages with standard controls, including education. The parameter ρ_u governs the rate at which workers' human capital depreciate over the unemployment spell. Since we do not have a long enough panel dataset to properly estimate the human capital depreciation in Brazil, we rely on the estimates of Bobba et al. (2021) who report an average annual depreciation rate of 10% using Mexican data. This is the moment we target in the calibration of ρ_u. Next, we assume that $\sigma_j = \sigma_u = \sigma$ and use the Gini coefficient of labor income to pin down σ. The values that we obtain are presented in Table 2. To compute $F_j(z, z')$ and $F_u(z, z')$, we apply the algorithm described in Tauchen (1986) to approximate the stochastic processes in (4) and (5) by a first-order Markov chain with 41 points.

Figure A.2 shows how human capital evolves over the employment spell in both sectors under the baseline calibration. In the figure, we display the average human capital of a sample of agents who enter the market with mean human capital drawn from $F_u(z, z')$. In both sectors, workers' productivity grows, on average, over time and the profile is steeper in the first few years and then slows down as experience increases. We also show in Figure A.2 the average human capital of a sample of individuals who enters unemployment with the average human capital among employed workers.

Technology: The values of the technological parameters are presented in Table 2. We set the capital share at 0.30. This number is consistent with the one reported by Gomes et al. (2005), when the correction suggested by Gollin (2002) and Young (1995) about the self-employed income is taken into account. The depreciation rate, in turn, is obtained by $\delta = \frac{I/Y}{K/Y} - g$. We set the annual investment-product ratio I/Y equals to 0.18 and the annual capital-product ratio K/Y equals 2.6.[13] The economic growth rate, g, is constant and consistent with the average growth rate of GDP over the second half of the last century. Based on data from Penn-World Table, we set g equal to 1.7%, which yields a depreciation rate of nearly 5% in annual terms. Finally, the scale parameter ψ is chosen so that the average wage in the benchmark is equal to 1.

Recruiting cost and separation rate: The difference in unemployment rates among types is directly related to the variation in the job separation rate. Thus, we estimate the implied separation rates such that the unemployment rate for each education group is consistent with the data. According to the PNADC data, the average unemployment rates decline with skill and equal 10.4%, 7.9%, and 4.5%, respectively. The resulting values of ς_e are

[13] These values are taken from Cavalcanti and Santos (2021). Using the Heston et al. (2012) PennWorld Tables 7.1 and the inventory method, they find a value of 2.60 for the capital-to-output ratio in the Brazilian economy.

reported in Table 2. The values we find for ς_e are in line with their counterpart in the data. Next, we calibrate the recruiting cost parameters κ_e to match the job finding probability in the data. We compute monthly job transitions using the CPS Merged Outgoing Rotation Group from 1995-2019, while restricting the sample to household heads aged 25-65. The resulting transition rates from unemployment to employment by level of education are 30.7%, 28.4%, 27.3%, and 27.6%, respectively. In particular, given the productivity levels e, the expected individual productivity, and the separation rates, we use the free entry of firms in 25 to solve for κ_e.

Matching function and worker's bargaining power: Since there is no available data on open vacancies in Brazil, we can not directly estimate the matching elasticity. We are also unaware about estimates for comparable developing countries. Thus, in line with most of the literature focusing on developing economies, we target a matching elasticity of 0.6, which is the median point of estimates in Petrongolo and Pissarides (2001).[14] This procedure yields a value for η equal to 1.60. We then use the Hosio's condition to set the bargaining weight to 0.60 following Shimer (2005) and many others.

