Unemployment Insurance, Informality and Precautionary Savings*

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Abstract

An important stylized fact about precautionary savings in a labor market characterized by formal and informal workers is that the former saves more compared to the latter. In this paper, we build a search and matching model that incorporates informality in an incomplete markets framework to see the role of Unemployment Insurance (UI) in such behavior. Thus, we add in our UI design the possibility of becoming eligible and exhaust the benefit after some specific period. Moreover, based on empirical evidence, we add the possibility of worker to receive the benefit while working in informality. Then, we calibrate the model to be consistent with micro and macro evidence for Brazil.

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J.E.L. codes: D52, E26, J46, J64, J65, O17.

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1 Introduction

The Great Recession and the COVID-19 pandemic pushed the unemployment rates to the top in several countries, renewing attention to labour market fluctuations and the effects of job displacement insurance (JDI) programs. One relevant policy that financially support displaced workers is the unemployment insurance (UI) scheme, which provides periodic payments for a limited duration contingent on non-employment spell. Such social insurance policy has been adopted around the world, in developing and developed economies, becoming one of the most important JDI programs. (Gerard and Naritomi, 2020).

The existence of such JDI programs, however, generates ambiguous effects on welfare and labour market outcomes. Such effects can be summarized by the tension between incomplete markets framework and frictional labour market. On the one hand, in an incomplete markets setup, as in Aiyagari (1994), unemployment insurance benefit must be high to help smooth consumption during an employment shock, characterized by unemployment in a frictional labor market, or a uninsurable idiosyncratic shock. One the other hand, such effect may decrease vacancy creation, since the outside option of the worker rises, which increase wages and depresses firms profits, leading to an increase on unemployment.

Most of the literature that analyses the impact of UI with incomplete markets and labour market frictions is based on developed countries and as a consequence of that, little is known about adverse incentive effects on developing countries, in particular the interaction between unemployment insurance, informality and precautionary savings.[1] Hence, this paper fulfill this gap in literature. To do this, we build on a classical search and matching model that incorporates the non-formal sector in an incomplete markets framework with uninsurable idiosyncratic shock.[2] The model is build to reconcile the micro data empirical evidence on two fronts: *i*) The major labour market aggregates, including unemployment, informality and job finding rates, as well the possibility of workers collect UI benefit while employed in the informal sector[3] and *ii*) the precautionary savings decisions on both sectors, formal and informal.

[1] Differently from developed countries, emerging economies are characterized by a high level of non-formal sector. For Brazil, we find that 33% of workforce is employed in the informal sector while Bobba et al. (2018) finds a number closely to 35% for Mexico.

[2] We use the classical term search and matching refereeing to the model build on ideas of Diamond-Mortensen-Pissarides (henceforth, DMP). In this paper, we use those terms interchangeably.

[3] According to data from PNADC (PNAD Contínua), an yearly Brazilian household survey from IBGE, we find that from 2012 to 2018, among all individuals collecting unemployment insurance benefit, roughly 29% reports working in the informal sector at the same time.

In our model, workers are ex-ante homogeneous and ex-post heterogeneous on the asset that they accumulate and uninsurable idiosyncratic shocks. Hence, we use the endogenous job separation like in Bils et al. (2011). Job seekers can find work on both sectors, that is, the labour market is not segmented. To be able to collect the UI benefit, the worker must spend some time in the formal sector to become entitled to the benefit. If she decides to go informal or to unemployment, the benefit may run out after some specific period, being necessary to go back to the formal sector to, again, become eligible to collect the benefit. The UI benefit is going to be defined as a fraction of previous formal wage, defined by a replacement rate, up to a ceiling, i.e, the UI benefit is going to have a cap, mimicking the UI design on Brazil. From the firm perspective, the formal sector entails some obligation with tax authorities, hence, firm must pay production and payroll taxes. Such regulation does not occur in the shadow economy, although there is some penalty to high-productivity firms, mimicking the concept of high-productive informal firms must grow, which brings inspection by authorities.[4]

As discussed in Zhang and Faig (2012), this entitlement effect of UI opens a mechanism that is not well explored in the literature since most of the papers assume that unemployed individuals can collect the benefit as long as she stay out of job. Hence, the JDI becomes an opportunity cost of getting a job and, for the employers, a threat point when bargaining over the wage. Nonetheless, when we add the possibility of worker becoming eligible to collect unemployment insurance, the UI indirect foster vacancy creation in the formal sector. From the firm perspective, it will be more profitable to create vacancies in the formal sector because the wage paid is going to be lower compared to those firms that hire eligible workers. For the informal sector, it does not matter, since the lack of government monitoring makes the eligible unemployed worker to receive UI benefit working informally. In fact, our results show that the differential formal wage between entitled and untitled decreases as the eligibility criteria increases, purging the UI benefit in the wage formation. Such effect will be very important along the results in this paper.

Our model was developed to address such questions to emerging economies. The model is calibrated to be consistent with micro and macro evidence for the Brazilian economy. As many developing countries, Brazil is an interesting laboratory since the informal sector is large and affects the worker optimal behavior in several layers, from savings to job search effort. Our unemployment insurance design is calibrated to reconcile with the Brazilian legislation about JDI program. So, in the benchmark economy, is necessary to work 12 months in a row in the regulated sector to be able to receive the UI benefit.

[4]See De Paula and Scheinkman (2011), Meghir et al. (2015) and Ulyssea (2018).

Moreover, if the worker is laid off, she may collect it for 5 months before expiration, as unemployed or an informal worker. To be able to collect again, the job seeker must return to the formal sector.[5]

The model is able to match closely the labour market aggregates in Brazil, in targeted and non-targeted moments. Moreover, based on empirical evidence, the model reproduces the fact that the richest formal workers saves more compared to the non-formal counterpart.

We find that rising eligibility period foster vacancies in the formal sector and decreases unemployment rate. Increasing the eligibility criteria shed some light in the role of eligible and non-eligible workers within formal sector. When we increase from 3 months to 24 months (2 years) to be entitled to collect UI, unemployment rate decreases 0.14 percentage point. Mainly, UI exerts some pressure on formals wage trough Nash Bargaining. As workers have better outside option, eligible formal workers will have higher wages compared to those non-eligible. As the eligibility criteria increases e.g, the time that you have to spend in the formal sector to become eligible to collect unemployment insurance is higher, there is an increase in the share of non-eligible workers, whose wages are lower. Thus, such effect boosts vacancy creation in the regulated sector, leading to a increase in the formal sector and an opposite effect in unemployment. This result is not stronger since formal worker foresees that is more difficult to obtain UI and increases his precautionary savings, which increases her wages trough the effect that assets have on wage formation.

The key component to understand the interaction between UI and informality is the duration of the benefit, the exhaustion rate. When the economy goes from 2 months of UI installments to 12, the share of informal UI takers increases from 7.8% to 43.9%, indicating that as long as the worker can collect UI benefit for a longer period, the incentive to complement the JDI program with informal work becomes stronger. In some sense, this result goes in the same direction as quasi-experiment evidence.[6] Despite that spike in the share of UI takers that goes to the informal sector, only when the exhaustion period increases from 8 to 12 months we see a informality rises, but mainly as residual effect. The moral hazard effect acts trough endogenous job destruction in the formal sector as individuals

[5] In Brazil, each installment of UI is paid monthly, and not weekly.

[6] Gerard and Gonzaga (2021) show evidence that informality exacerbates the moral hazard problem, indicating that displaced workers return slowly to formal jobs while they collect the UI benefit, regardless of the fact that workers continue to seek opportunities in the informality. Britto (2020) goes on the same direction and points that increasing UI duration pushes worker to informal sector as well. Doornik et al. (2022) go further on that interaction and demonstrates that firms and workers collude to extract rents from the UI system in the presence of informal labour markets, highlighting the importance of imperfect monitoring in such context.

prefer to stay unemployed as going to work in the regulated sector since they can collect UI for almost 1 year now. As the flow of workers to formal sector declines, the inflow to informal stays the same, which causes some informality spikes.

The replacement rate has almost negligible effects on unemployment. Differently from the classical papers that incorporates DMP, the UI benefit here is capped by a ceiling, reducing the value of UI benefit for the most productive workers. Also, the combination with the exhaustion rate and eligibility criteria dampens such effect on economy. However, the combination of several aspects leads to interesting results in such component of UI. While formal sector is slightly affected by the replacement rate, this leads to a decrease in the informal sector vacancy posting due to an indirect effect in their precautionary savings, affecting wages thus, leading to a rise in the non-regulated sector.

Being all the separate components of UI design examined, we ask what is the optimal UI design in welfare sense. We find that in this tension between DMP and incomplete markets, the latter overcomes the former, with an increases in the insurance provided by unemployment insurance benefit. The eligibility criteria increases 1 year, being necessary to spend 24 months in the formal sector to become entitled to collect UI. The duration of the benefit extends to 8 months while the replacement rate goes to 100% of the previous formal wage. Although the rise in the duration of the benefit and the replacement rate increases the wage for eligible workers, which have negative effects on vacancy posting, the eligibility criteria goes in the direction of fostering vacancy creation in the formal sector. Such effect, combined with the effect of UI duration and replacement rate on informal wages rises the cost of posting vacancy in the non-regulated sector, leading to slightly decrease in informality due toi costs .Thus, we have an increase in wages in the informal sector due to indirect effect of UI which leads to a better distribution of resources among non-regulated workers, leading to an increase in welfare.

The impacts of each element of UI design is small compared to classical papers that analyses the benefit with incomplete markets, such as Krusell et al. (2010) and Setty and Yedid-Levi (2020). Hence, we shut down the main elements of unemployment insurance and see what happens. The major effect comes from when we eliminate the eligibility criteria together with UI cap.[7] The welfare of the economy is reduced in 1.4% with unemployment rate 0.40 percentage point higher, formality decreasing roughly 2 percentage points and informality increasing from 31.9% to 33.7%, mainly, due to cost increasing in formal sector trough the push effect of UI on nash bargaining. Thus, we recalibrate the

[7]When we eliminate eligibility criteria, we say that every formal worker is eligible to receive UI benefit. About UI cap, it does not bind anymore to most productive individuals.

model but without UI cap and eligibility criteria, in a similar way to Krusell et al. (2010), to see what is the optimal UI design in the economy. We found that such results goes in the direction of less UI benefit in the economy, even with the presence of informal sector. The hike in the UI duration and replacement rate pushes unemployment and informality rate to the top compared when we had eligibility criteria and UI cap. The former increases 0.9 percentage points (0.4 in replacement rate) while the latter hikes from 30 to 35% (30 to 32.4%). Again,the result is consequence of the UI pressure on formal wages, which rises the vacancy costs of the firms, decreasing the regulated sector on that situation.

Related Literature

This paper relates to a growing literature analyzing the interactions between informality and labor market outcomes in a frictional labor market.[8] Albrecht et al. (2009) builds on a classical search and matching model to see the dynamics of informality with ex-ante heterogeneity in formal sector productivity. Mainly, the authors concentrates their analyses in payroll taxes and severance payment. Ulyssea (2010), on the same framework, analyses the entry formal cost and see how it impacts on the non-regulated sector.[9] Two papers incorporates on-job-search to account the possibility the transition of formal and informal sectors between jobs. Bosch and Esteben-Pretel (2012) builds on a classical model, introducing the possibility of transition between formal and informal sector and how the role of enforcement affects such transitions as well the unemployment. Meghir et al. (2015) depart from a Burdett and Mortensen (1998) and builds a model exploring the overlap of productivity between the two sectors, hence, allowing on-the-job search and mobility between formality and informality. Bobba et al. (2018) see the interaction of on-the-job human capital accumulation with informality in a frictional labor market. None of these papers, nevertheless, model an explicitly role to unemployment insurance.

Mainly, this paper is related to the scarce literature of searching and matching combined with informality and the optimal design of unemployment insurance. Margolis et al. (2012) describe the effect of introducing the UI benefit in the Malaysian economy. The authors, nonetheless, following Albrecht et al. (2009), separate informal, formal and self-employment. Although they consider what they call "vestion period" and duration benefit, which can be similar to our eligibility criteria and benefit exhaustion, respectively,

[8]Here, we focus only on the related literature of search and matching with informality. On another strand, we have Álvarez Parra and Sánchez (2009), De Paula and Scheinkman (2011), Bardey et al. (2015) and Ulyssea (2018). Ulyssea (2020) has a great literature review about informality.

[9]The author does an exercise to see how unemployment insurance affects the labor market, however, the way that he models the benefit is strictly different from the way we do, mainly, for allowing the benefit as source of income while working in the formal sector, which is differently from the Brazilian legislation. Haanwinckel and Soares (2020) incorporates UI benefit in the same way.

they do not take in consideration the possibility of collecting UI benefit while employed in the informal sector neither take in consideration the incomplete market framework, which is crucial to understand the insurance role of UI. Bosch and Esteben-Pretel (2015) on the other hand, develop a DMP with informality, introducing UI benefit in the Mexican economy. Differently from Margolis et al. (2012), they introduce a more complex UI design, allowing the worker to become eligible to UI benefit in the formal sector and the possibility of collecting it while in the informality. Nonetheless, they do not use those eligibility criteria and the duration of the benefit to do counterfactual exercises, although the quasi-experiment evidence show that such criteria are important to understand the role of UI in the labor market dynamics.[10]

[11]

Esteban-Pretel and Kitao (2021) introduces a dual-sector economy with incomplete markets such as Aiyagari (1994). Inserting life-cycle components and human capital accumulation, with some friction in the labor market, the model introduces the possibility of collecting the benefit while working informally and the possibility of exhaustion of UI. Nonetheless these features, there is a lack of analysis about the possibility of becoming eligible to the benefit and how it may affect the savings behavior of the worker.[12]

We extend this literature incorporating a more complex design of unemployment insurance with asset accumulation in a frictional labor market that faces a severe degree of informality. We provide counterfactual exercises that allows to see the impact of unemployment insurance in the efficiency, welfare and insurance in the economy.

The remainder of the paper is structured as follows. In order to motivate our study Section 2 presents some empirical evidence. In section 3 we present the model economy, followed by the calibration and the quantitative analysis in Section 4. Finally, Section 5 contains concluding remarks.

2 Evidence

In this section we document some empirical evidence that is going to support some of our quantitative exercise on the next section. We rely on data from POF (*Pesquisa de Orça-*

[10] Carvalho et al. (2018) show such evidence. They observe that the incentives of UI account for 11-13% of dismissal in Brazil.

