Job Search, Unemployment Protection and Informal Work

Iain W. Long[1] and Vito Polito[2,*]

[1]Cardiff University, Economics Section, Cardiff Business School, Colum Drive, Cardiff, CF10 3EU, UK, longiw@cardiff.ac.uk
[2]University of Sheffield, Department of Economics, 9 Mappin Street, Sheffield, S1 4DT, UK, v.polito@sheffield.ac.uk
[*]Corresponding author

JEL: J46, J64, J65, K42

Abstract

Informal work is a significant feature of labour markets in many developed countries, despite having unemployment protection programmes. We use a model of job search over the duration of unemployment to study how the structure of these programmes influences the incentive of the unemployed to engage in informal work whilst searching for formal jobs. Accounting for informality enables the model to jointly explain three known features on job search dynamics: a temporary re-employment spike; low search effort; and negative duration dependence. The quantitative analysis finds that both informality and unemployment can be reduced by redistributing (across either workers or programmes), rather than increasing, the overall unemployment protection budget.

1 Introduction

Informal work is often associated with poverty, involving weak employment conditions and a lack of social security protection (ILO 2018). Whilst long regarded as pertinent to developing countries, these issues have recently become a policy priority in developed countries due to the rise of non-standard forms of employment in which the incidence of informality is high.[1] Such jobs are often carried out on a temporary basis, like seasonal or casual work. The policy most often advocated to tackle informality among officially unemployed workers is to increase the generosity of the unemployment protection (UP) system (ILO 2016). The objection is that the increased tax burden required to fund this policy would further distort the labour market, ultimately leading to reduction in employment.

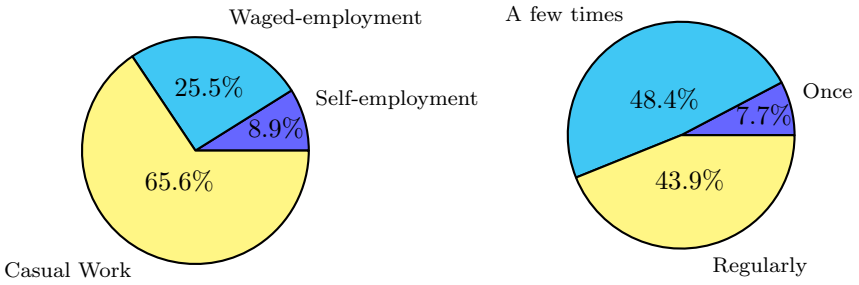
UP systems provide a safety net against the risk of unemployment and are a prominent component of labour market policy in many developed countries. Under a typical UP system, workers initially receive constant, regular payments through unemployment insurance (UI). After UI is exhausted, they transfer onto less generous unemployment assistance (UA) until they secure a job or that too is exhausted. For those ineligible for UP, social assistance (SA) provides minimum income support (OECD 2014a).

Despite the widespread provision of UP in developed countries, a significant proportion of unemployed workers (about 21% in Europe and 28% in the United States) engage in informal work each month to supplement their income.[2] The majority of these activities are casual jobs undertaken on a temporary basis (Figure 1). Survey data from Europe European Commission [2014] shows that the vast majority (about 60%) of declared informal work by the unemployed is undertaken for friends or family, rather than being waged-work for businesses

[1] See the *European Platform for Tackling Undeclared Work* established by the European Commission in 2016 to develop best practices for reducing informal work more effectively, `http://ec.europa.eu`.

[2] For the purpose of this paper, informal work is defined as any paid market-based economic activity that is legal but concealed from public authorities to avoid taxes and social security contributions (Schneider and Enste 2000).

Figure 1: Informal work undertaken by unemployed workers in developed countries



(a) Activities (b) Frequency

Sources: European Commission [2007, 2014],Federal Reserve Bank of New York [2015]
Notes: See Appendix A for more details on these data.

or strangers, or self-employment. According to the ILO [2018], temporary work around the world is more likely to be informal (56.7%) than permanent (15.7%) or part-time (44%) employment.

We formulate a job search model where unemployed workers are eligible for finite-duration UP payments (as Mortensen 1977). This is augmented by allowing benefit recipients to accept temporary informal work, whilst engaging in formal job search. As claiming UP whilst working informally constitutes fraud, informal work carries the risk of being sanctioned by the UP authorities. Remaining benefit payments are withdrawn, and the worker may also be fined. We use this framework to study how the UP system influences the incentive of unemployed to work informally while searching for a formal job, and whether it would be possible to implement budget-neutral changes to the *structure* of UP that may reduce this incentive without negatively affecting formal job search. We make two main contributions. One is theoretical, the other is quantitative.