Transfers:

Other government parameters: First, we set government consumption, G, to 17% of the economy's output under the baseline calibration. Based on Paes and Bugarin (2006), we set the revenue tax rate at 5%, the payroll tax rate at 31% and the capital tax rate at 15%. The parameter ξ, which governs the progressivity of the labor income taxes, is calibrated to match the actual average tax rates **?** Marginal tax rates are chosen to raise enough revenue to balance the government budget constraint. The value we find for τ_w is 0.82.[15] The parameters of the UI system are taken from the Brazilian legislation. The parameters $(w_1, w_2, \bar{b})$ — the bend points applied in the UI benefit formula — are normalized by the average income, while the parameters $(\vartheta_1, \vartheta_2)$ are set to 0.8 and 0.5, respectively. The probability π is set to 0.75 so that UI benefits expire, on average, after 26 weeks — roughly four periods in the model — in line with Brazilian policies.

5 Benchmark economy

In Figure 3 we present the fit of the model (black bars) relative to the data (gray bars). In the top left panel, we see the share of total wages that accrue to each wage quintile. The model captures the distribution nicely with, for instance, 3.9% (3.7%) of wages being earned by the bottom wage quintile in the model (data), and 48% (47%) by the top wage quintile. The top right panel plots the same distribution for wealth quintiles. Again the model does an

[14]See, for instance, Albrecht et al. (2009) and Bosch and Esteban-Pretel (2015)

[15]Recall that $\tau_w(1-\xi)w^{-\xi}$ is the marginal retention rate, $1 - T'(y)$.

Table 2: Estimation and calibration of model parameters

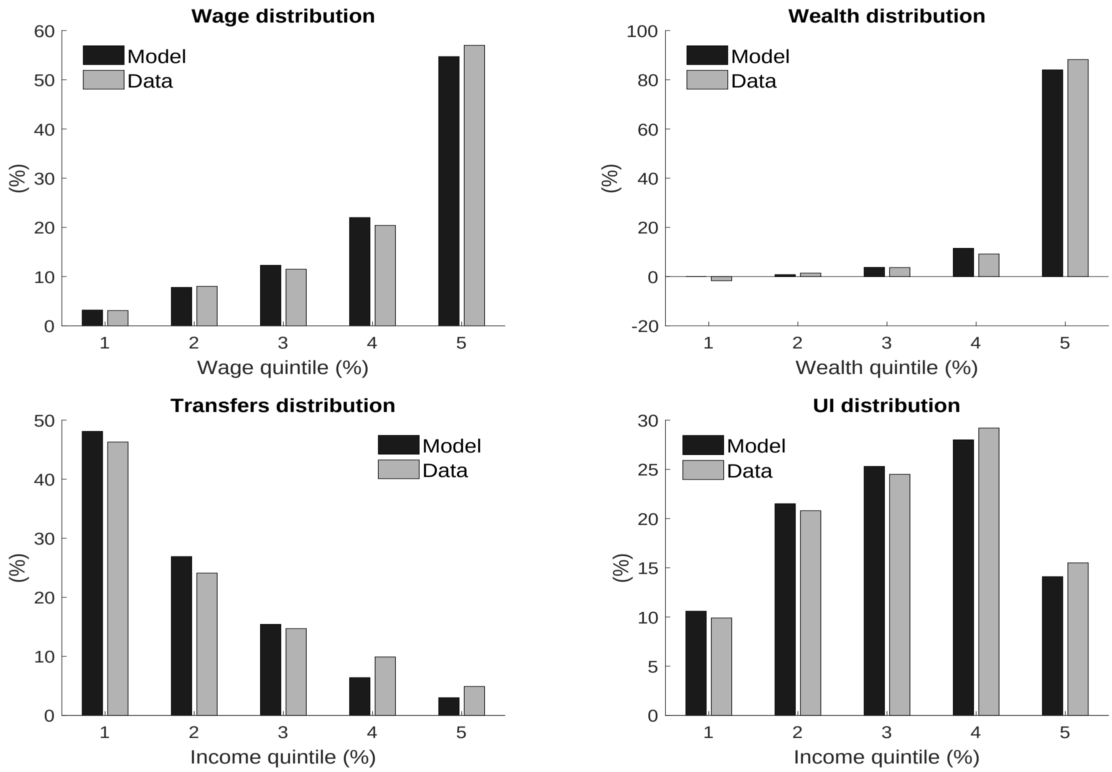
External calibration			
Parameter	Description	Values	Source/target
γ	Risk aversion	2	Standard
ν	Death probability	$1-\frac{1}{320}$	40 years working life
α, δ	Capital share, depreciation rate	0.3, 1.04%	NIPA, I/Y ratio
τ_c, τ_k	Consumption and capital tax	7%, 30%	Fuster et al. (2007)
ξ	Tax progressivity	0.098	Guner et al. (2014)
$\vartheta, 1-\pi$	Repl. rate, prob. of UI expiring	0.40, 0.25	US policies
η	Matching function curvature	1.60	Schaal (2017)
ζ	Worker's bargaining power	0.60	Hosio's condition
e_1	Permanent productivity <HS	0.65	Median earnings PSID
e_2	Permanent productivity HS	0.83	Median earnings PSID
e_3	Permanent productivity SC	1.00	Median earnings PSID
e_4	Permanent productivity C	1.42	Median earnings PSID
Internal calibration			
Parameter	Description	Values	Target
β_1	Discount factor <HS	0.9995	Wealth distribution
β_2	Discount factor HS	0.9996	Wealth distribution
β_3	Discount factor SC	0.9998	Wealth distribution
β_4	Discount factor C	1.0001	Wealth distribution
κ_1	Recruiting cost <HS	0.05	Job finding probability
κ_2	Recruiting cost HS	0.11	Job finding probability
κ_3	Recruiting cost SC	0.12	Job finding probability
κ_4	Recruiting cost C	0.15	Job finding probability
ς_1	Separation rate <HS	4.39%	Unemployment rate
ς_2	Separation rate HS	2.73%	Unemployment rate
ς_3	Separation rate SC	1.78%	Unemployment rate
ς_4	Separation rate C	0.99%	Unemployment rate
$\bar{z}, \varphi$	Mean and persistence of prod.	1.55, 0.985	Mean earnings profile
σ	Std of innovation	0.004	Residual inequality
τ_w	Tax level	0.77	Balance gov. budget constraint
b_{max}	Ceiling for UI benefits	0.24	48% of median wage
d	Utility from leisure	0.06	Corr. between w and a
χ	Cost of search	0.60	Time spent on job search
ϕ	Cost of search	1.90	Elasticity of u duration w.r.t b