[11] See, for instance, Hopenhayn and Nicolini (1997), Chetty (2008), Hopenhayn and Nicolini (2009), Landais et al. (2018) and Mitman and Rabinovich (2019).

[12] Moreover, the article does not introduce search externalities that comes from the change in the labor market conditions, summarized by the vacancy-unemployment ratio.

mento Familiares), a household expenditure survey from 2017/2018 and PNAD Contínua (*Pesquisa Nacional por Amostra de Domicílios*), a nationally representative quarterly and annual household survey.

According to Brazilian legislation, every employment contract must be officially registered in a booklet called "*carteira de trabalho*". If an individual is hired by a firm without a booklet, this worker is called informal. If a formal worker is displaced by the firm, she has access to JDI programs as unemployment insurance and severance payment, hence, entitled by the Brazilian social insurance network, differently form the informal sector. For all surveys analyzed, we consider "informal" those who work in the private sector without a booklet as well those who are self employed and do not possess the tax identification number required for Brazilian firms (*Cadastro Nacional de Pessoa Jurídica (CNPJ)* or do not contribute to the social security agency.[13] From formal, we exclude those called "*estatutários*", public employees with granted stability in the government.[14]

From POF, which assesses the structure of consumption, expenditures, income and asset variation of the households, providing a profile of the life conditions of the population based on the analysis of the household budgets. Using the 2017/2018 survey, we are able to compute the share of formal and informal workers by income quintile as well the savings for each sector.

In the top left graph of Figure 1, we see the share of formal and informal individuals for each of net income quintile.[15] As we can see, informality is more prevalent among individuals in the top quintiles, while workers from the top quintiles are more propense in the formal sector. For instance, in the first quintile, 71,5% of individuals are informal and 28,5% are formal while in the last quintile, 25% of them are informal and 75% formal. Now, on the top right graph, we compute the savings distributions by income quintile. This graph shows that the richest 40% accounts for nearly 90% of the household savings in Brazil. This is the reason that, on the bottom left graph, we show the savings rate for the top 40% and the total savings rate. As we can see, individuals working in the formal

[13] Although some papers in the literature excludes "self-employment" in the informal context (see, for instance, Narita (2020), Maya and Pereira (2021) and Seminario-Amez (2021)), we decided to keep it since most of self-employment in Brazil is informal, as we show in Figure 7. We also exclude auxiliary family workers.

[14] In both surveys that we analyze, we are seeing workers from 25 to 64 years old who work more than 20 hours a week. Now, from the public sector perspective, as in several countries, the dynamic is quite different from the private sector. Most of the jobs requires performing a contest test (*"concurso"*) to be able to work, and, in general, pays more than the private counterpart. However, since the majority of them cannot be laid-off, only for cause, they are not entitled to receive UI benefit. See Bettoni and Santos (2021) and Bettoni and Santos (2022) for that.

[15] Here, the income is defined as net income, including transfers, rents and deducting all taxes.

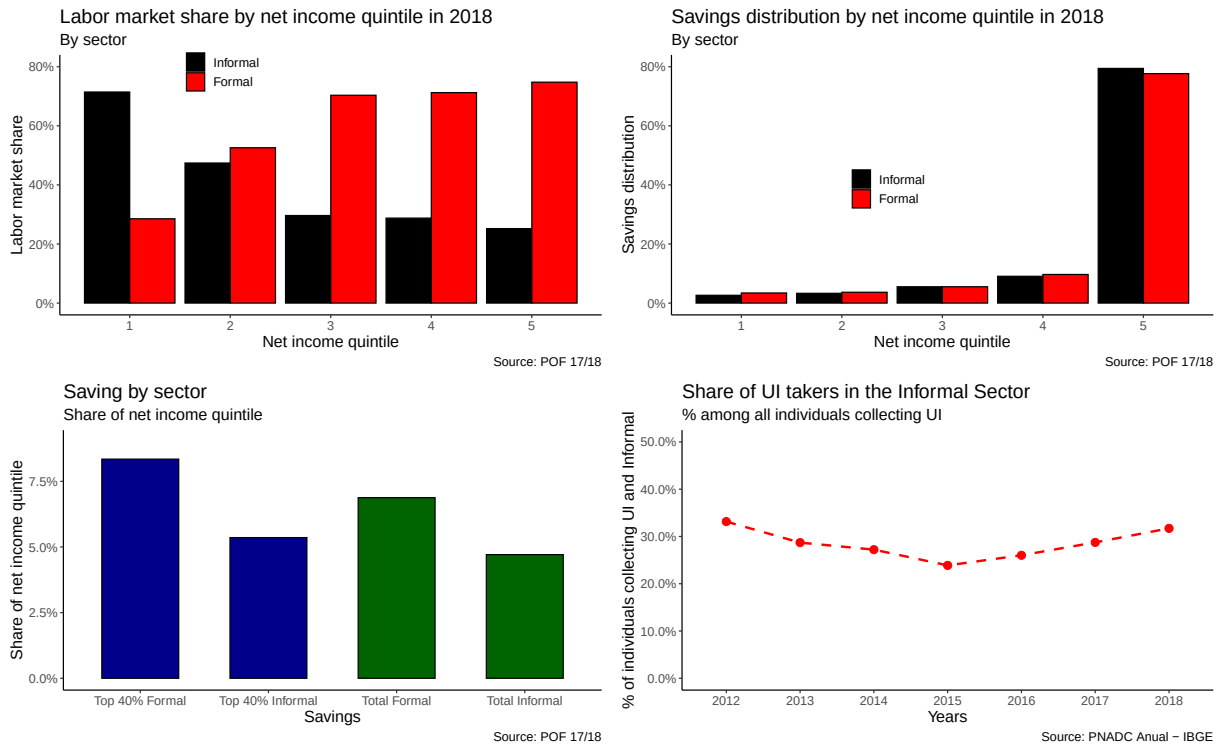

Figure 1: **Facts about UI, informality and precautionary savings**. *First row*: The left graph shows the share of individuals in informal (black) and formal (red) sectors by net income quintile. The right graph displays the accumulated share of individuals that saves in the informal (black) and formal (red) sectors by net income quintile. *Second row*: The left graph shows the savings share of net income that all formal and informal (green) and the savings share of net income that top 40% formal and informal (blue).The right graph displays the share of UI takers that works in the informal sector, among all UI takers. *Source*: POF 17/18 and PNADC yearly 2012-2019.

sector save more compared to the informal counterpart. The savings rate among formal workers is about 6.9% while non-regulated workers saves 4.7%. Nonetheless, this savings difference between sector rises as we consider the savings rate among the richest in this economy, those who actually save. In such measure, formals save 8,35% while informal saves 5,36%.[16]

PNAD Contínua is a nationally representative survey conducted since 2012 which aims to provide information about Brazilian labor market dynamics on a quarterly and annual frequency, tied to demographic and educational characteristics on national level. Hence, it's possible to compare those workers in different segments across several indicators. In addition, it's possible to track the individual in a rotating panel for five consecutive periods in the quarterly survey, which allows to construct the transitions between unemployment and formal/informal sector. Moreover, in the yearly version, the survey asks if the household collected UI benefit, which is important to see the interaction between this type of benefit and informality.

At the bottom right graph, we see that the share of UI takers that reports working in the informal sector varies from 24% to 33% from 2012 to 2018. For instance, in 2018, among all individuals that receives UI benefit, 33% of them also reported working in the informal sector while collecting the benefit. As far as we know, we are the first to show evidence that individuals collecting unemployment insurance work in the informal sector at the same time.

The empirical evidence above just give stylized facts about the relation between unemployment insurance, informality and precautionary savings but the exact mechanisms about how each component affects the other remains unclear. In the next section, we present the model for studying this mechanism.

3 The Environment

In this framework, we have the following environment:

Preferences

Time is discrete and runs forever. There is a unity measure of consumers/workers in this economy. Workers are risk-averse while firms are risk-neutral. The utility u is a constant relative risk-aversion (henceforth CRRA) function where they derive utility from

[16] When we control for education, this pattern persists yet, with formal workers saving more than informal. See Figure 8.

consumption $c > 0$.[17] We also denote the variable ψ as the survival parameter, indicating that new individuals may born and enter in this economy unemployed, with zero assets, with no bequest. Individual labour productivity is determined by a uninsurable idiosyncratic shock z that follows a stochastic law of motion and is explained below. We follow the approach of Hagedorn and Manovskii (2008) to separate UI benefit from household production (or leisure), in which the latter is denoted by h. Hence every unemployed worker has some degree of leisure if unemployed, while only those eligible can receive UI benefit $b(z)$. UI depends on the idiosyncratic shock, indicating that such values will monotonically increasing as the level of idiosyncratic shock increases. As usual, β represents the discount factor.

Asset markets

Consumers face uninsurable idiosyncratic 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 input for production, and equity x, which is a claim for the aggregate profit. Let r be the return to capital and d 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:

$$p = \frac{d + p}{1 + r - \gamma} \tag{1}$$

where γ is the depreciation of capital.

Since capital and the equity both are riskless and provide the same return and therefore are the same form 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:

$$a = (1 + r - \gamma)k + (p + d)x \tag{2}$$

We use a as the state variable for consumer. Since we are in an incomplete market framework, individual can self-insure with a, although we do not allow borrowing ($\underline{a} = 0$). Firms seek to maximize the expected value of the sum profits streams, discounted by $\varphi = \frac{1}{1+r-\gamma}$. We follow Krueger et al. (2017) and Setty and Yedid-Levi (2020) in assuming that the assets of the deceased pay extra returns to survivor, as the effective discount being $\varphi\psi$.

[17] As usual, we assume that such utility is strictly increasing and concave.

Labour markets frictions

Firms are ex-ante identical and small in the sense that the match is one firm - one worker.

The encounter between a firm and a worker is via search, where this search is random, i.e, does not depend on the specific characteristics of firms/workers. We assume the unemployed one always seek for a job in the formal sector. If not successful, the worker is going search in the non-formal labour market. As usual in this framework, the technology that put together firm and worker and results on the number of jobs match per unit of time is given by $M(u, v_s)$, which is assumed to be a constant-return-to-scale function, where u is the number of unemployed workers in this economy and v_s the number of vacancies, where s denotes the sector of this economy, $s = i$ if the workers does not have a booklet (informal) or f if employer/employee has a signed booklet (formal).[18] Denoting $\theta_s = \frac{v_s}{u}$ as the tightness of the labour market structure, the job seekers meets the prospective employers with probability $m(1, \theta_s) = \chi_s(\theta_s)^{1-\zeta_s}$ while the other way around occurs with probability $q(\theta_s^{-1}, 1) = \chi_s(\theta_s)^{-\zeta_s}$, where s can be i or f as the previous context. The job finding rate in the formal sector is given by $m(1, \theta_f)$. Hence, $m(1, \theta_i)$ can be understood as the probability of finding a job in the non-formal sector.[19]

There is also the possibility of exogenous separation, which is given by δ_s, where $s = f$ for the formal sector and i for the informal one.

Production Technology

The production of the firm occurs when a match is formed in a decentralized way and is given by $f(k(\tilde{z})) = k(\tilde{z})^{\alpha}$, where $k(\tilde{z}) = \frac{k(z)}{1-u(z)}$, so, capital per labor ratio and α is the share parameter of capital. We assume a standard neoclassical production function such that $f' > 0$ and $f'' < 0$. Capital depreciates at rate γ. The aggregate level of capital is going to be determined depending on the aggregate level of asset accumulated by the individuals, i.e, by market clearing. Since we are assuming a frictionless capital market, all firms pay the same rental rate r, that is going to be determined as the first-order condition of the production function. Hence, this rental rate is endogenous in the model.

i) **Idiosyncratic productivity shock**: An employed worker's idiosyncratic productivity shock evolves according to the AR(1) process:

[18] Here, we are following most of the search and matching literature assuming that $M(u, v_s) = \chi_s u^{\zeta_s} v_s^{1-\zeta_s}$, i.e, a Cobb-Douglas matching function.

[19] Here, we denote the probability of finding a job and the job finding rate interchangeably due to our model calibration. See calibration section below.

$$\log z' = \rho \log z + \epsilon' \tag{3}$$

Take note that $\epsilon \sim N(0, \sigma_\epsilon^2)$. Here, ρ denote the persistence of innovation. We assume that a new ϵ is drawn every employment period, regardless of the sector, and when transitioning from unemployment to employment. A worker who transits out of employment maintains her lever of productivity z throughout the unemployment spell, while newborns draw initial productivity from the invariant distribution. The continuous-valued autoregressive process is usually replaced by a discrete state-space Markov chain $G(z, z')$ using the approximation method proposed by Rouwenhorst (1995).

Government Policy

The unemployment insurance benefit $b(z)$ is provided by the government. To be eligible to receive it, the worker must spent some time in the formal sector. This stochastic event is given by the probability Pe. While collecting the UI benefit, the individual may run out of benefits, which is summarized by the stochastic event Pu. We use an index i_u, where $i_u \in \{0, 1\}$, to denote if the unemployed or informal worker can collect the UI benefit or not. Likewise, we also use an index i_e, where $i_e \in \{0, 1\}$ to denote if the formal employee became able to receive this JDI policy or not. The exhaustion and possibility of becoming eligible to receive UI benefit are governed by the following transition matrices:

$$Pu = \begin{bmatrix} 1 & 0 \\ Pu & 1 - Pu \end{bmatrix} \quad Pe = \begin{bmatrix} 1 - Pe & Pe \\ 0 & 1 \end{bmatrix}$$

Where the first and second lines indicates $i_u = 0$ and $i_u = 1$, and the first and second columns represents $j_u = 0$ and $j_u = 1$, respectively, with the same representation to Pe. The benefit value is calculated as the $\max\{\varrho \times w_f(a, z, i_e = 1), \bar{b}\}$, where ϱ represents the replacement rate of UI benefit and $\bar{b}$ the cap of the benefit, following the Brazilian UI legislation. As long as the ceiling $\bar{b}$ does not bind, the UI benefit is a fraction ϱ of the average wage $w_f(a, z, i_e = 1)$ earned by entitled ($i_e = 1$) formal employee of productivity z. Note that since a worker who transits from employment to unemployment maintains the most recent z through the unemployment spell, the benefits are directly linked with worker's wage in the last job.