The theoretical contribution consists of specifying a stylised job search model suitable for the quantitative analysis that can *simultaneously* explain three features often identified in job search data that it hitherto struggled with (Feldstein 2005). The first is that the job-finding rate increases only temporarily at the point where benefits are exhausted: the so-called re-employment spike (hereafter F1).[3] The canonical model instead predicts that the job-finding rate should increase permanently as benefit exhaustion approaches. In our model, when benefits reduce, any given informal income opportunity becomes more valuable to the worker. The job-finding rate tends to fall immediately after a UP programme is exhausted, as workers switch from formal job search to informal work, generating a temporary re-employment spike. We refer to this

[3]See, e.g., Katz and Meyer [1990] for the US; Card et al. [2007a] for Austria; Alba et al. [2012] for Spain.

as the *payment effect*. The second is that search effort is much lower than the canonical model would predict under standard calibrations (F2).[4] In our model, working informally increases the marginal cost of formal job search. Access to informal opportunities also increases the continuation value of unemployment relative to employment, reducing the marginal benefit. Formal job-finding rates are therefore lower for any given set of parameters than would otherwise be the case. The third feature is that job-finding rates tend to decline over the duration of unemployment: so-called negative duration dependence (F3).[5] In contrast, the canonical model predicts that re-employment is (weakly) increasing over time. The payment effect leads to discrete reductions in job-finding as workers transition to less generous programmes. Moreover, within a UP programme, two further effects influence job-finding. A *deterrence effect* derives from the sanctions informal workers face. As benefit exhaustion approaches, the threat of loosing remaining payments becomes less of a deterrent, increasing the incentive to accept informal work. Offsetting this is an *exhaustion effect*, which relates to the fact that workers' incentive to search for formal work increases as benefit exhaustion approaches, curtailing informal participation. Since informal work distracts from formal job search, we observe negative duration dependence also within programmes if the deterrence effect dominates the exhaustion effect.

The quantitative contribution is based on an enriched version of the model that carefully captures (i) the structure of UP programmes in a typical developed country, (ii) the system of sanctions for benefit fraud, and (iii) accounts for skill heterogeneity amongst workers. The model is calibrated on data for Spain for three main reasons. Firstly, Spain has a UP system similar to that of a typical European country, comprising temporary UI and UA programmes, and SA for those in long term unemployment. Secondly, the size of the Spanish informal sector has been historically close to that of the average European country.[6] Thirdly, unemployment is often found to be high in countries with large informal sectors, and in Spain it has been historically higher than in the average European country.[7] For these reasons the numerical analysis is pertinent not only for developed economies that provide UP, but also for developing countries considering its introduction.

Our main finding is that informality and unemployment can be simultaneously reduced by *redistributing*, rather than *increasing*, existing UP funds. We identify two channels that achieve this outcome. The first works across workers within the UI programme. Since UI payments are proportional to previous earnings, higher-skilled recipients tend to receive more each month than lower-skilled. For this reason higher-skilled recipients tend to accept informal work less often than lower-skilled workers. Thus, reducing higher-skilled recipients'

[4] See time use surveys of, e.g.,Krueger and Mueller [2011, 2012].

[5] See, e.g., Kroft et al. [2013] for the US; Bover et al. [2002] for Spain.

[6] According to Schneider [2013] and Medina and Schneider [2018] the average informal sector size as a proportion to GDP in Spain and Europe were 18.6 and 18.1, respectively, during 2003-2017.

[7] Based on the OECD Economic Outlook 108 ed. 2020/2, the unemployment rate averaged 16.9 and 8.5% in Spain and Europe, respectively, during 2003-2017.

payments slightly and using the savings to increase payments for lower-skilled recipients does reduce the overall dependence of unemployed on informal income, enabling greater effort on formal job search. The second channel works across programmes, redistributing existing UP funds from more generous programmes, such as UI, to less generous ones, such as UA. The intuition is similar. Whilst lowering UI payments does increase informal work and reduce job search among UI recipients, this is more than compensated for by the reduction in informal work and increased job search among recipients. For this reasons, redistributing benefits from UI to recipients can reduce informality and unemployment simultaneously.