Notes: The internally calibrated parameters are estimated using the simulated method of moments (SMM) in which we minimize the sum of the equally weighted squared distance between model and data moments.

excellent job capturing the distribution of wealth, which is visibly more unequal than it is for labor income.

The bottom left panel shows that transfers are largely captured by the bottom income quintile in the model (49%) and the data (49%). The top income quintile receives 4.1% of transfers in the data, which is lower in the model (2.6%). This is because the calibration has only limited power to change the distribution of transfers, given that they are governed by exogenous parameters estimated outside the model. In the right panel in the bottom, we see that a small fraction of UI payments accrue to the bottom income quintile in the data (10.4%) and the model (9.8%), which is is due to the high incidence of informality among this group.

Figure 3: Benchmark model fit: Inequality and transfers



Notes: The figure shows the model fit by comparing the shares of total wages, wealth, transfers, and UI being held/received by each quintile in the model (black) and data (gray).

In Figure 4, we show the model fit in terms of labor market outcomes. In the top left panel, we see that the model matches the patterns of the unemployment rates across education groups closely. Out of those with less than high school education, 8.8% (8.7%) are unemployed in the model (data), while for those with a college degree, the unemployment rates in the model (data) are much lower at 2.9% (2.9%). The bottom right panel displays the job finding probability across education groups. Those with less than high school education face a 49% (50%) probability of transitioning from unemployment to employment in the model (data), while for those with college education the probability is 44% (44%).