To finance this social insurance policy, the government set a tax on the wage payroll τ_w and a production tax τ_p that only binds on the formal sector. Due to Brazilian labor legislation, the employee do not finance the UI fund, being restricted such fund to employers

contribution as a tax in revenue.[20] We introduce a government budget constraint, where τ_p and τ_w are fixed and τ_c pinned down to balance such budget, that includes an exogenous flow of expenditures G_c that is deemed to be unproductive in our model. G_c is just useful to allow the model to match the actual aggregate share of government spending in the economy and it is kept constant in the quantitative exercise.

We assume imperfect govern monitoring[21], in the sense that firms may employ informal workers, however, the distortion created in the economy depends on its size, indicating that firms that are more productive are, in fact, bigger and embeds in the non-formality, increases the probability of being audited.[22] This is summarized by $\lambda(z) = e^{\iota z}$, which is assumed to be increasing and convex in firm's/worker's productivity.

3.1 Bellman Equations

To formulate the workers decision in recursive way, let's denote by V_s the value functions of workers, s indicates if the worker is in the formal sector (f), the informal one (i) or unemployed (u). Hence, $V_u(a, z, i_u)$ denote the value function of a unemployed agent with uninsurable idiosyncratic shock z, who owns asset a and may collect ($i_u = 1$) or not ($i_u = 0$) unemployment insurance benefit. Idiosyncratic productivity shock is given by the transition matrix $G(z, z')$. As standard in the dynamic programming approach, we denote prime ($\prime$) as an indicator of the next period.

The value function of a unemployed worker can be stated as:

$$\begin{aligned} V_u(a, z, i_u) = u(c) + \beta\psi \sum_{i_u, j_u} Pu \Big[& m(\theta_f) \sum_{z\prime} G(z, z') \max\{V_f(a', z', i_e = 0), V_u(a', z', j_u)\} \\ & + m(\theta_i) \sum_{z\prime} G(z, z') \max\{V_i(a', z', j_u), V_u(a', z', j_u)\} \\ & + (1 - m(\theta_f) - m(\theta_i)) V_u(a', z, j_u) \Big] \end{aligned} \tag{4}$$

Where it subject to the following budget constraint:

$$(1 + \tau_c)c + \varphi\psi a' = a + h + \mathbb{1}_{\{i_u=1\}} b(z) \tag{5}$$

[20] The UI in Brazil is funded by a tax on firms revenue (generally, between 0.65% and 1.0% depending on the sector) and such tax finance the *Fundo de Amparo do Trabalhador (FAT)* (Worker Support Fund). See **?** and Farias (2018).

[21] Almeida and Carneiro (2009), using a World Bank climate investment survey in 2003, shows that only 0,5% of the firms received fines because of the use of informal labour in Brazil

[22] See De Paula and Scheinkman (2011), Meghir et al. (2015) and Ulyssea (2018).

Here, $\mathbb{1}_{\{i_u=1\}}$ is an indicator function that is equal to 1 when the displaced worker receive the payment of unemployment insurance. Take note that almost all the value functions have the state variable j_u, indicating, in the next period, the worker may collect or face the possibility of the benefit exhaustion accordingly to the stochastic matrix Pu. However, when the worker is collecting the UI benefit and unemployed, i.e, $V_u(a, z, i_u = 1)$ and seeks a job in the formal sector, they must have a tenure to be able to collect the UI benefit again. For this reason, the continuation value for someone seeking a formal job ($V_f(a', z', i_e = 0)$) always assume that the worker must become entitled to collect the benefit after some period working in the regulated sector.

The value function of a employed worker in the formal sector (f) is the following:

$$\begin{aligned} V_f(a, z, i_e) = u(c) + \beta\psi \sum_{i_e, j_e} Pe \Big[(1 - \delta_f) \sum_{z'} G(z, z') \max\{ V_f(a', z', j_e), V_u(a', z', j_e) \} \\ + \delta_f V_u(a', z, j_u) \Big] \end{aligned} \tag{6}$$

Where it subject to the following budget constraint:

$$(1 + \tau_c)c + \varphi\psi a' = a + w_f(a, z, i_e) \tag{7}$$

Take note that with probability Pe, the worker become eligible to receive the benefit, which would be indicated by $i_e = 1$. The only path to receive UI in this economy is spending some time in the formal sector. The budget constraint now contains the formal wage $w_f(a, z, i_e)$, that will be determined through Nash Bargaining process, that will be explained below.

The value function of a employed worker that does not have a booklet (informal) may be stated as:

$$\begin{aligned} V_i(a, z, i_u) = u(c) + \beta\psi \sum_{i_u, j_u} Pu \Big[(1 - \delta_i) \sum_{z'} G(z, z') \max\{ V_i(a', z', j_u), V_u(a', z', j_u) \} \\ + \delta_i V_u(a', z, j_u) \Big] \end{aligned} \tag{8}$$

Where it subject to the following budget constraint:

$$(1 + \tau_c)c + \varphi\psi a' = a + w_i(a, z, i_u) + \mathbb{1}_{\{i_u=1\}} b(z) \tag{9}$$

The informal workers, if eligible, may combine the UI benefit $b(z)$ with the informal wage $w_i(a, z, i_u)$, as supported by the empirical evidence in Section 2.

Firms

On the other side of the market, there is a continuum of risk-neutral firms. First, starting from unfilled vacancies. Let's denote κ_s as the flow cost of posting a vacancy, where s can be f or i depending on the decision of having a booklet or not. The value function for an unfilled vacancy in the formal sector (f) is given by:

$$V_f^{unf} = -\kappa_f + \varphi\psi q(\theta_f) \sum_{z\prime} G(z, z') \max\{J_f(a', z', j_e), 0\} \frac{\mathbb{S}(a, z, j_e)}{u} \tag{10}$$

Where $\mathbb{S}(a, z, i_u)$ is the measure of non-employed workers at the beginning of the period being eligible or not eligible to collect the UI benefit. A firm with a vacancy does not know what worker type it will meet next period. The firm does know, nonetheless, the distribution of worker types among the unemployed. Take $\frac{\mathbb{S}(a,z,i_u)}{u}$ as the conditional density function. As standard in search and matching literature, each firm having one job only, profit maximization is equivalent to a zero-profit condition for firm entry. The value function for a unfilled vacancy in the informal sector (i) is given by:

$$\begin{aligned} V_i^{unf} = -\kappa_i + \varphi\psi q(\theta_i) \sum_{z\prime} G(z, z') \Big[& \max\{J_i(a', z', j_u), 0\} \frac{\mathbb{S}(a, z, j_u)}{u} \\ & + \sum_{j_u} Pu \max\{J_i(a', z', j_u), 0\} \frac{\mathbb{S}(a, z, j_u)}{u} \Big] \end{aligned} \tag{11}$$

The free entry conditions above pins down the labour market tightness for the formal and informal sector (θ_f, θ_i). No vacancies are created in submarket s if the value of expected profits conditional on matching is sufficiently low in that submarket.

The firms value functions of filled jobs are denoted by J_s, where we use the same notation to make reference if the worker hired is to the formal sector or informal sector. Let's characterize the value functions of filled vacancies. In particular, despite of the fact that firms do not collect the UI benefit for themselves, the possibility of the worker to receive or not receive may affect the wage this worker receive by the Nash Bargaining. For this specific reason, the present-discounted value of expected profit from an occupied job depends of the worker eligibility to collect the UI benefit.

Hence, the value of a filled vacancy in the formal sector with signed labour card (f) is

given by:

$$\begin{aligned} J_f(a,z,i_e) =&(1-\tau_p)zf(k(\tilde{z})) - rk(\tilde{z}) - (1+\tau_w)w_f(a,z,i_e)+ \\ &\varphi\psi \sum_{i_e,j_e} Pe(1-\delta_f) \sum_{z\prime} G(z,z') \max\{J_f(a',z',j_e),0\} \end{aligned} \tag{12}$$

Characterizing for the informal sector, the value function of a filled vacancy in the formal sector with no booklet (i) is the following:

$$\begin{aligned} J_i(a,z,i_u) =&zf(k(\tilde{z})) - rk(\tilde{z}) - w_i(a,z,i_u) - \lambda(z)+ \\ &\varphi\psi \sum_{i_u,j_u} Pu(1-\delta_i) \sum_{z\prime} G(z,z') \max\{J_i(a',z',j_u),0\} \end{aligned} \tag{13}$$

Remark that $\lambda(z)$ represents a penalty function. The idea is that firms that are more productive may be bigger, which can be easier to the government monitor. Hence, as in the informal firm become more productive, the probability of being detected by the government increases and enters negatively in the profit flow of the firm.

3.2 Nash Bargaining

Wages are determined, period by period and without commitment, using a Nash Bargaining within each worker-firm pair. The worker outside option depends on the eligibility of the UI benefit, hence, the worker outside option may be $V_u(a,z,i_u=0)$ or $V_u(a,z,i_u=1)$, being the latter a threat point to bargain with the firm.

Although the bargaining power may be different for both sectors, as mentioned by Bosch and Esteben-Pretel (2012), we follow the literature and used the same parameter for formal and informal workers. Denote the wage by w_s, where s=f if the agent has a booklet and s=i otherwise.

The wage for someone who is a formal worker is:

$$w_f(a,z,i_e) = \arg\max_{w} \left\{ \left[V_f(a,z,i_e) - V_u(a,z,i_u)\right]^{\eta} J_f(a,z,i_e)^{1-\eta} \right\} \tag{14}$$

The wage for someone who is informal, i.e, has not a signed labour card can be stated as:

$$w_i(a, z, i_u) = \arg\max_{w} \left\{ [V_i(a, z, i_u) - V_u(a, z, i_u)]^{\eta} J_i(a, z, i_u)^{1-\eta} \right\} \tag{15}$$

Similarly to Krusell et al. (2010) and Setty and Yedid-Levi (2020), the Nash solution generates, on average, a wage that is increasing in a worker's assets, reflecting that being unemployed is less painful for a worker with greater assets.

3.3 Stationary Equilibrium

In this subsection, we describe the stationary equilibrium of the economy. For ease the notation and consistency with computational methods we describe a discrete state space. Take notice that, when possible, s denotes the sector of worker/firm, where $s = f$ when formal, $s = i$ when informal and $s = u$ when unemployed for the former. The stationary equilibrium consists of:

(i) A set of value functions $V_s(a, z, i_u)$, $J_s(a, z, i_u)$ and V_s^{unf} where s may represent unemployment, formal or informal sector.

(ii) Consumption $c_s(a, z, i_u)$ and asset accumulation policy functions $g_s(a, z, i_u)$.

(iii) Prices r, $w_s(a, z, i_u)$ and π.

(iv) Vacancies v_s and demand for capital (per worker) $k(\tilde{z})$.

(v) Vacancy per unemployment ratio (θ_s), job finding probabilities $m(1, \theta_s) = \chi_s(\theta_s)^{1-\zeta_s}$ and job filling vacancies $q(\theta_s^{-1}, 1) = \chi_s(\theta_s)^{-\zeta_s}$.

(vi) A UI replacement rate ϱ, a cap on benefits $\bar{b}$.

(vii) Taxes τ_p, τ_w and τ_c and unproductive government spending G_c.

(viii) Dividends d.

(ix) Distributions over sector s (formal, informal or unemployed), assets a and individual productivity z, denoted by $\mathbb{S}_s(a, z, i_u)$.

such that:

(i) Given the job finding probability $m(1, \theta_s)$, the wage function $w_s(a, z, i_u)$ and prices (r, π), the workers choices of $c_s(a, z, i_u)$ and $g_s(a, z, i_u)$ solve the optimization problem for each individual. This results in the value functions of $V_s(a, z, i_u)$ and $J_s(a, z, i_u)$.

(ii) Given the wage functions, prices, the distributions $\mathbb{S}_f(a, z, i_e)$ and $\mathbb{S}_i(a, z, i_u)$ and the workers asset accumulation decisions, each firm solves the optimal choice of $k(\tilde{z})$. Those decisions results on $J_f(a, z, i_e)$ and $J_i(a, z, i_u)$.

(iii) Given the wage functions, prices, the distributions $\mathbb{S}_u(a, z, i_u)$ and the unemployed asset accumulation decisions, and the job finding probability $m(1, \theta_s)$, firms compute the value V_s^{unf}. With free entry, $V_s^{unf} = 0$.

(iv) The asset market clears, and the aggregate demand for capital equals supply minus the price (value) of the firm:

$$K = \varphi A - p \tag{16}$$

(v) The wage functions $w_s(a, z, i_u)$ are determined by Nash Bargaining.