1.1 Related Literature

The present paper is related to several works in the job search literature. Informal work is not the only explanation for the three features of job search dynamics described above. F1 could be due to manipulation of job start dates or rehiring to coincide with benefit exhaustion (Card and Levine 2000). F2 can be due to despondency at a lack of job offers (Krueger and Mueller 2011, 2012), social stigma (Contini and Richiardi 2012) or liquidity effects (Chetty 2008). In general, any model with dual (formal and informal) labour market implies a lower formal job search effort. F3 is often associated with human capital depreciation (Pavoni 2009). Undoubtedly, all play important roles, but none explain F1-F3 simultaneously.

The paper closest to ours is that of Álvarez-Parra and Sánchez [2009]. Like us, they use a partial equilibrium framework to consider the interaction between unemployment insurance and informal work and, like us, they calibrate their model to Spain. However, there are three important differences that distinguish our contribution from theirs. Firstly, we consider *any* finite-duration, constant payment UP system with uncertainty about sanctions and informal income. Their paper considers instead a particular UP system – the optimal one – and does not account for sanctions and uncertainty about informal earnings. As a result, the deterrence and exhaustion effects are new to our model, helping to reconcile the qualitative predictions with F1-F3, without requiring workers not to take informal jobs during unemployment spells as under the optimal contract. Secondly, their numerical analysis is normative, deriving the optimal UI schedule, whereas ours is positive, considering the entire range of existing UI, and SA programmes. Their optimal UI scheme features benefits that are sufficiently generous to crowd-out all informal work, such that the unemployed only work informally after benefit exhaustion. In contrast, in our model, unemployed can work informally even when they receive UP payments as typically observed across labour markets.[8] Thirdly, Álvarez-Parra and Sánchez [2009] consider a representative worker in their numerical analysis, whereas we allow for skill heterogeneity among workers. This highlights the potential for cross-sectional redistribution in our numerical analysis, a further novel contribution

[8] See, e.g., Fuller et al. [2015] for evidence on informal work among UP recipients in the US.

of our paper. The results relating to cross-programme redistributions are consistent with the optimal UI scheme that requires constant rather than declining benefit payments, and further suggest that the typical UP system in developed countries is suboptimal once accounting for informality.

The present paper belongs to the broader literature that employs job search models to study labour market dynamics over the duration of unemployment under either the actual UP system (Lalive et al. 2006, Chetty 2008) or the optimal UP system (Shavell and Weiss 1979, Hopenhayn and Nicolini 1997, Pavoni and Violante 2007). For optimal UP systems the impact of informality has been studied using both static and dynamic models (Álvarez-Parra and Sánchez 2009, Espino and Sánchez 2015). For actual UP systems, informality has been studied only using static models (Bardey et al. 2015). To the best of our knowledge, this paper is the first that studies informality under the actual UP system using a dynamic framework.[9] As a result, the present paper complements existing analyses by quantifying how informal sector participation varies over time, its cross-sectional distribution over benefit programmes and earnings, and the effect of policy measures that target specific components of an existing UP system.

There is also a growing literature employing general equilibrium models to study labour market flows and policy intervention in developing countries with large informal sectors (Albrecht et al. 2009, Bosch and Esteban-Pretel 2015, Meghir et al. 2015, Di Porto et al. 2017). These models account for the whole informal sector in the economy, but, owing to the added complexity of a general equilibrium environment, only assess the effect of changing the overall level of (assumed constant) unemployment benefits on the labour market. The objective of our paper is to study how job search and informal participation are influenced by the UP structure over the duration of unemployment. It would be intractable to investigate these questions in a general equilibrium model (Rogerson et al. 2005). Our analysis focuses only on a segment of the informal sector (unemployed workers) and takes wages as given but, like similar works, complements this literature by highlighting that the distribution of benefit payments across UP programmes, workers and time, as well as their level, is an important determinant of labour market outcomes.

Our approach to modelling informality is very different from the general equilibrium models mentioned above. This reflects a difference in focus. In developing countries, informal work often refers to permanent employment, modelled as a joint decision between workers and firms on whether to declare a job. As illustrated in Figure 1 and long highlighted by survey evidence, informal work in developed countries is often a lot less structured, perhaps due to better monitoring, and mostly consists of temporary work such as babysitting, cleaning, decorating, helping to move house, etc.[10] Consequently, we capture

[9] The informal sector is not the only source of distortion to workers' decisions. Long and Polito [2014] study optimal UI when unemployed workers can engage in property crime. Mesén Vargas and Van Der Linden [2017] derive sufficient statistics for optimal UI payments when unemployed workers engage in subsistence activities, as opposed to informal work.