Finally, in the bottom graph of Figure 4, we show the unemployment rate by wealth decile for the model and the data. The actual values are computed using the microdata from the SIPP for household heads aged 25 to 65. It can be seen that, both in the model and in the data, unemployment in the bottom decile is twice as high as for the second decile and four times higher than the remaining deciles. Since these are not directly targeted moments in our calibration, the figures provide an external validation by showing that our model replicates well not only the relationship between wages and wealth inequality observed in the data – as shown in the previous section – but also the relationship between unemployment and wealth inequality. This is important because the implied efficiency-equity trade-off of transfers depends on the endogenous relationship between vacancy creation, incentives to work, and savings behavior. Our general equilibrium framework allows us to study how these ingredients interact to determine the distributional and aggregate consequences of transfers.

6 Policy experiment

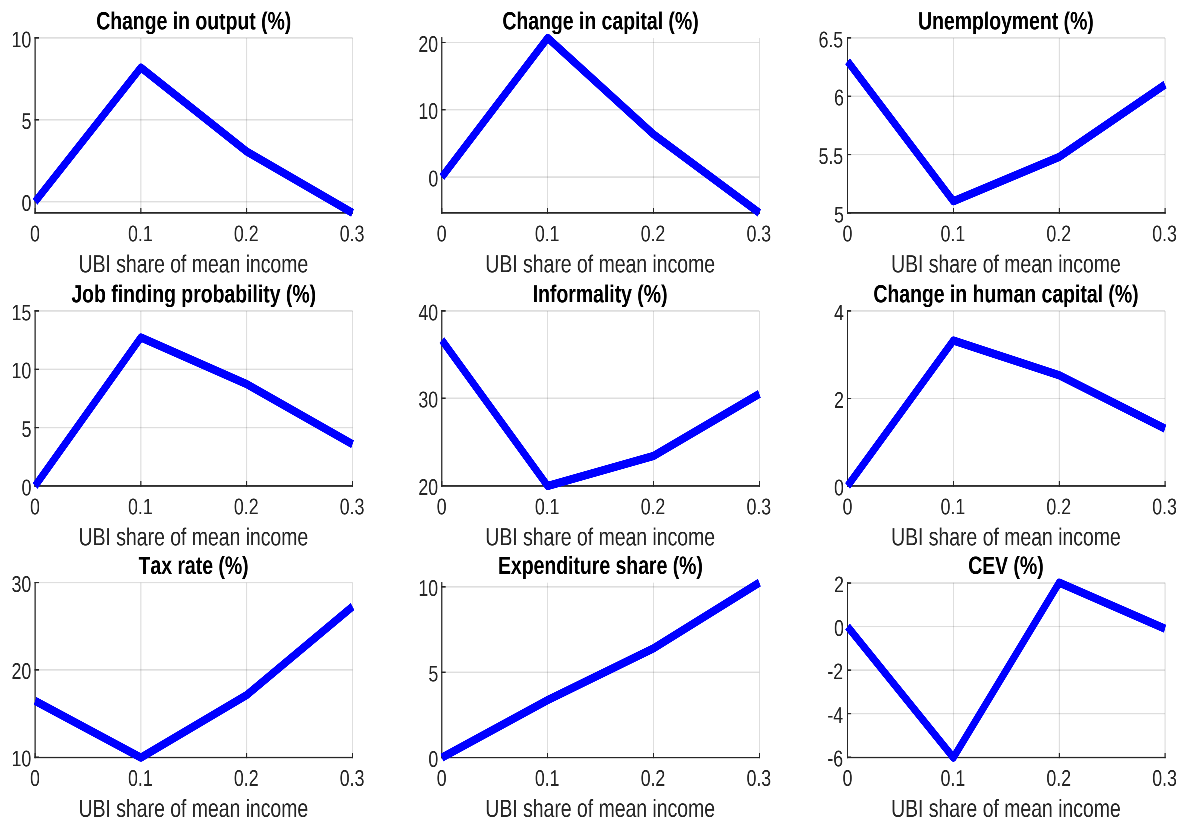
In the following, we study a policy experiment in which we replace the UI and means-tested transfers with a UBI that is set as a pre-determined fraction of average total income in the benchmark. We present the aggregate and distributive effects for levels of universal basic income: 10%, 20%, and 30% of average income. The costs of the scheme are financed by adjusting the level of taxation through τ_w in order for the government budget to be balanced in equilibrium. In each panel of Figure 5, we display relative changes for outcomes in the benchmark whose levels do not have an obvious interpretation, and we present levels for outcomes with a clear interpretation.