(vi) The consumption tax rate, τ_c, is such that it balances the government's budget constraint period-by-period:

$$\begin{aligned} &G_c + \sum_a \sum_z b(z) \Big[\mathbb{S}_i(a, z, i_u = 1) + \mathbb{S}_u(a, z, i_u = 1) \Big] = \\ &\tau_w \Big[\sum_a \sum_z \sum_{i_e} w_f(a, z, i_e) \mathbb{S}_f(a, z, i_e) \Big] + \tau_p \Big[\sum_a \sum_z \sum_{i_e} z f(k(\tilde{z})) \mathbb{S}_f(a, z, i_e) \Big] + \\ &\tau_c \Big\{ \sum_a \sum_z \Big[\sum_{i_e} c_f(a, z, i_e) \mathbb{S}_f(a, z, i_e) + \sum_{i_u} \Big(c_i(a, z, i_u) \mathbb{S}_i(a, z, i_u) + c_u(a, z, i_u) \mathbb{S}_u(a, z, i_u) \Big) \Big] \Big\} \end{aligned} \tag{17}$$

(vii) The dividend paid to equity owners every period is the sum of flow profits from all matches, net of expenditures on vacancies:

$$d = \sum_a \sum_z \Big\{ \sum_{i_e} \Big[(1-\tau_p) z f(\tilde{k}(z)) - r\tilde{k}(z) - (1+\tau_w) w_f(a,z,i_e) \Big] \mathbb{S}_f(a,z,i_e) - \xi_f v_f \Big\} + \sum_a \sum_z \Big\{ \sum_{i_u} \Big[z f(\tilde{k}(z) - r\tilde{k}(z) - w_i(a,z,i_u) - \lambda(z) \Big] \mathbb{S}_i(a,z,i_u) - \xi_i v_i \Big\} \tag{18}$$

(viii) The distributions $\mathbb{S}_f(a,z,i_e)$, $\mathbb{S}_i(a,z,i_u)$ and $\mathbb{S}_u(a,z,i_u)$, for each type of i_e and i_u are invariant and generated by $(m(1,\theta_s),\delta_s,\psi,P_e,P_u)$. Hence, the law of motion for idiosyncratic productivity shock and asset accumulation policy functions are the following:

$$\mathbb{S}_f(a',z',j_e=0) = \psi \Big\{ \sum_a \sum_z \Big[(1-P_e)(1-\delta_f) \mathbb{S}_f(a,z,i_e=0) G(z,z') \Big] \mathbb{1}\{g_f(a,z,i_e=0)=a'\} + \sum_a \sum_z \Big[m(\theta_f) \mathbb{S}_u(a,z,i_u=0) G(z,z') \Big] \mathbb{1}\{g_u(a,z,i_u=0)=a'\} \Big\} \tag{19}$$

$$\mathbb{S}_f(a',z',j_e=1) = \psi \Big\{ \sum_a \sum_z \Big[P_e(1-\delta_f) \mathbb{S}_f(a,z,i_e=0) G(z,z') \Big] \mathbb{1}\{g_f(a,z,i_e=0)=a'\} \Big\} \tag{20}$$

$$\begin{aligned} \mathbb{S}_i(a',z',j_u=0) = \psi \Big\{ & \sum_a \sum_z \Big[(1-\delta_i) \mathbb{S}_i(a,z,i_u=0) G(z,z') \Big] \mathbb{1}\{g_i(a,z,i_u=0)=a'\} + \\ & \sum_a \sum_z \Big[m(\theta_i) \mathbb{S}_u(a,z,i_u=0) G(z,z') \Big] \mathbb{1}\{g_u(a,z,i_u=0)=a'\} + \\ & P_u \Big(\sum_a \sum_z \Big[(1-\delta_i) \mathbb{S}_i(a,z,i_u=1) G(z,z') \Big] \mathbb{1}\{g_i(a,z,i_u=1)=a'\} + \\ & \sum_a \sum_z \Big[m(\theta_i) \mathbb{S}_u(a,z,i_u=1) G(z,z') \Big] \mathbb{1}\{g_u(a,z,i_u=1)=a'\} \Big) \Big\} \end{aligned} \tag{21}$$

$$\mathbb{S}_i(a',z',j_u=1) = \psi \Big\{ (1-P_u) \Big[\sum_a \sum_z \Big((1-\delta_i) \mathbb{S}_i(a,z,i_u=1) G(z,z') \Big) \mathbb{1}\{g_i(a,z,i_u=1)=a'\} + \sum_a \sum_z \Big(m(\theta_i) \mathbb{S}_u(a,z,i_u=1) G(z,z') \Big) \mathbb{1}\{g_u(a,z,i_u=1)=a'\} \Big] \Big\} \tag{22}$$

$$\begin{aligned}\mathbb{S}_u(a', z, j_u = 0) = \psi\Big\{(1 - P_e)\Big[\sum_a \sum_z \Big(\delta_f \mathbb{S}_f(a, z, i_e = 0)\Big)\mathbb{1}\{g_f(a, z, i_e = 0) = a'\}\Big] + \\ P_u\Big[\sum_a \sum_z \Big(\delta_i \mathbb{S}_i(a, z, i_u = 1)\Big)\mathbb{1}\{g_i(a, z, i_u = 1) = a'\} + \\ \sum_a \sum_z \Big((1 - m(\theta_i) - m(\theta_f))\mathbb{S}_u(a, z, i_u = 1)\Big)\mathbb{1}\{g_u(a, z, i_u = 1) = a'\}\Big] + \\ \sum_a \sum_z \Big((1 - m(\theta_i) - m(\theta_f))\mathbb{S}_u(a, z, i_u = 0)\Big)\mathbb{1}\{g_u(a, z, i_u = 0) = a'\}\Big\} + \\ (1 - \psi)\sum_{i_e}\sum_{i_u}[\mathbb{S}_f(a, z, i_e) + \mathbb{S}_i(a, z, i_u) + \mathbb{S}_u(a, z, i_u)]\end{aligned} \tag{23}$$

$$\begin{aligned}\mathbb{S}_u(a', z, j_u = 1) = \psi\Big\{P_e\Big[\sum_a \sum_z \Big(\delta_f \mathbb{S}_f(a, z, i_e = 1)\Big)\mathbb{1}\{g_f(a, z, i_e = 1) = a'\}\Big] + \\ (1 - P_u)\Big[\sum_a \sum_z \Big(\delta_i \mathbb{S}_i(a, z, i_u = 1)\Big)\mathbb{1}\{g_i(a, z, i_u = 1) = a'\} + \\ \sum_a \sum_z \Big((1 - m(\theta_i) - m(\theta_f))\mathbb{S}_u(a, z, i_u = 1)\Big)\mathbb{1}\{g_u(a, z, i_u = 1) = a'\}\Big]\Big\}\end{aligned} \tag{24}$$

4 Quantitative Analysis

4.1 Calibration and estimation

The model presented before does not have a closed-form solution and, for this reason, we must solve it numerically. To facilitate comparison, we assume one model period corresponds to one month, which makes easier to reconcile the UI structure in Brazil, since eligibility and exhaustion criteria are defined monthly. We separate the parameters into two groups: the exogenously given, and parameters calibrated through simulated method of moments. As is costumary, we associate the parameters with the target that provides the most intuition for its value, but all parameters are determined jointly. The value of parameters and their source/target are shown in Table 1 and Table 2. Every parameter with subscript f denotes formal sector while i denotes the informal one.

We separate the parameters into two groups: those in the first are determined exogenously, and those in the second group are calibrated internally.

Preference parameters: We set the risk aversion as equal to 2, indicating that individuals are more risk-averse than usually the papers in this framework assume. The survival rate ψ is $1 - 1/480$, implying that workers are in the market for an average of 40 years. The discount factor β is choose to be 0.9955, that together with the survival rate, yield an annual real interest rate of 5%. We calibrate h to be equal to 0.15, which target unemployment rate in the data.

Uninsurable idiosyncratic shock: The parameters that characterizes the stochastic component of uninsurable idiosyncratic shocks are: ρ and σ_ϵ. For computational reasons, we use the algorithm described in Rouwenhorst (1995) to approximate these stochastic processes for each sector by a first-order Markov chain with 5 points. We rely on Mincer regressions estimates from Cavalcanti and Santos (2021), transforming from annual values to monthly using the calculation from Yongsung and Kim (2006). σ_ϵ is jointly calibrated with others parameters to reach on moments found in the data. We set $\sigma_\epsilon = 0.068334$ with, together with the penalty paramater (see below), help to calibrate the wage premium.[23]

Technology: The capital share α is equal to 0.3 as described by Krusell et al. (2010) and Setty and Yedid-Levi (2020) and is standard in the literature. The depreciation rate γ, in turn, is obtained internally. We target such rate to be equal to 0.6% monthly, which corresponds to an investment-output ratio ($\frac{I}{Y}$) of 22%. The penalty parameter (ι) is calibrated such to generate a formal wage premium accordingly to the data. Hence, $\iota = 1.3$.

Search and Matching block: About the job separation rate, the transition to unemployment parameters δ_s are calculated to generate the same share of informal and formal workers provided by the data. The resulting values are reported on Table 1. In Figure 7, we show how those transitions were calculated. Of course, the cost of posting vacancy in both sectors is going to be set such as the the vacancy-unemployment ratio in the steady state of the model is equal to 1, with no further consequences in others variables of the model. Thus, also as consequence of θ_s normalization, the scale parameters ξ_s are going to reflect the job finding rate of both sectors. Also, in the line of Shimer (2005) as well others papers in the literature, we choose the elasticity of matching function to be equal for both sector, and, hence, equal to the bargaining parameter, satisfying the Hosios (1990) condition. Thus, $\eta = \zeta_s$, for both sectors.[24]

UI design: Specifically, about the UI structure, we follow the literature and the Brazil-

[23] Cavalcanti and Santos (2021) reported an annual value for the persistence parameter of 0.88. Using $0.88^{1/12}$, we have $\rho = 0.989403759$ in monthly terms. We can calculate $\sigma_\epsilon = \sigma_z\sqrt{(1-\rho^2)}$, where $\sigma_z = 0.470649$.

[24] As highlighted by Landais et al. (2018) and Setty and Yedid-Levi (2020), the Hosios (1990) condition does not hold in economies with risk-averse individuals and with UI. Despite that, we follow the good practice of most DMP models.

ian labor and social security law to discipline the parameters. The replacement rate ϱ is going to be equal to 70% of the previous income, since in Brazil, the empirical evidence shows the replacement rate is in the ballpark of 70% and 100% (Farias (2018); Gerard and Naritomi (2020)). We choose the lower bound of this range to allow the possibility of more counterfactual exercises towards the upper bound. The probability of becoming eligible (Pe) and to exhaust (Pu) the benefit are going to be set as 0.083 and 0.20, which matches a tenure of 12 months to become entitled to receive UI and the maximum number of UI payments, 5 months respectively. The UI cap $\bar{b}$ is going to be calibrated as the UI law in Brazil. The benefit ceiling must be as high as 1.9 times the minimum wage. Since the average income in Brazil is 2 minimum wages, we calibrated such parameter to be: $\bar{b} = 1.9 \times \frac{\bar{y}}{2}$, where $\bar{y}$ is the average income in this economy.

Government: We set the production tax (τ_p) equal to 0.065%. Such value mimics the tax on firms revenue PIS/COFINS, that fund the UI pool in Brazil. The payroll tax follows the Brazilian legislation. In Brazil, they are compulsory and mainly include 20% for Social Insurance, direct payroll taxes of 9% and 8% towards workers seniority account. For this reason, we set τ_w for 38% as in Ulyssea (2018). The exogenous flow of expenditures G_c that is deemed to be unproductive in our model, is calibrated to be 17% of output. To balance the government budget constraint, we impose a tax on consumption τ_c that holds for all agents in this economy.

Parameter	Description	Values	Source
α	Capital share	0.30	Literature
ϱ	Replacement rate	0.70	Literature
Pe	Eligibility	1/12	Brazilian legislation
Pu	Exhaustion	1/5	Brazilian legislation
ψ	Survival probability	1-1/480	40 years in the market
μ	Risk aversion coefficient	2	Literature
χ_f, χ_i	Matching function scale parameter	0.076, 0.086	PNADC Survey
τ_w	Payroll tax	0.38	Ulyssea (2018)
τ_p	Production tax	0.0065	Brazilian legislation
G_c	Unproductive government spending	17% of output	Literature
ζ_f, ζ_i	Matching function elasticity	0.6, 0.6	Hosios Condition
η	Bargaining power	0.6	Literature
ρ	Idiosyncratic persistence	0.9894	Cavalcanti and Santos (2021)

Table 1: **External calibration**

Parameter	Description	Values	Target
h	Leisure	0.15	Unemployment Rate = 7.3%
δ_f, δ_i	Job separation rate	0.007, 0.0175	Informality/Formality Share
$\bar{b}$	Cap of UI	2.39	1.9 x $\frac{\bar{y}}{2}$
β	Discount factor	0.9955	Yearly effective net interest rate = 5%
γ	Depreciation rate	0.006	$\frac{I}{Y}$ = 22%
κ_f, κ_i	Costing of posting a vacancy	1.39, 0.44	Normalization of $\theta_f, \theta_i = 1$
τ_c	Consumption tax	4.06%	Balance government budget constraint
ι	Penalty	1.3	Wage premium = 7.0%
σ_ϵ	Idiosyncratic shock	0.068334	Wage premium = 7.0%

Table 2: **Internal calibration**: 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.

5 Results

5.1 Benchmark economy

Before discussing the properties of the model, we state our measures of wealth and savings. The concept of household wealth we use is simply net asset holdings, a. This notion of saving used is then simply the change in wealth holding across a period. Thus, saving for a particular household is a' - a.

In Table 3 we present the fit of the model relative to the data. The model do a good fit in the targeted moments. Those moments were based on statistics from PNADC Survey from 2012 to 2014, with exception for Formal Wage Premium, which was measured from a panel data over the whole period available from quarterly PNADC.[25]

The average unemployment rate from 2012 to 2014 was estimated in 7.29% while the model yields 7.27%. Also, it yields a good fit (31.90%) on the share of informal workers compared to the data (33.89%). The formal and informal job finding rate have also a perfect fit, with the former being 7.60% in the data and the model in the model while the latter is 8.60%, in the data and the model. The model underestimates the formal wage premium for almost 2.5 percentage points compared to the data, indicating a relative lower wage for the formal compared to the informal one, however, since we do not focus our paper about wages outcomes and any wage distribution analysis, we can carry on. Also, the model reproduces quite well the investment-output ratio. In the non-targeted moments, the model

[25]We target the period from 2012 to 2014 to avoid the recession period that began in Brazil in the end of 2014. Although we covered this period to measure the wage premium, we ran a panel data with year fixed-effects. See B for more information.

provides a good fit of the share of informal UI takers, i.e, the share or people receiving UI benefit and working in the informal sector at the same time among all individuals collecting UI. The model shows that informal UI takers are 24.1% while in the data is almost 29.3%. As we will demonstrate in the next section, this moments is associated with the number of UI installments (or the exhaustion period). As we increase Pu, this share will increase as well. Albeit not perfectly, the model reproduces the fact that the richest formal workers saves more compared to informal ones, as we document in Section 2. While the top 40% is reproduced perfectly (8.34%) compared to the data (8.35%), the informal savings is overestimated by the model (8.16%) compared to the data (5.35%).

The model also reconcile with the empirical evidence from **??** about the job destruction rate in the formal and informal sectors. While we estimate from the data a formal job destruction rate of 0.8%, the model does a very good fit of 0.7%. The same holds for the non-regulated workers, with the job destruction rate of 1.75% while the data displays 1.25%.

Targeted moments	**Data**	**Model**
Unemployment rate	7.29%	7.27%
Informality rate	33.89%	31.90%
Formal job finding rate	7.6%	7.6%
Informal job finding rate	8.6%	8.6%
Wage premium	7%	4.5%
Investment/output	22%	22.9%
Non-targeted moments	**Data**	**Model**
Share of informal UI takers	29.3%	24.2%
Top 40% formal savings rate	8.35%	8.34%
Top 40% informal savings rate	5.35%	8.16%
Formal job destruction rate	0.8%	0.7%
Informal job destruction rate	1.25%	1.75%

Table 3: **Targeted and non-targeted moments**: The first part of the table shows the moments targeted by the parameters in Table 2. The second part in the table shows the moments that don't have any counterpart in the calibration strategy.