[10] See, e.g., European Commission 2014, Williams 2014, Williams and Horodnic 2018.

informal work as a sequence of random, frictionless opportunities that unemployed workers can choose to accept or reject.

An important question is whether informal jobs are similar or different to formal jobs. While there is little evidence on this, the existing empirical literature has long highlighted two key dimensions that distinguish informal work from formal work: it is less remunerative and more precarious. In most recent analyses of informal work, the ratio between informal and formal wage is always less than one; and the job separation rate in the informal sector is typically higher than in the formal sector (see, for example, Boeri and Garibaldi 2007, Fugazza and Jacques 2004, Albrecht et al. 2009, Charlot et al. 2015, Bosch and Esteban-Pretel 2015 and Di Porto et al. 2017). Further, as in most of the recent literature, our model is consistent with the view that the informal sector offers unregulated work opportunities that workers voluntary take while waiting for formal employment.

The labour literature has long argued that it is difficult to reduce informality by increasing monitoring without incurring the cost of higher unemployment. This is because the increase in audit costs resulting from greater monitoring need to be financed by increased payroll taxation, which reduces formal sector employment (see Fugazza and Jacques 2004, Albrecht et al. 2009 and Bosch and Esteban-Pretel 2015). Boeri and Garibaldi [2007] however highlight that an increase in aggregate productivity can reduce both informality and unemployment. Ulyssea [2010] and Charlot et al. [2015] show that this outcome is achieved by labour market policies that reduce business entry costs. More recently, Di Porto et al. [2017] show that informality and unemployment can be reduced simultaneously by using fiscal-monitoring policy mixes that trade off the incentives of workers with different productivity and contracts (for example stepping up monitoring for the low productive informal sector while financing the higher cost with higher payroll taxation high productive workers on permanent contracts). Our paper adds to this literature, highlighting the scope for joint reduction of informality and unemployment through a new channel, the budget-neutral redistribution of existing benefits.

The paper proceeds as follows. Section 2 describes the economic environment. Section 3 derives the payment, deterrence and exhaustion effects. Section 4 describes the quantitative model, the baseline calibration and evaluates its robustness along several dimensions. Sections 5 illustrates the model dynamics under the baseline calibration. Section 6 present the results of the policy experiments. Section 7 concludes. Additional supporting information is included in Appendices at the end of the article.

2 Economic environment

The environment consists of a discrete-time search model with temporary UP and two labour markets: formal and informal. An infinitely-lived, risk averse representative worker becomes unemployed in period $t = 1$. For $t = 1, ..., T$, she

is covered by UI, and receives payments of $b_t = b^{ui} > 0$. b^{ui} can either be a flat payment, or a proportion, rr^{ui}, of pre-unemployment wages. If the worker is still unemployed after the date of exhaustion T, she receives no further payments, $b_t = 0$. We abstract from UA and SA only to ease explanation, without any loss of generality. The worker has no savings and cannot borrow.[11]

All formal jobs are identical and provide after-tax wage w, which is assumed sufficiently high that offers of formal employment are always accepted. Formal employment can terminate in every period at the exogenous job destruction rate λ.

While unemployed, the worker receives an offer of informal work – an *informal opportunity* – providing her with income χ_t. Informal opportunities last for one period, and are independent and identically distributed according to $F(\chi)$, capturing the temporary nature of informal work, as described in the Introduction. Our specification of informal opportunities also includes a constant informal sector wage as a special case, when $F(\chi)$ is degenerate.

To characterise the choices of unemployed workers as they pass through UP, we make formal and informal work mutually exclusive (as in Albrecht et al. 2009, Espino and Sánchez 2015). Allowing employed agents to also work in the informal sector would not qualitatively affect our results.

The unemployed worker makes three decisions each period. First, she chooses whether to accept or reject her current informal opportunity (denoted by $a_t = 1$ and $a_t = 0$ respectively). Accepting informal work provides higher income, $b_t + \chi_t$, but requires costly effort described below. Second, she chooses her formal job-finding probability, p_t, incurring an effort cost.[12] Third, if the worker is part of the UI programme, she decides whether to remain in ($x_t = 0$) or voluntarily exit ($x_t = 1$).[13] Accepting informal work whilst receiving UI constitutes fraudulent behaviour. If the worker remains in the programme, she risks her informal work being detected and thus facing sanctions. Her perceived probability of detection is denoted by $\delta > 0$. Whilst the exact structure of sanctions is specified in the quantitative analysis of Section 4, for the theoretical results it is sufficient that it involves exclusion from UI.