It can be seen that lower levels of UBI increase economic activity. In fact, for a UBI of 10%, aggregate capital and output go up by 33% and 12% in the long-run, respectively, while unemployment rate falls by 1.1 percentage points. In addition, average human capital also goes up, accounting for nearly 26% of the increase in labor. Interestingly, note that increase in job creation is concentrated in the formal sector as the informality rate falls nearly 17%.

The reason for these positive effects are twofold. On the one hand, note first that low levels of UBI entail less social insurance in the counterfactual economy relative to the benchmark, which boosts precautionary savings in good times and search effort in bad times, especially among low and middle income agents. Higher asset accumulation, in turn, entails that firms have more capital at their disposal, increasing their incentives to create vacancies. Note that this effect is bigger in the formal sector as registered workers are, on average, productive. On the other hand, there is a second effect that acts on the supply side. Since employed and unemployed agents receive the same value, a universal basic income policy – if not set too high – provides no ex-ante disincentive to work formally, as agents do not loose their benefits if they accept an offer from the formal sector.

As UBI becomes more generous, the incentives to save and search for a job reduce and the supply side effect mentioned above becomes dominant. For instance, for a UBI of 20%, even though aggregate capital falls -1.89% and search intensity is similar to the benchmark, the increase in the job finding probability is still large, nearly 38%, if all programs are removed. In contrast, when a UBI of 20% is paired with UI, the job finding probability collapses 15%. These patterns go hand in hand with the ones observed for unemployment and aggregate labor. Even for a UBI of 25% – nearly $15,600 annually – we find that unemployment (labor) is lower (higher) compared to the benchmark if UI is also eliminated.