5.2 Labour market aggregates

In this section, we are going to measure the steady state effects of changing the major components of our benchmark UI design. We are going to show how unemployment, informality, formality and the share of informal UI takers (share among all UI takers) changes

when there is a different eligibility criteria Pe (how long the worker must spend in the formal sector to become entitled to collect UI), exhaustion criteria Pu (the number of possible UI installments that the unemployed can collect) and replacement rate ϱ (how much the UI benefit replaces from previous wage). In each of these changes, we keep the others elements constant. For instance, when we change the eligibility criteria from the benchmark, 12 months, we keep the exhaustion period (5 months) and the replacement rate (70%) constants. All the results are presented in Figure 2. The red dot on those graphs represents the benchmark situation.

The increase in the eligibility criteria decreases unemployment. When it becomes more difficult to obtain UI benefit, the incentive is to stay employed in the formal sector since it takes longer to become eligible. As a matter of fact, is more profitable to post vacancies in the formal sector compared to the informal one. As the eligibility criteria increases, there is a hike in the number of non-eligible formal workers (and a decline of their counterpart), whose wages are lower compared to the eligible ones (see Differential wage on next subsection). Due to this composition effect, it becomes more profitable to post vacancies in the formal sector. Hence, formal employment rises which leads to a decrease in unemployment. The unemployment rate decreases from 7.39% to 7.25% when the eligibility criteria increases from 3 to 24 months.[26] This relation between eligible and non-eligible workers within formal sector will be crucial to understand the UI effects on the next sections. As we can see from the last row of the first column, the entitlement effect does not affect the share of informal UI takers.

The aggregate effects on labour market for exhaustion criteria are small. Informality/formality and unemployment remains almost constant, nonetheless, as we can see in the fourth line of Figure 2, the share of informal UI takers rises as the number of UI installments increases. Such number increases from 7.8% to 43.9% when the UI duration goes from 2 to 12 months. This results reconcile with quasi-experiments from Britto (2020) and Gerard and Gonzaga (2021), which show that an extension of UI benefits increases the probability of finding job in the informal sector. Hence, as the duration of UI increases, workers go to informal sector to combine UI and paid wage by the informal sector.

Although the incentives of the duration of UI pushes the worker to the informal sector, is only when the exhaustion period increases from 8 months to 1 year that informality expands. Such effect occurs because individual postpone her reentrance in the formal

[26]The entitlement effect was already described by Zhang and Faig (2012) and Lavive et al. (2015). Our contribution here relies in showing this channel occurs through the formal sector in a context tagged by a sizable non-regulated sector.

labour market, increasing unemployment rate and, as residual, increasing informality rate as well.[27] The unemployment rate increases from 7.27% to 7.32% when the duration of the benefit increases from 8 to 12 months. The formality rate decreases from roughly 60.8% to 59.8% and, as residual, informality increases from 31.9% to 32.8%. Hence, the moral hazard effect of UI occurs through the formal sector when the duration of the benefit expands to 1 year from 8 months, a result that resemble with the classical literature about UI, but actually here what triggers the moral hazard is the duration of the job-displacement insurance program, departing from the emphasis that literature gives to the level of the benefit.[28]In general, the combination of UI when the informal sector binds is that the individual is pushed to the non-regulated sector.

For the replacement rate, the model goes away about what we would expect in a DMP model. When the replacement rate rises from 20% to 100%, unemployment rate remains almost constant. A combination of the model aspects drives such result. The UI benefit cap holds the benefit value to the most productivity ones. Even a large increase in the benefit is not equally shared to everyone on this economy. The exhaustion rate also gave a contribution to that, since not all unemployed workers were eligible to collect the benefit. However, within those changes, there is a interesting component about how UI replacement rate affects the share of formal and informal workers. The decrease on informal firms profit is higher than the slightly decrease of formal firms profit, which induces formal firms to post more vacancies compared to informal ones, leading to a rise in the formal sector and a decline in the non-regulated sector. As a matter of fact, formal workers decreases their precautionary savings as the generosity of the benefit rises. Mainly, this reduces the wages for ineligible workers since those can anticipate higher UI benefit in the future which leads to less savings (the effects of UI design in wages and savings will be described in the next sections). Since UI benefit has a upward effect on eligible wages, such results just slightly decreases formal profits while those in the informal sector declines more relatively.[29] The net effect is almost negligible, since unemployment rate stays almost in the same pattern.

On Figure 3, we bring some results how the design of unemployment insurance affects the worker savings decision. As UI incentive workers to go to formal sector, since is the only way to become entitled to receive the benefit in case of lay-off, most of the effect oc-

[27]The probability of finding a job in the formal sector when unemployed decreases from 100% to 98%.

[28]See Hopenhayn and Nicolini (1997), Chetty (2008), Hopenhayn and Nicolini (2009). With risk averse-individuals, see Shimer and Werning (2008).

[29]The increase in savings in the informal sector have a positive effect on wages, which reduces profit in the non-regulated sector, leading to less informality.

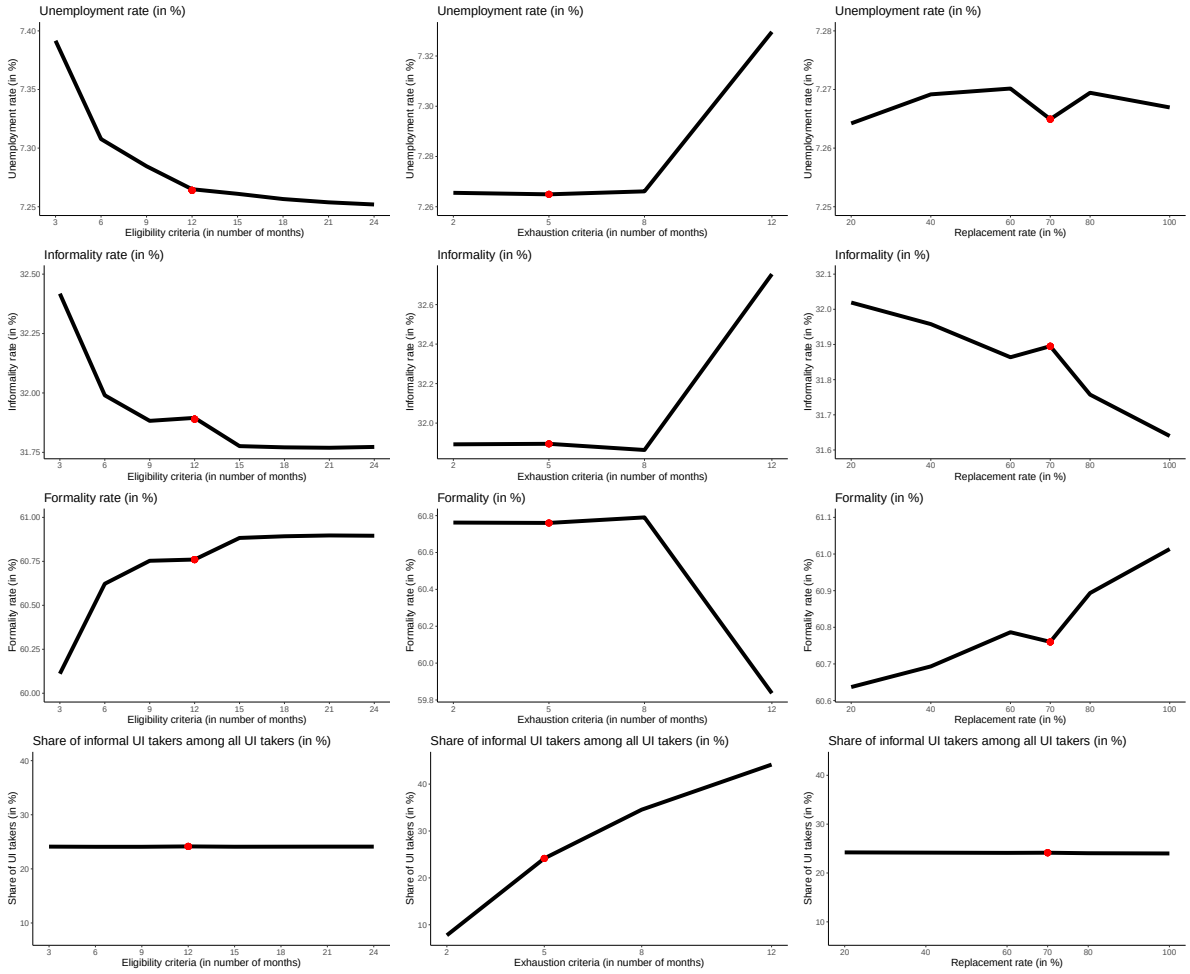

Figure 2: **Labour market outcomes**: The first column shows how labour market aggregates varies as the eligibility criteria changes for unemployment rate, informality, formality and share of informal UI takers, all in %. The second and third columns shows the same labour market aggregates but for variation in the exhaustion criteria and the replacement rate, respectively. The red dot represents the benchmark situation.

curs through formal workers. As it becomes more difficult to obtain UI benefit, the top 40% formal workers increases their savings, from 3.1% to 9.0%. Formal worker foresees that in case of an employment shock she is going to increases savings to smooth consumption since the criteria to collect UI benefit is stricter than used to be. Since eligibility criteria only affects the regulated workers, for informal workers the effects are almost negligible.

As we increase the exhaustion period, i.e, the number of UI installments that an eligible work can collect, we see a downward effect on savings. For top 40% formal, savings diminishes from 9.1% to 6.2%. Using the same reasoning from the previous paragraph, since workers are forward looking, as the possibility of keeping collecting UI for longer periods increases, workers rely less on precautionary savings to smooth consumption. Again, the effect of exhaustion criteria is weaker on informal workers, although the top 40% informal ones decreases their savings from 8.4% to 8.0%, and increase again from 8 to 12 months, most by composition effect since there is an increase in the number of informal workers due to the moral hazard effect of UI, as explained in the beginning of this section.

The effect of decreasing replacement rate is similar to effect that we find on exhaustion period although not so strong. Since the level of benefit increases, the level of savings from top 40% workers declines from 9% to 8.1%. UI benefit crowds out savings as it generosity rises. A surprisingly result comes from the effect of UI level on the top 40% savings from informal workers, which increases from 6.5% to 8.3% as the UI benefit replacement rate increases from 20% to 100%. As the formal sector becomes more congested due to the possibility of higher UI, informal workers rely more on precautionary savings.

5.3 Wages

At most, the aggregate wage functions on assets $w_f(a, z, i_e)$ and $w_i(a, z, i_u)$ reconcile with the empirical evidence from Lise (2013), in which the wage function is increasing on individuals wealth. See Figure 11.[30]

As we did in the last subsection, Figure 4 provide average differential wage for formal sector, here, calculated as the difference between the eligible and ineligible workers formal wage.[31] The difference between them in the formal sector monotonically shrinks from

[30] Krusell et al. (2010) and Setty and Yedid-Levi (2020) show that the model that combines DMP with incomplete markets brings those characteristics. The concavity of the wage function features two characteristics: i) The increasing function, more pronounced closely to the borrowing constraint and ii) the natural upper bound, which is the value the risk-neutral workers would obtain because they are perfectly insured.

[31] Such difference is calculated by the following equation: $\frac{w_f(a, z, i_e = 1)}{w_f(a, z, i_e = 0)}$.

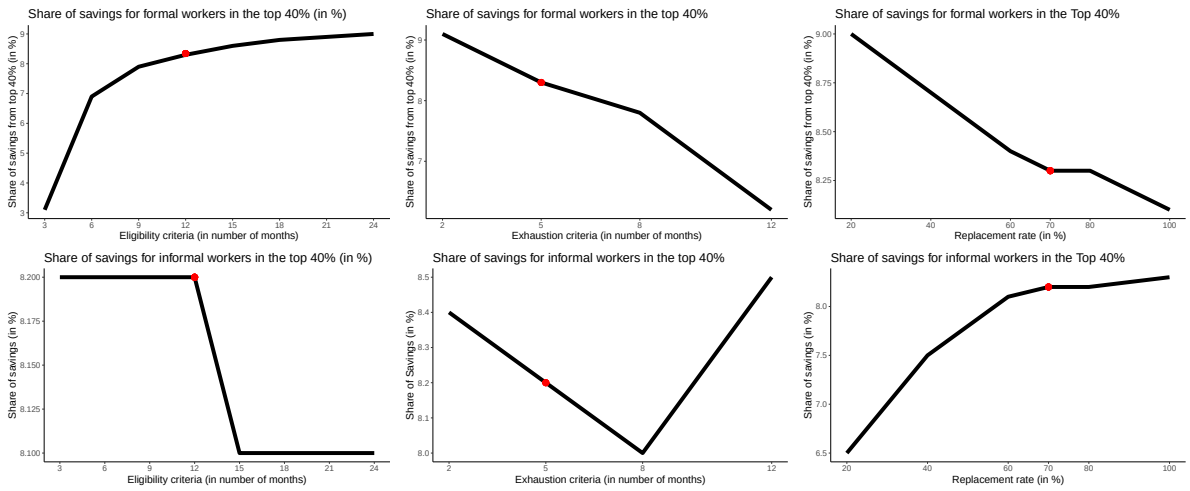

Figure 3: **Savings in the top 40%**: The first column shows how the share of savings (share of net income) varies as the eligibility criteria changes for formal and informal sector, all in %. The second and third columns show the same share of savings but for variation in the exhaustion criteria and the replacement rate, respectively. The red dot represents the benchmark situation.

61.2% to 5.5% as we increase the eligibility criteria from 3 to 24 months. Mostly of the effect comes from the formal wage for someone that is not eligible, i.e, $w_f(a, z, i_e = 0)$. This type of worker take in consideration that is more difficult to become entitled to receive UI benefit and increases her precautionary savings, which produces an upward effect on his wages, while the salary for someone eligible remains almost constant.

On the other hand, the effect of exhaustion criteria increases the wage differential in the formal sector on twofold: *i*) It decreases the wage for ineligibles and *ii*) increases for the eligible ones, the same effect that occurs with replacement rate. Economic agents foresees that UI duration will take longer, with a downward effect on savings, decreasing wages as a consequence, while eligible workers have better outside option since UI benefit lasts longer. The same arguing holds to replacement rate.