The worker chooses $\{a_t, p_t, x_t\}_{t=1}^{\infty}$ to maximise her expected lifetime utility:

$$\mathbb{E}\left\{ \sum_{t=1}^{\infty} \beta^{t-1} \left[u(y_t) - c(a_t, p_t) \right] \middle| \chi_t \right\}, \tag{1}$$

where $\mathbb{E}$ is the expectation over informal opportunities and employment states, β is the discount factor and y_t is income, defined as $y_t = b_t + a_t\chi_t$ if receiving

[11] The literature on UP and informal work cited in the Introduction typically assumes that benefit recipients have no access to saving or credit on the grounds that they come from low-income households (Albrecht et al. 2009, Bosch and Esteban-Pretel 2012).

[12] Endogenising the worker's job-finding rate captures the same decision as allowing the worker to draw offers from a formal labour market wage distribution. An increase in p_t is equivalent to a reduction in her reservation wage. We will refer to p_t and search effort interchangeably.

[13] The decision of voluntarily exit yields negligible quantitative effects. This is described in more details in Appendix B.

benefits and working informally, $y_t = a_t\chi_t$ if working informally while not receiving benefits, or $y_t = w$ if employed. Each period, the worker derives utility from consuming her income, $u(y_t)$. Utility exhibits positive but diminishing marginal returns. She also incurs an additively separable effort cost, $c(a_t, p_t)$, jointly dependent upon her informal work and formal job-finding rate. $c(a_t, p_t)$ is assumed to be both increasing and convex in p_t (as, for example, in Chetty 2008) and increasing in a_t.

No search effort is required to generate informal opportunities and working in the informal sector crowds out job search.[14] The marginal cost of p_t increases when $a_t = 1$, introducing a trade-off between formal job search and informal work for the worker. In principle, working in the informal sector could be a stepping-stone towards finding formal employment. Whilst our quantitative analysis does not preclude this possibility, our calibration suggests that crowding-out effects dominate. A balanced social security budget is implicitly accounted for in the proposed specification of the environment since w is an after-tax wage. We do not need to model this explicitly because the worker takes the UP system and its financing as given when making her decisions.

The worker's problem, (1), can be represented as a system of four recursive Bellman equations. The first describes the value of employment, V^e, as:

$$V^e = u(w) + \beta\left[(1-\lambda)V^e + \lambda\mathbb{E}V_1^u\right]. \tag{2}$$

In equation (2), the first term on the right side is the current period utility form consuming wage income. The second term is the continuation value of employment: with probability $1-\lambda$, she keeps her job in the following period, whereas with probability λ, the job is lost and she enters the first period of unemployment. V^e is stationary, and would remain so if the model were extended to allow employed workers to accept informal work or on the job search.[15]

The second describes the value being unemployed while receiving UI and a particular informal opportunity, χ_t, $V_t^{ui}(\chi_t)$, as:

$$V_t^{ui}(\chi_t) = \max_{a_t\in\{0,1\},p_t\in[0,1]} \big\{u(b^{ui} + a_t\chi_t) - c(a_t,p_t) + \beta(1-a_t\delta)[p_tV^e + (1-p_t)\mathbb{E}V_{t+1}^u] + \beta a_t\delta[p_tV^{es} + (1-p_t)\mathbb{E}V_{t+1}^{us}]\big\}.$$

In the above, the first term on the right side is the utility from the current period consumption, which depends on the benefit payment b^{ui} and, if accepted ($a_t =$

[14] This is the same assumption made by Álvarez-Parra and Sánchez [2009]. Albrecht et al. 2009 go further by assuming that informal work entirely precludes job search.

[15] As in Álvarez-Parra and Sánchez [2009], we rule out on-the-job search as it would only alter the stationary value of employment, with no qualitative effects on the worker's incentives whilst unemployed. Assuming that (i) on-the-job search is costless, (ii) new jobs are accepted only when they pay a higher wage, and (iii) the job separation rate is invariant to change in formal employment, then the value of employment with on-the-job search, say V^{e*}, cannot be lower than without, i.e. $V^{e*} \geq V^e$. Bosch and Esteban-Pretel [2015] calibrate the search efficiency of those in employment to be 80% lower than that of unemployed. For this reason, on-the-job search is not quantitatively significant. We simulate the quantitative effects of on-the-job search for robustness and comment on these results in Appendix F.