Figure 4: The impact of different levels of UBI on the economy

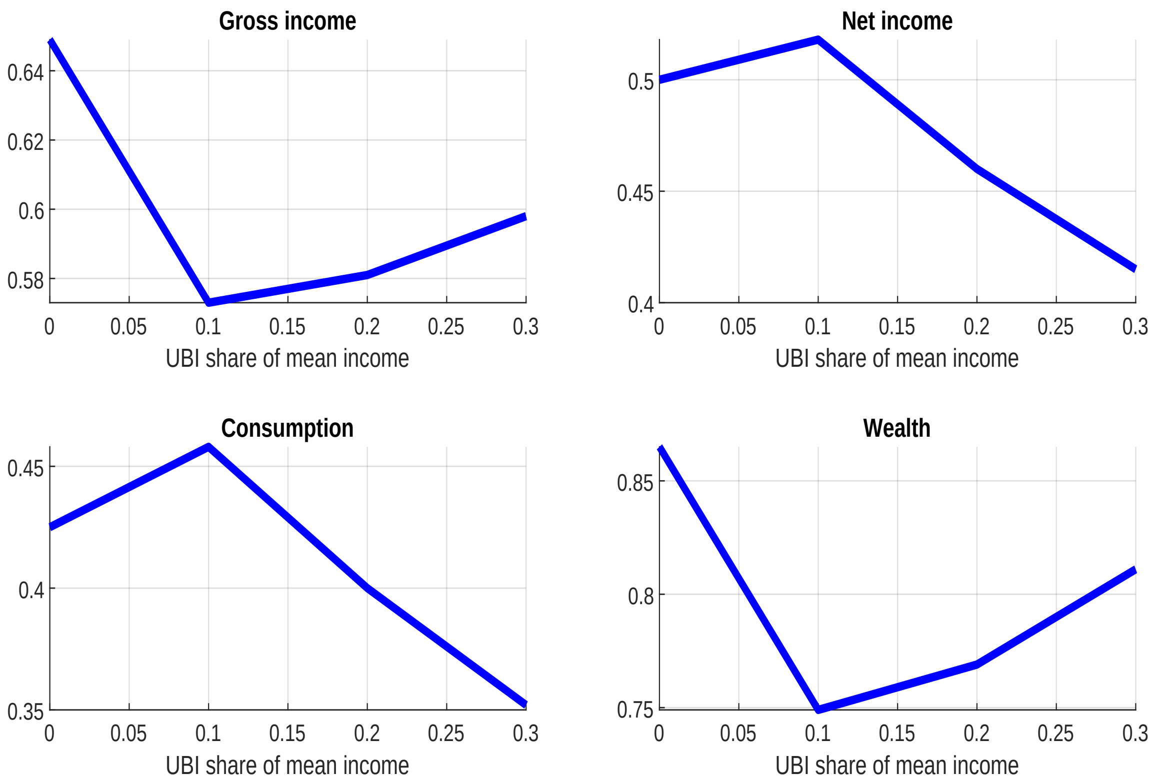


Notes: Each panel shows the effect of introducing different levels of UBI relative to the benchmark economy for the case where both the transfers and UI are eliminated.

Conclusions

to be done

Figure 5: The impact of different levels of UBI on inequality



Notes: The figure shows changes in the Gini coefficient relative to the benchmark for the case where both the transfers and UI are eliminated.

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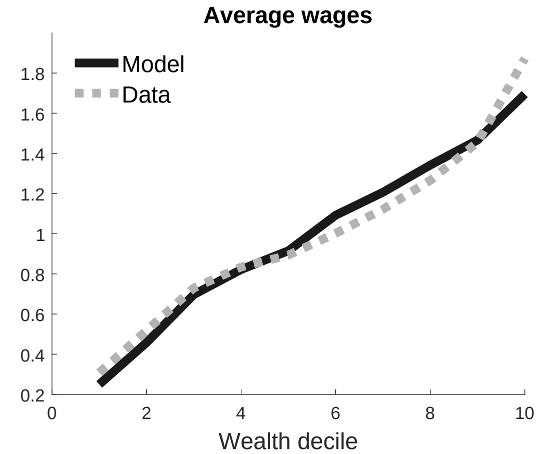
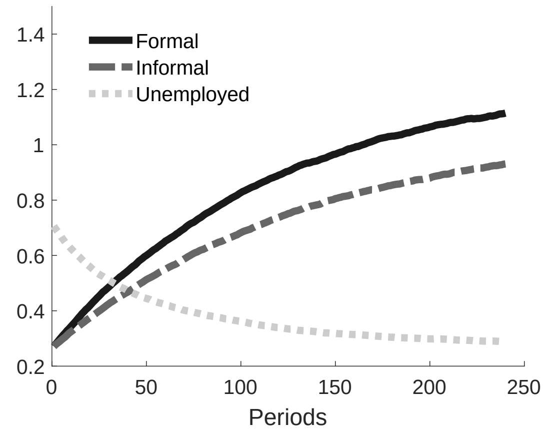
A Additional tables and figures

Figure A.1: Average wages



Notes: Average wages are normalized to 1 both in the data and in the model.

Figure A.2: Life-cycle profile of mean human capital



Notes: One model period on the x-axis is equivalent to 1.5 months. The line "Formal" ("Informal") corresponds to the average human capital, e^z, of a sample of newborns who enters the market with mean human capital drawn from $F_u(z, z')$ and stay continuously employed in the formal (informal) sector. The line "Unemployed" corresponds to the average human capital of a sample of newborns who enters unemployment with average human capital among employed workers.