The wage premium measures how much the formal workers earns more then informal one.[32] Using the same arguing that we used before, the wage increase for ineligible formal workers drives wage premium down when eligibility criteria increases due to composition of formal workers. The wage premium goes from 4.77% to 4.47%. The increase in the share of ineligible workers, whose wages are lower compared to entitled ones makes this premium fall since informal wages remains constantly. Hence, when becomes more

[32] We calculate the wage premium as: $\sum_a \sum_z \left\{ \frac{\sum_{i_e} w_f(a,z,i_e) \times \mathbb{S}_f(a,z,i_e)}{\sum_{i_e} \sum_{i_u} \mathbb{S}_f(a,z,i_e) \times \mathbb{S}_i(a,z,i_u)} \times \left[\frac{\sum_{i_u} w_i(a,z,i_u) \times \mathbb{S}_i(a,z,i_u)}{\sum_{i_e} \sum_{i_u} \mathbb{S}_f(a,z,i_e) \times \mathbb{S}_i(a,z,i_u)} \right]^{-1} \right\}$.

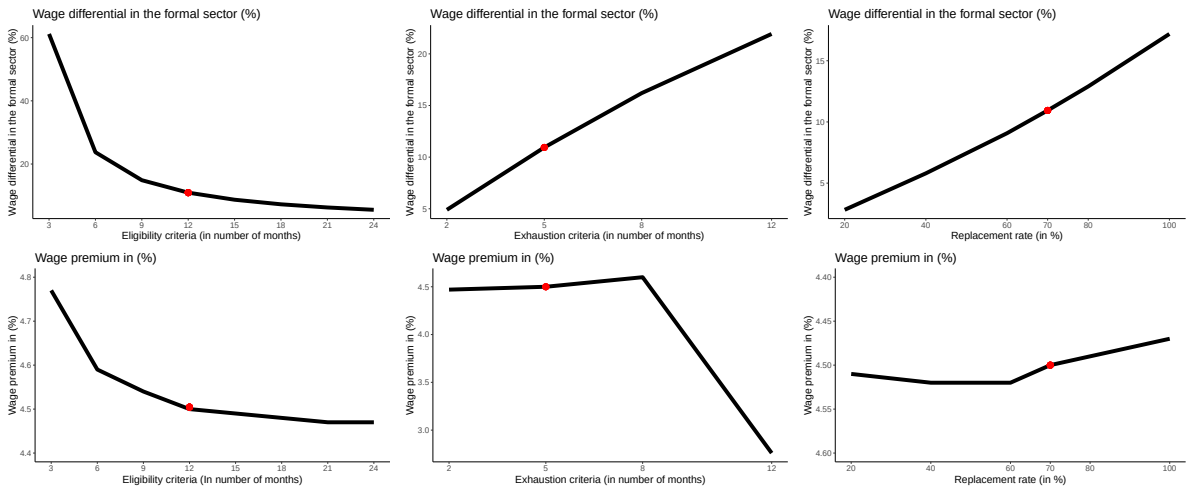

Figure 4: **Differential wage and wage premium**: The first row shows how the differential wage (the ratio of eligible to non-eligible wage within formal sector) varies as the eligibility criteria changes in %. The second row shows how wage premium (The ration between the labour income of formal and non-regulated sector) varies as the eligibility criteria changes, in %. The second and third columns show the same labour measures but for variation in the exhaustion criteria and the replacement rate, respectively. The red dot represents the benchmark situation.

complicated to get access to unemployment insurance, the wage premium decreases, indicating that such benefit affects how formal firms pays workers compared to the informal ones.

The effects of exhaustion criteria are straightforward. While from 2 to 8 months, the wage premium remains constant, the subsequent period shows a large decline in the wage premium, mostly explained by the increase in the share of informal workers and decrease in the regulated sector, as we showed in the last subsection. An increase on replacement rate has negligible effects on wage premium. Although the rise of UI benefit increases wages for someone that is entitled to receive the benefit, it also increases to someone that is informal and, surprisingly, ineligible. The net effect is that wage premium stays in the same pattern regardless of replacement rate.

5.4 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

$$E \sum_{t=0}^{\infty} \beta^t u(c_t) \tag{25}$$

Take note that 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 distortions that changes in the UI design imposes on job creation.

We compute the welfare change, ν, 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 UI design 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 UI design that we intend to evaluate. Then, define:

$$V^0(\omega) = E\Big[U_{t,0}((1+\nu)c_t)\Big] \tag{26}$$

Where $U_{t,0}$ is the flow utility attained by the agent under the benchmark at period t. Our relevant measure of welfare variation is:

$$CEV = \min_{v}[E_\omega V^0(\omega) - E_\omega V^1(\omega)] \tag{27}$$

CEV Decomposition Aiming at understanding the source of welfare gains we decompose the CEV in variations that are due to improved insurance and those that are due to a more efficient use of aggregate resources. Let $C_{0,t}$ denote the average consumption in period t at the benchmark, and $C_{1,t}$ the same but at the counterfactual UI system. We may, in this case, implicitly define ν_{lev} through:

$$\sum_{t=0}^{\infty} \beta^{t-1} U_{t,0}((1+\nu_{lev})C_{0,t}) = \sum_{t=0}^{\infty} \beta^{t-1} U_{t,1}(C_{1,t}) \tag{28}$$

For $c_{t,0}$, the benchmark equilibrium allocation, and $c_{t,1}$ the equilibrium allocation under the alternative policy, implicitly define ρ_0 and ρ_1, through:

$$\sum_{t=0}^{\infty} \beta^{t-1} U_{t,0}((1+\rho_0)C_{0,t}) = \sum_{t=0}^{\infty} \beta^{t-1} U_{t,0}(C_{0,t}) \tag{29}$$

$$\sum_{t=0}^{\infty} \beta^{t-1} U_{t,1}((1+\rho_1)C_{1,t}) = \sum_{t=0}^{\infty} \beta^{t-1} U_{t,1}(C_{1,t}) \tag{30}$$

In both expressions, E denotes the unconditional expectation operator with respect to

all possible permanent types and histories. Then,

$$\nu_{unc} = \frac{1-\rho_1}{1-\rho_0} - 1 \tag{31}$$

Hence, the two components approximately sum to the total welfare effect, as also established by Heathcote et al. (2008), i.e, $\nu \approx \nu_{lev} + \nu_{unc}$.

5.5 Optimal unemployment insurance policy

In this section, we estimate the optimal unemployment insurance policy in terms of Consumption Equivalent Variation (CEV), as explained in the previous subsection, taking in account changes in the eligibility criteria, the duration of UI and the replacement rate, all at the same time. We conducted our experiment changing the eligibility criteria, the exhaustion criteria and the replacement rate in the following set of possibilities: Pe (in months) $\in \{3, 9, 18, 24\}$, Pu (in months) $\in \{2, 8, 12\}$ and ϱ (in %) $\in \{20, 60, 100\}$. The first column in Table 4 shows the variable that we are analyzing, the second one displays the benchmark situation while the third one displays what is the possible combination among all the possibilities of the UI design that maximizes welfare.

We find that the policy design that maximizes CEV demands an eligibility criteria of 24 months, i.e, the worker must spend 24 months in the formal sector to be entitled to collect UI benefit once unemployed/informal, hence, adding 1 year to the benchmark model. Also, the exhaustion period increases from 5 to 8 months as well the replacement rate, which we find to increase to 100% to be optimal. Such results goes in different direction compared to Krusell et al. (2010) and Setty and Yedid-Levi (2020), that find the UI should be shut down in the economy. In this tension between the incomplete markets and search and matching models, in our framework, the Bewley-Hugget-Aiyagari (BHA) setup overcomes the DMP issues that may occur in the economy, as their agents asks for more insurance in detriment of a laissez-fair economy.

Mostly of the aggregates variables in this economy remains constant. Capital per labour, consumption, output and interest rate do not features any changes. Nonetheless, on the labour market outcomes, we can see some variation on major aggregates. Unemployment rate displays a slightly decrease, from 7.27% to 7.23% due to increase in formal job finding rate (which increases from 7.60% to 7.67%) and decline in the informal one (8.60% to 8.56%). This leads to an rise in formality rate (from 60.76% to 61.07%) and a decrease in informality (31.90% to 31.62%). As demonstrated in the last row of Figure 2, the longer UI benefit duration pushes the UI taker to the informal sector. The share of infor-

mal UI takers rises from 24.15% to 34.47%. Since more agents (unemployed workers and informal ones) are demanding UI benefit, consumption tax goes up from 4.06% to 4.44%.

When we analyze the optimal UI design on wages, we see more clearly the role of informal sector in shaping such result. Although the formal wage premium remains constantly (4.51%), the formal differential wage increases from 10.94% to 12.84%, induced by the increase in the duration and replacement rate of UI benefit. This indicates that with the wage premium constant, the wage in the informal sector increases as well, mainly, the wage for those not eligible to collect unemployment insurance. This reduces the incentives to informal firms to post vacancies, which leads to a relative increase in the formal vacancy posting, rising formality in this economy.

The wage increase in the informal sector lead to a redistribution of resources among the agents in this economy. Gross (net) income gin decreased from 0.374 (0.338) to 0.359 (0.319). We can see such pattern also in the consumption inequality, that decreased from 0.336 to 0.333. Such income redistribution toward informal sector is pronounced by the CEV results in the bottom of the table. When decomposing the result of CEV in level and uncertainty, we can see the latter informal component induces a positive result in the general CEV. Hence, the CEV for informal sector increased 1.25% due to the rise of 1.83% in the uncertainty component. Bottom line, the optimal design of UI is the one who pushes for more insurance in the economy, leading to a better redistribution of resources, mainly those in the informal sector.

5.6 Eliminating elements of UI design

In this section, we study how the current UI design affects the labour market and aggregate variables. Table 5 display the findings that for the case where we eliminate eligibility (i.e, every formal worker becomes eligible to receive UI benefit), UI cap (i.e, we eliminate the restriction of a UI benefit ceiling), eligibility and UI cap and the whole elimination of UI benefit on this economy.

We start by describing the effects on labour market outcomes of eliminating eligibility. The main effects come from the incentives of formals firms to post vacancies, that declines when every formal worker is eligible to work in the formal sector. As everybody in the formal sector can collect UI, the share of formal worker ineligible goes to 0 which decreases firms profits as consequence of only paying wages to eligible workers, whose outside option is better due to UI. Hence, declining the vacancies posted on the economy. For that, unemployment rates increases from 7.27% to 7.57%, formality decreases from

Variable	Benchmark	Optimal UI design
Eligibility (in months)	12	24
Exhaustion (in months)	5	8
Replacement rate	70%	100%
Capital per labour	171.01	171.01
Consumption	2.86	2.86
Output	4.16	4.16
Interest rate	4.97%	4.97%
Consumption tax	4.06%	4.44%
Top 40% formal/informal savings rate	8.34%/ 8.16%	8.57%/ 8.12%
Unemployment	7.27%	7.23%
Formality/Informality	60.76%/ 31.90%	61.07%/ 31.62%
Formal/Informal job destruction rate	0.70%/ 1.75%	0.70%/ 1.75%
Formal/Informal job finding rate	7.60%/ 8.60%	7.67%/ 8.56%
Informal UI takers	24.15%	34.47%
Formal wage premium	4.51%	4.51%
Differential wage	10.94%	12.84%
Gini		
Gross income	0.374	0.359
Net income	0.338	0.319
Consumption	0.336	0.333
Assets	0.559	0.560
Welfare (in %)		
CEV	-	0.32
Formal/Informal	-	-0.27/ 1.25
Unemployed	-	0.83
CEV Level	-	0.16
Formal/Informal	-	0.52/ -0.57
Unemployed	-	0.11
CEV Uncertainty	-	0.16
Formal/Informal	-	-0.78/ 1.83
Unemployed	-	0.72

Table 4: **Optimal unemployment insurance**: This table presents changes when we change eligibility, exhaustion and replacement rate of UI benefit to reach the optimal policy, measured as Consumption Equivalent Variation (CEV) in %.

60.76% to 59.19%. Both results induced by the fall in the formal job finding rate, which declined from 7.60% to 7.12%. As residual, since the informal job finding rate remains almost constant, the informal sector rises 1.26 percentage points. The wage differential does not longer exists while the formal wage premium increases 0.57pp., due to the formal wage increase. The job destruction rates remained the same, which indicates that endogenous destruction was not triggered by the elimination of eligibility.

The overall welfare result is negative, indicating a disagreement among different workers. While formal workers are the most reward by the change, due to the fact now that every regulated worker may collect UI when unemployed, informal and unemployed are hurt by such conditions. Both of them are benefited by some better appropriation of consumption in the economy, however, since they are risk averse, the increase in uncertainty decreases their welfare results.[33]

Removing UI cap, i.e, the UI benefit ceiling, does not affect so much the economy compared to the benchmark criteria. Mainly of the disagreement between individuals comes from the fact that the reduction of UI cap provides more insurance to those that have a higher capacity to self-insure against employment/idiosyncratic shocks, as are the formals workers. The remove of the cap, an element of UI benefit with distributional properties as highlighted by Setty and Yedid-Levi (2020), brings disagreements between formal and informals workers, as showed in the uncertainty component. Informal workers suffers more since the income inequality increases in every measure in the economy. Although formal workers experiences a decrease of 0.07% in the uncertainty component, the strong declines comes from the informal sector, which experiences a fall of 0.59% in such measure. The increases in inequality disturbs both type of workers, however, the informal suffers more with that compared to the formal counterpart.

In the fourth column of results, we remove the eligibility criteria and the cap of the benefit, hence, every formal workers becomes entitled to collect UI and they collect at the most possible high value. We can see that the major labour market aggregates are affected. Unemployment rate increases from 7.27% to 7.67% since the price of formal worker hiked, which is evidenced by the 0.80 percentage point hike in the formal wage premium (from 4.51%) and by the fact that every worker is eligible to collect UI, and those have higher wages. With higher wages, formals firms posts less vacancies, decreasing the job finding rate in such sector while the non-regulated sector remains almost constant. Such effect

[33]Since the level of consumption remains almost constant, and we have a increase in the share of unemployed and informal worker, their participate more in the consumption share that used to be. Their negative results are also highlighted by the increase in gini of net income, gross income and asset. Our welfare measure favors those policies that reduces inequality.

increases informal sector to 33.68%. Despite the growth of informal sector, which is highlighted by the higher appropriation of consumption by them[34], the effect in inequality hurts the well-being of non-regulated workers, helping drive CEV down 1.40%. We can see that all the gini index (exclusive assets) rises compared to benchmark situation. In sum, the elimination of eligibility criteria together of UI cap hurts the overall conditions of economy by making formal workers expensive relative to informals one, which increases both informal sector size and inequality, being the latter crucial to understand the welfare results.