1), income from the informal opportunity χ_t. The second term is the effort cost required to search for a formal job, which generates a new offer with probability p_t. The remaining terms measure the continuation value of unemployment for those receiving UI. Accepting informal work ($a_t = 1$) whilst in receipt of UI may trigger a sanction with probability δ. If undetected, with probability $1-a_t\delta$, the continuation value depends on whether the worker finds a job and receives V^e with probability p, or remains unemployed with probability $1-p$, receiving the expected value of future unemployment, $\mathbb{E}V^u_{t+1}$. If detected, with probability $a_t\delta$, the worker is sanctioned. As this does not prevent the worker from accepting a formal job offer, the continuation value from being sanctioned depends on whether she enters formal employment, V^{es}, or remains unemployed, V^{us}. The theoretical results do not rely on any particular specification of sanctions. This is postponed to Section 4.1 for the case of Spain. Thus the model solution nests a broad range of possible sanction regimes. For the moment, it is sufficient that sanctions involve exclusion from UP. Since UP is the only source of non-stationarity in the model, the continuation value of being sanctioned is constant. As in many dynamic models of the informal sector (e.g. Fugazza and Jacques 2004, Boeri and Garibaldi 2007), she is either caught immediately or her informal work goes undetected.

The third recursive Bellman equation describes the value of being unemployed outside of the UP programme, $V^{out}(\chi_t)$, as:

$$V^{out}(\chi_t) = \max_{a_t\in\{0,1\},p_t\in[0,1]} \left\{u(a_t\chi_t) - c(a_t,p_t) + \beta[p_tV^e + (1-p_t)\mathbb{E}V^{out}]\right\}. \tag{4}$$

This has a similar interpretation to (3), but the worker receives no UI payments and faces no sanctions. Clearly, V^{out} is stationary. To derive meaningful results, we require that, *ex post*, the worker would always have preferred to either reject an opportunity or exit UI to accept it: $V^{es} < V^e$ and $V^{us} < \mathbb{E}V^{out}$.

The fourth recursive equations describes the expected value of unemployment, $\mathbb{E}V^u_{t+1}$ as:

$$\mathbb{E}V^u_{t+1} = \begin{cases} \mathbb{E}\left[\max_{x_{t+1}\in\{0,1\}}\left\{(1-x_{t+1})V^{ui}_{t+1}(\chi_{t+1}) + x_{t+1}V^{out}(\chi_{t+1})\right\}\right], & t+1 \le T \\ \mathbb{E}V^{out}, & t+1 > T. \end{cases} \tag{5}$$

The above is influenced by the temporary nature of UI payments. Suppose the worker is in the UI in period $t < T$. In $t+1 \le T$, she receives informal opportunity χ_{t+1} and then decides whether to exit, choosing between $V^{ui}_{t+1}(\chi_{t+1})$ and $V^{out}(\chi_{t+1})$. If $t = T$ then her UI payments are exhausted and she is automatically outside UP.

Summarising, the timing is as follows. Each period of unemployment begins with the worker receiving an informal opportunity that yields income $\chi_t \sim i.i.d.F(\chi)$. The worker decides whether to accept the opportunity (a_t), her formal job-finding probability (p_t) and whether to exit the UI programme (x_t). She then transitions to the next period, learning whether she has received a

formal employment offer and whether she faces any sanctions if she accepted informal work.

3 Worker decisions

We describe the decisions of the worker over the duration of unemployment, considering choices whilst receiving UI, once benefits are exhausted and at the date of leaving UI.[16]

3.1 Decisions under UI

During UI, the worker makes three decisions every period: whether to accept her current informal income opportunity, her job-finding rate, and whether to exit UI to accept informal work without facing sanctions. Since the latter requires an understanding of the worker's indirect utility outside the programme, its discussion is left until Section 3.3. We will instead proceed under the assumption that the worker chooses to remain in the UI.