5.7 Outcomes and CEV without UI cap and eligibility

In this section, we eliminate two of main components of UI design, the eligibility criteria and the UI cap, and see how the labour market outcomes and CEV changes when we change the duration and replacement rate of the benefit. This choice of design mimics Krusell et al. (2010), where every individual that works in the formal sector is entitled to receive UI and ceiling of the benefit does not bind.[35] Figure 5 displays the unemployment rate, informality, formality and share of informal UI takers when we increase the exhaustion criteria (in the first column) and the replacement rate (second column). The black solid line is the situation when we keep eligibility criteria being the same as the benchmark situation (12 months) with UI cap and the red dot-dashed line represents the model when every agents in the formal sector is entitled to receive the benefit and there is no ceiling in the level of the benefit. We estimated the model to be consistent with the benchmark calibration presented in the previous sections, changing the parameters when necessary.

The elimination of eligibility and UI cap boosts the impact of UI in the labour market aggregates. While the unemployment rate (black solid line) remains almost constant in the benchmark situation, it increases a lot (red dot-dashed) in the situation without eligibility and UI cap. In the latter, unemployment rate increase 0.8p.p to 7.8%. when the duration of the benefit goes from 2 to 12 months. Not surprisingly, the result of UI duration shows a elasticity higher compared to the replacement rate. The unemployment rate only increases 0.4 percentage point. when we increase the replacement rate from 20% to 80%.

The rise of UI duration and replacement rate increases the wage in formal sector, as we showed in Figure 4. Those who are eligible (in this exercise, every formal worker) have a higher wage compared to non-eligible, which hurts firms profit conditions, leading

[34]The CEV decomposition in level grows by 4.81% while formal sector decreases 3.89%.

[35]Since we have informal sector and individuals can collect the benefit in this sector, we do not eliminate the UI duration otherwise every individual would go to the non-regulated sector.

to less vacancy posting in the regulated sector. Hence, formality decreases faster and, as residual, informality increases in both exercises. The behaviour of informal UI takers is not modified without the entitlement effect and UI cap neither in the replacement rate exercise, although this measure being slightly higher in that situation, evidenced by the parallel behaviour of the red dot-dashed line in the last graph of second column.

Figure 6 shows the same exercises from Figure 5, but focused on Consumption Equivalent Variation (CEV, in %). The optimal results goes in the direction of less UI benefit in this economy. Although the formal sector experiences a increase in welfare when we increase UI duration and replacement rate, mainly due to the rise of wage in the formal sector, surprisingly, informal and unemployed workers goes in the opposite way and experience a decline in welfare. Figure 12 help us understand what drives such results.

The decomposition tell us that what drives CEV down is the uncertainty component in both informal sector and unemployed as well the replacement rate. Since individuals are risk averse, any increase increase in inequality brings such results. For unemployed ones, the increase in the job finding probability of going to informal sector, where wages are lower and risk of being unemployed again are higher brings a rise in consumption dispersion. The same holds for the informal sector. As we can notice, the share of workers in the informal sector increased almost 3 p.p. In general, what holds now in this tension between frictional labour market models such as DMP and incomplete markets models is the former.

To summarize, the UI increase in both, level and duration, strengths the formal worker position when bargaining about a better wage. Since every formal worker is entitled to receive UI and their wage is higher than those non-entitled and also higher than the informal counterpart (summarized by wage differential and wage premium on Figure 4, an increase in UI duration and the level of benefit affects the decision of posting vacancies in the formal sector, pushing workers to informal sector, where the wages are lower compared to the regulated formal counterpart, or to unemployment, where the UI benefit just helps for some period and the leisure component is lower compared to wages in both sector, which brings instability in income. This is the reason that the CEV uncertainty component hikes when the duration and the level of benefit rises as well.

6 Concluding remarks

To be written

Variable	Benchmark	Removing Eligibility	Removing UI cap	Removing Eligib. and UI cap	Removing UI
Eligibility (in months)	12	1	12	1	
Exhaustion (in months)	5	5	5	5	
Replacement rate	70%	70%	70%	70%	
Capital per labour	171.01	171.33	171.50	172.28	
Consumption	2.86	2.84	2.86	2.84	
Output	4.16	4.16	4.16	4.17	
Interest rate	4.97%	4.95%	4.94%	4.90%	
Consumption tax	4.06%	4.70%	4.31%	5.02%	
Top 40% formal/informal savings rate	8.34%/ 8.16%	-83%/ 8.41%	8.09%/ 8.60%	-88.3%/ 9.03%	
Unemployment	7.27%	7.57%	7.29%	7.67%	
Formality/Informality	60.76%/ 31.90%	59.19%/ 33.16%	60.69%/ 31.95%	58.57%/ 33.68%	
Formal/Informal job destruction rate	0.70%/ 1.75%	0.70%/ 1.75%	0.70%/ 1.75%	0.70%/ 1.75%	
Formal/Informal job finding rate	7.60%/ 8.60%	7.12%/ 8.57%	7.57%/ 8.59%	6.95%/ 8.59%	
Informal UI takers	24.15%	24.07%	24.12%	24.13%	
Formal wage premium	4.51%	5.08%	4.60%	5.31%	
Differential wage	10.94%	-	10.56%	-	
Gini					
Gross income	0.374	0.385	0.384	0.391	
Net income	0.338	0.344	0.355	0.356	
Consumption	0.336	0.334	0.339	0.336	
Assets	0.559	0.560	0.561	0.561	
Welfare (in %)					
CEV	-	-0.88	-0.29	-1.40	
Formal/Informal	-	2.03/ -4.63	-0.19/ -0.40	2.63/ -6.50	
Unemployed	-	-4.42	-0.55	- 6.11	
CEV Level	-	-0.68	0.01	-0.76	
Formal/Informal	-	-2.91/ 3.23	-0.12 /0.19	-3.89/ 4.81	
Unemployed	-	3.60	0.39	5.01	
CEV Uncertainty	-	-0.20	-0.30	-0.65	
Formal/Informal	-	5.09/ -7.62	-0.07/-0.59	6.79/ -10.8	
Unemployed	-	-7.74	-0.94	- 10.59	

Table 5: **Eliminating components of UI design**: This table presents changes when we eliminate components of UI design. The second column represents the benchmark situation; The second columns displays the changes in the economy when we remove the eligibility effect, so everybody that goes to the formal sector is qualified to collect UI. The third one shows when we eliminate the cap of UI benefit, indicating that everybody can collect a UI benefit that represents 70% of your previous formal wage. The fourth column displays the combination of eliminating eligibility and UI cap and the last column shows the results when we eliminate UI benefit from the economy.

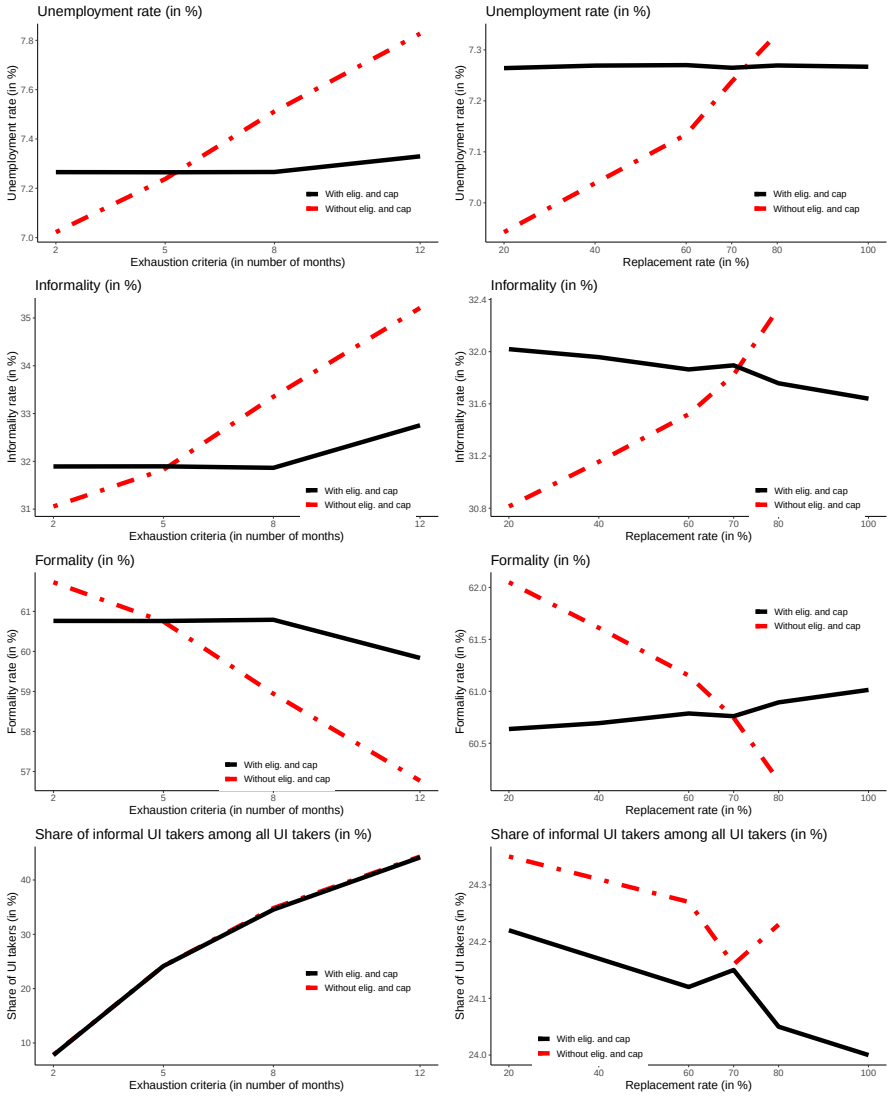

Figure 5: **Labour market outcomes with and without eligibility and UI cap**: The first column shows how labour market aggregates varies as the exhaustion criteria changes for unemployment rate, informality, formality and share of informal UI takers, all in %. The second column shows the same labour market aggregates but for variation in the replacement rate, respectively. The black line display the result to the model calibrated with eligibility of 12 months and a cap ($\bar{b}$) for the UI benefit. The red dot-dashed line shows the same results with every worker eligible to collect UI ($Pe = 1$) and without any cap.

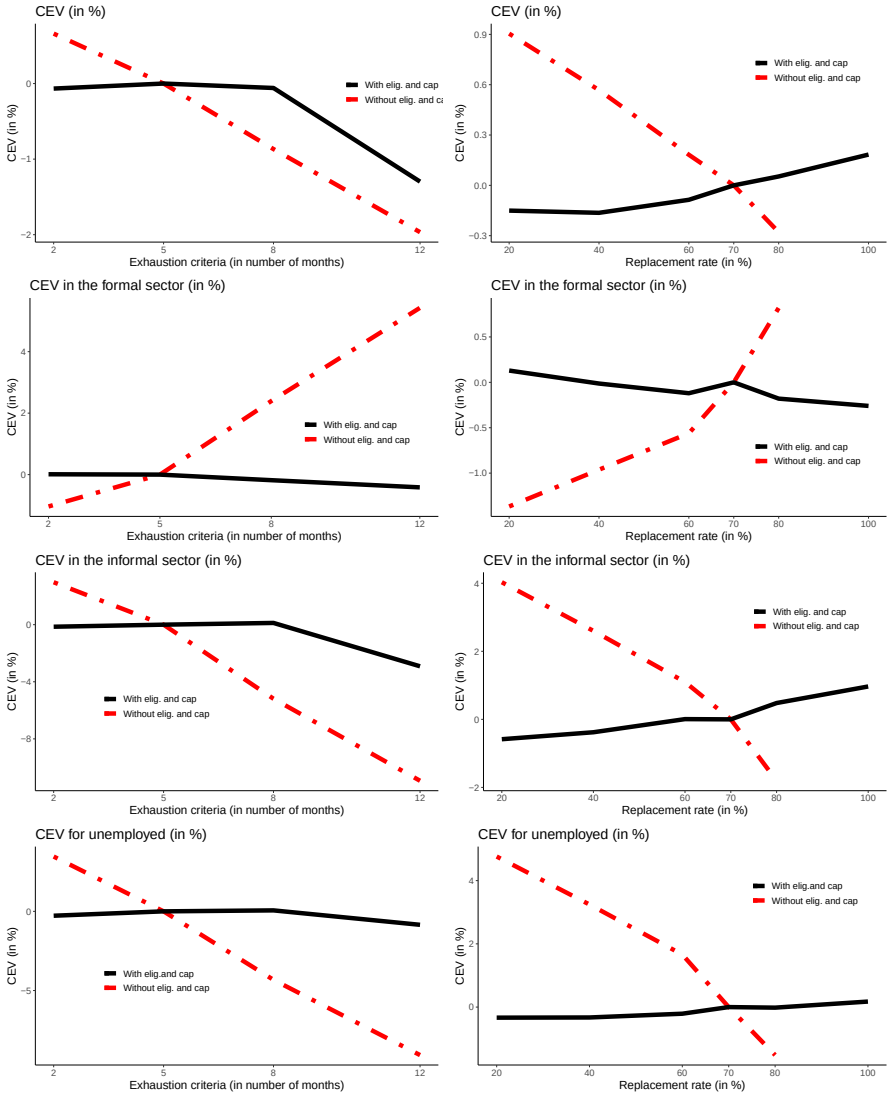

Figure 6: **Consumption Equivalent Variation (CEV) with and without eligibility and UI cap**: The first column shows how Consumption Equivalent Variation (in %) varies as the exhaustion criteria changes for formal, informal and unemployed. The second column shows the same CEV for variation in the replacement rate, respectively. The black line display the result to the model calibrated with eligibility of 12 months and a cap ($\bar{b}$) for the UI benefit. The red dot-dashed line shows the same results with every worker eligible to collect UI ($Pe = 1$) and without any cap.

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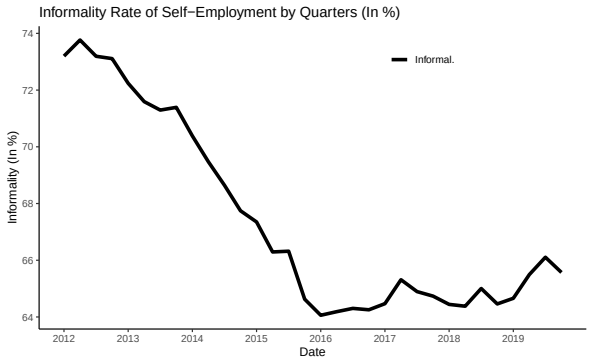

Figure 7: **Informal self-employment rate by quarters** The black solid line shows among all self-employed individuals, the rate that is informal. *Source*: PNADC quarterly - 2012-2019.