The worker's optimal *conditional job-finding rate* $p_t^{ui}(a_t)$, taking a_t as given, satisfies:

$$\beta\left[(1-a_t\delta)\left(V^e-\mathbb{E}V_{t+1}^u\right)+a_t\delta\left(V^{es}-V^{us}\right)\right]=c_p\left[a_t,p_t^{ui}(a_t)\right], \qquad (6)$$

where $c_p(a,p)=\partial c/\partial p$ is the marginal cost of search. By searching more intensively, the worker increases the probability that she gets a formal job offer. If she is not detected working in the informal sector (with probability $1-a_t\delta$), she starts work in the following period, increasing her lifetime utility from $\mathbb{E}V_{t+1}^u$ to V^e. If she is detected and sanctioned (with probability $a_t\delta$) she still starts her job, increasing her lifetime utility from V^{us} to V^{es}. The novel feature in equation (6), compared to similar conditions in existing job search models with informal sector, is that it captures the intertemporal effects of sanctions on the value of finding a jobs, through δ, V^{es}, V^{us}.

Note that, if $V^{es}-V^{us}>V^e-\mathbb{E}V_{t+1}^u$, the marginal benefit of search is higher when the worker accepts informal work, as the worker wishes to insure themselves against harsher sanctions.

Searching more intensively requires additional effort. If the worker accepts informal work then her marginal cost is higher still, consistent with the crowding out of job search.

That both the marginal benefit and marginal cost of search potentially increase when the worker accepts informal work leads to ambiguous theoretical results. To avoid this, we will occasionally assume that the worker's conditional job-finding rate is lower whenever she accepts informal work:[17]

$$\beta\delta\left(V^{es}-V^{us}\right)<c_p(1,0)-c_p(0,0). \qquad (7)$$

[16] Proofs of all analytical results are in Appendix C.

[17] This assumption is also made by Álvarez-Parra and Sánchez 2009, Mesén Vargas and Van Der Linden 2017).

Whilst our quantitative analysis in Section 4 does not impose this assumption, we find that $p_t^{ui}(1) < p_t^{ui}(0)$ in the calibrated model.

Turning to informal sector participation, the worker accepts informal work if and only if:

$$\begin{aligned} u(b^{ui} + \chi_t) - c\left[1, p_t^{ui}(1)\right] + \beta(1-\delta)\left\{p_t^{ui}(1)V^e + \left[1 - p_t^{ui}(1)\right]\mathbb{E}V_{t+1}^u\right\} \\ +\beta\delta\left\{p_t^{ui}(1)V^{es} + [1 - p_t^{ui}(1)]V^{us}\right\} \\ \geq u(b^{ui}) - c\left[0, p_t^{ui}(0)\right] + \beta\left\{p_t^{ui}(0)V^e + \left[1 - p_t^{ui}(0)\right]\mathbb{E}V_{t+1}^u\right\} \quad (8) \\ \iff \chi_t \geq \chi_t^{ui}. \quad (9) \end{aligned}$$

Whilst accepting informal work enables the worker to enjoy higher instantaneous utility from consumption, it increases her marginal cost of effort. She generates a formal job offer with a lower probability, reducing her expected future payoff. She also faces the risk of sanctions. She therefore only accepts informal income opportunities that provide a sufficiently large increase in instantaneous consumption to compensate for these adverse effects. There exists a *reservation informal opportunity* in each period, χ_t^{ui}, such that she accepts χ_t if and only if $\chi_t \geq \chi_t^{ui}$.

Equation (6) and inequality (9) jointly solve the worker's problem inside the UI programme. In each period, t, she accepts a proportion $1 - F(\chi_t^{ui})$ of informal opportunities. If she accepts informal work, she generates a formal job offer with probability $p_t^{ui}(1)$. Otherwise, she generates an offer with probability $p_t^{ui}(0)$. Her overall, *unconditional job-finding rate* is:

$$p_t^{ui} = [1 - F(\chi_t^{ui})]p_t^{ui}(1) + F(\chi_t^{ui})p_t^{ui}(0). \quad (10)$$

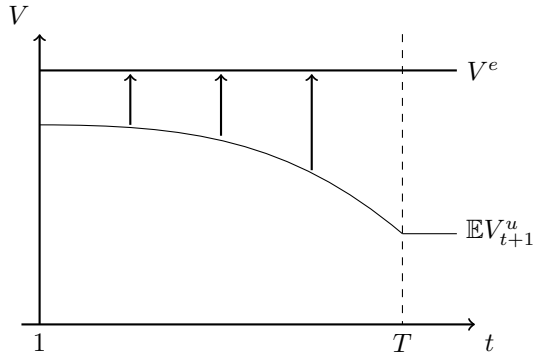
A greater willingness to accept informal work (a reduction in χ_t^{ui}) lowers the probability that the worker will find formal work, by increasing the weighting on $p_t^{ui}(1)$. This is how the present model explains F2, i.e. that job search effort is lower than the canonical model predicts in every period of unemployment.