A Data

B Estimation and Regression Results

As explained in the previous section, we used data from the PNADC to estimate some labour market parameters and untargeted moments. Figure 7 show the transitions from formal and informal sector into unemployment. Using the panel dimension of quarterly PNADC, we can compute the rate at which workers transition to and form unemployed. For each quarter, we restrict the sample of individuals in the labor force (one of the questions surveys is about if the individual is in the labor force) and then compute the empirical transition matrix across three states (unemployed, formal and informal). We restrict our analysis to the same group used before on empirical evidence form POF and yearly PNADC: We exclude public statutory employees and auxiliary family workers. We maintain others types of civil servants since they are eligible to collect UI benefit. We also keep self-employed individuals, since, on the average between 2012 and 2019, 67.4% are informal (as also showed in Figure 7).[36]

We also compute the share of informal and unemployed workers by quarters in the Figure 10

Now, let's see regression for wage premium:

[36]We define formal self-employed by two criteria: i) If it contributes to social security system (INSS) and ii) If it has a formal register of the firm (CNPJ).

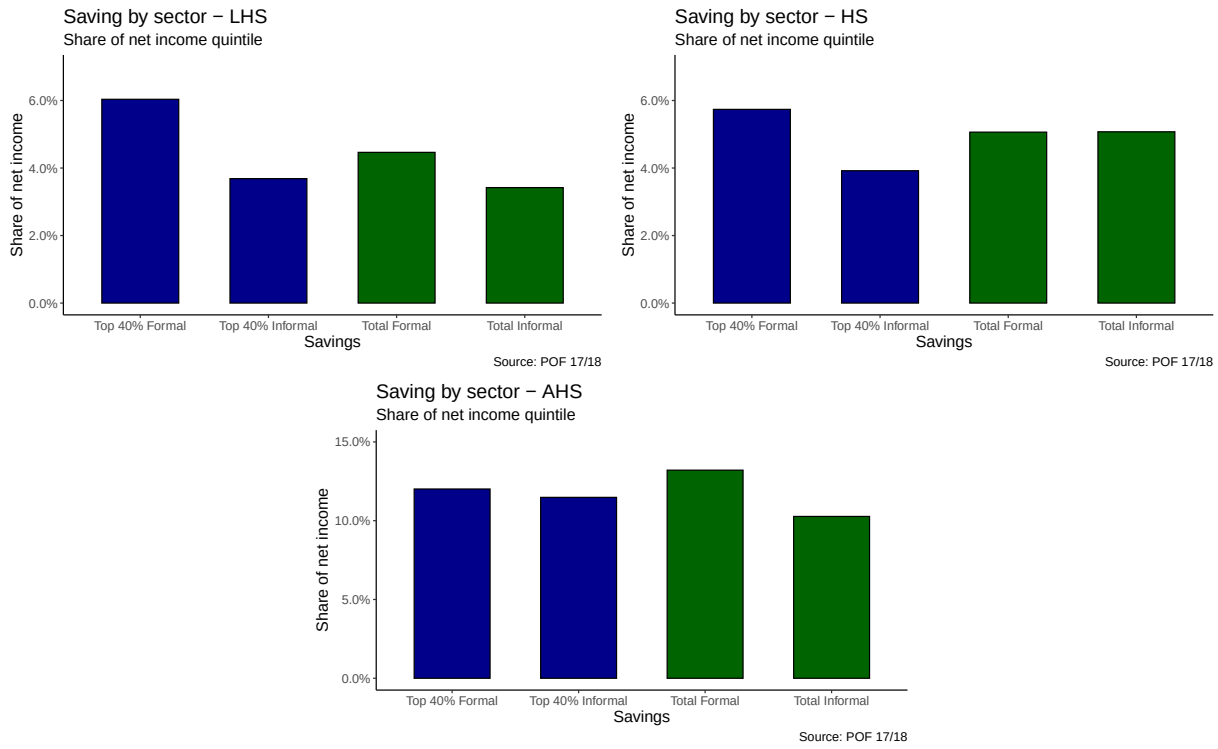

Figure 8: **Savings by education**. *First row*: The left graph shows the savings share of net income for all formal and informal (green) and the savings share of net income that top 40% formal and informal (blue) for individuals that have lower than high-school (LHS) education. The right graph shows the savings share of net income for all formal and informal (green) and the savings share of net income that top 40% formal and informal (blue) for individuals that have high-school (HS) education.*Second row*: The graph shows the savings share of net income for all formal and informal (green) and the savings share of net income that top 40% formal and informal (blue) for individuals that have above than high-school (AHS) education. *Source*: POF 17/18.

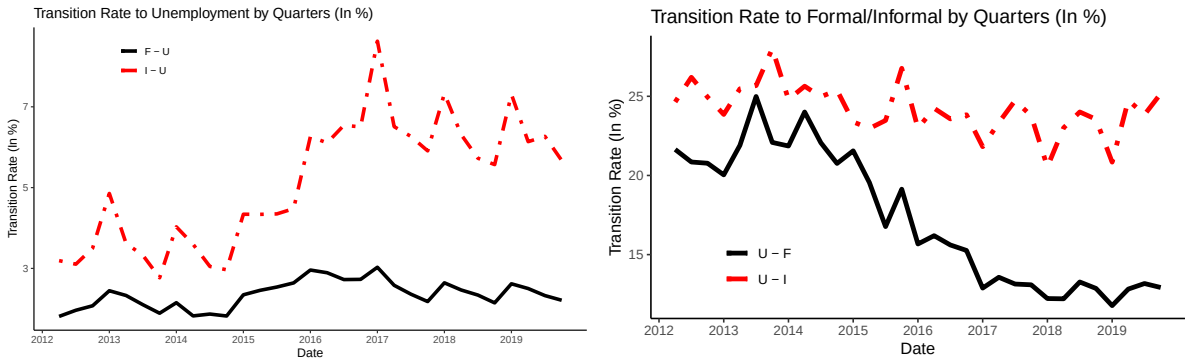

Figure 9: **Transitions rate to and from unemployment** *Left graph*: The black solid line shows transition rate from formal sector to unemployment. The red dot dashed line shows transition rate from informal sector to unemployment. *Right graph*: The black solid line shows transition rate to formal sector from unemployment. The red dot dashed line shows transition rate to informal sector from unemployment *Source*: PNADC quarterly - 2012-2019.

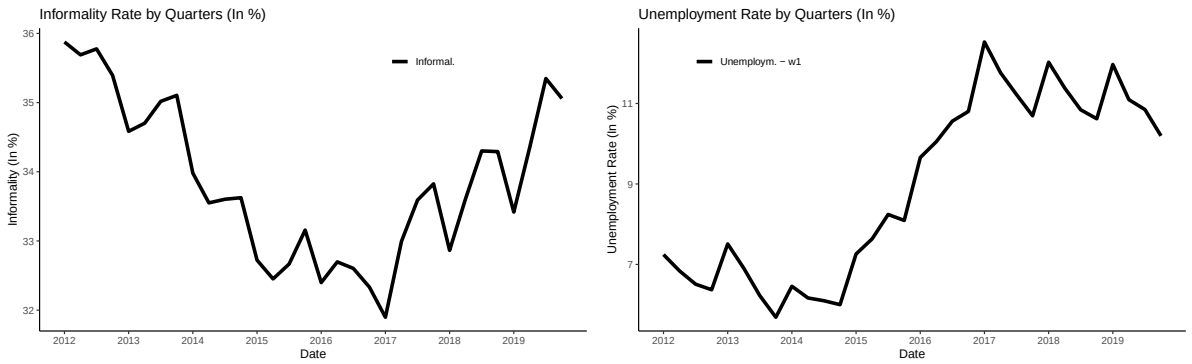

Figure 10: **Informality and unemployment rate by quarters** *Left graph*: The black solid line shows informality rate by quarter. *Right graph*: The black solid line shows unemployment rate by quarter. *Source*: PNADC quarterly - 2012-2019.

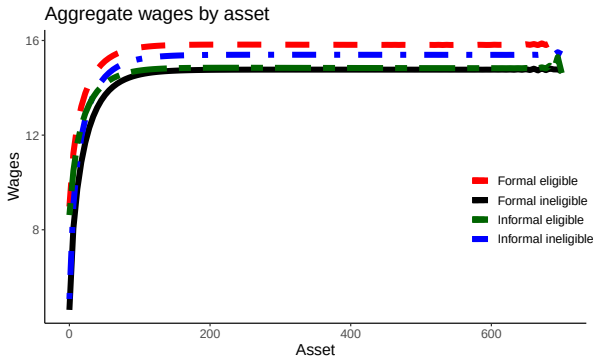

Figure 11: **Aggregate wage functions by asset** The black solid line shows aggregate wages for formal and ineligible. The red dashed line displays aggregate wage function for formal and eligible. The green two dashed line shows aggregate wage functions for informal and eligible and the dot dashed blue graph displays show aggregate wages for informal and ineligible ones.

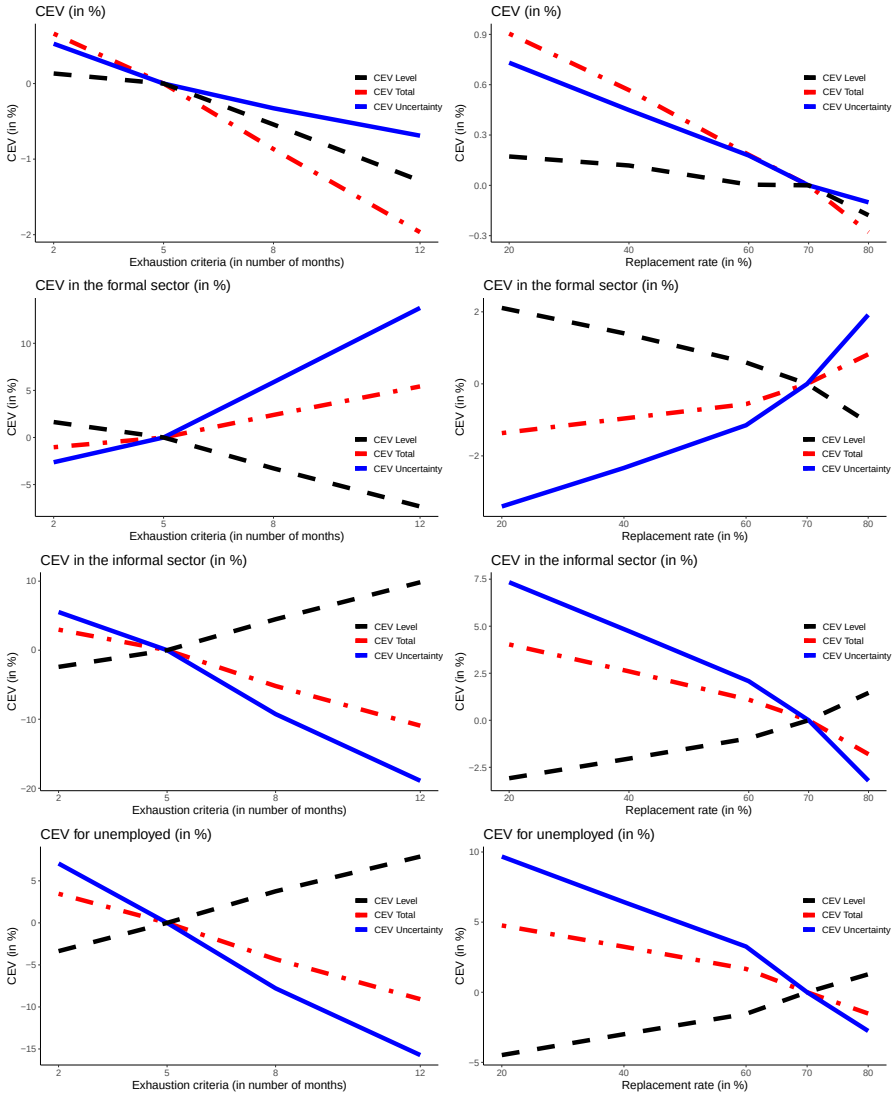

Figure 12: **Decomposition of Consumption Equivalent Variation (CEV) without eligibility and UI cap**: The first column shows how Consumption Equivalent Variation (in %) as well their decomposition in level and uncertainty varies as the exhaustion criteria changes for formal, informal and unemployed. The second column shows the same CEV decomposition for variation in the replacement rate, respectively. The red dot-dashed line display the CEV total, the black dashed line display the CEV decomposition in level and the blue solid line display the CEV decomposition due to uncertainty.

	All indiv. (≥16 yrs) (1)	All indiv. (≥16 yrs) (2)	All indiv. (24 - 65 yrs) (3)	Workers (24 - 65 yrs) (4)	Workers (24 - 65 yrs) (5)	Formal (24 - 65 yrs) (6)	Informal (24 - 65 yrs) (7)	Self-empl. (24 - 65 yrs) (8)
Age	0.0330***	0.0274***	0.0200***	0.0200***	0.0199***	0.0186***	0.0378***	0.0264***
	(0.0012)	(0.0013)	(0.0017)	(0.0018)	(0.0018)	(0.0014)	(0.0026)	(0.0038)
Age^2	-0.0003***	-0.0003***	-0.0002***	-0.0002***	-0.0002***	-0.0002***	-0.0004***	-0.0003***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Formal	0.0735***	0.0732***	0.0709***	0.0689***	0.0696***			
	(0.0007)	(0.0007)	(0.0007)	(0.0008)	(0.0008)			
Schooling	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time	No	Yes	Yes	Yes	Yes	No	No	No
Occupation	No	No	No	No	Yes	No	No	No
Num.Obs.	6,117,219	6,117,219	5,211,131	4,653,576	4,653,576	3,697,661	2,439,901	1,633,925
R2	0.892	0.892	0.891	0.881	0.882	0.910	0.877	0.879
R2 Adj.	0.831	0.831	0.832	0.813	0.814	0.854	0.762	0.779

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: **Log of income per hour**: Our preferred estimations is column 5, which shows a forma wage premium of 7.0%. All specifications include a constant, not reported. Standard errors are presented in parenthesis, * indicates significant at the 90 percent confidence level and ** a 95 percent confidence level and *** a 99 percent confidence level. *Source*: PNADC quarterly - 2012-2019.