We now consider how the worker's job search and informal sector participation vary over the duration of the UI programme. With finite UI, the prospect of remaining unemployed is less appealing over time, since with each passing period of unemployment workers have one fewer UI payment remaining before exhaustion. Thus the continuation value of remaining unemployed, $\mathbb{E}V_{t+1}^u$, is declining, even though the worker's instantaneous UI payment remains constant. This well-known feature of temporary UI introduces non-stationarity into the worker's decision-making. To analyse its effects, first we consider the worker's conditional job-finding rates, i.e. her choice of $p_t^{ui}(a_t)$ given $a_t = 0$ and $a_t = 1$. Second, we evaluate which informal opportunities she accepts. Finally, we combine these results infer about her unconditional job-finding rate.

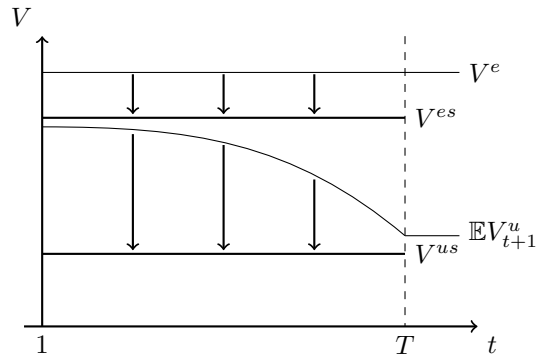
The declining $\mathbb{E}V_{t+1}^u$ implies that the conditional job-finding rates increase over the duration of UI:

Lemma 1 (Increasing job-finding rate) *For each $a_t \in \{0, 1\}$, the worker's conditional job-finding rate, $p_t^{ui}(a_t)$, is strictly increasing over the duration of the UI programme.*

Figure 2: The effects of non-stationarity



(a) Gain from employment



(b) Loss from detection

The lemma is stated without proof.[18] It is illustrated by Panel (a) of Figure 2, which shows both the stationary V^e, and the non-stationary $\mathbb{E}V^u_{t+1}$. Receiving a formal job offer causes the worker's lifetime utility to immediately increase from $\mathbb{E}V^u_{t+1}$ to V^e. Her gain from finding formal employment is thus the gap $V^e - \mathbb{E}V^u_{t+1}$. As $\mathbb{E}V^u_{t+1}$ declines, this gain increases. The marginal benefit of job search gets larger over time, resulting in higher conditional job-finding rates.

This non-stationarity causes informal participation to evolve over the duration of UI. $\mathbb{E}V^u_{t+1}$ features in both sides of inequality (9), which determines the worker's reservation informal opportunity. There are consequently two opposing effects.

We refer to the first as the *exhaustion effect*. It is entirely due to the exhaustion of UI payments, and can also be seen with reference to Panel (a) of Figure 2. When the worker accepts informal work, her conditional job-finding rate falls from $p^{ui}_t(0)$ to $p^{ui}_t(1)$. Part of the opportunity cost of informal work is thus foregoing the greater chance of enjoying the gain from formal employment. During the early stages of UI, this opportunity cost is relatively small as $\mathbb{E}V^u_{t+1}$ is high. The worker is thus willing to accept relatively small informal opportunities. As the duration of her unemployment increases, however, the worker has fewer future UI payments remaining. The gap $V^e - \mathbb{E}V^u_{t+1}$ increases, making her less willing to accept informal work.

The second, the *deterrence effect* derives from the presence of sanctions. This is illustrated by Panel (b) Figure 2. If the worker accepts informal work and is subsequently detected, sanctions cause her continuation value to jump either from V^e to V^{es} or from $\mathbb{E}V^u_{t+1}$ to V^{us} depending on whether her job search is successful. The utility loss from detection when the worker simultaneously receives a formal offer, $V^e - \mathbb{E}V^u_{t+1}$, is constant. However, the loss when the worker remains formally unemployed declines over the duration of UI receipt (the gap between $\mathbb{E}V^u_{t+1}$ and V^{us}). Intuitively, during the first few periods of unemployment, the worker risks a lot by accepting informal work. She has a lot of future UI payments to look forward to, and would lose them all if she were detected and failed to secure a formal job. She only accepts very profitable opportunities, as they sufficiently compensate her for this risk. Over time she has less to lose, making her more willing to accept informal work.

The dynamic evolution of informal sector participation depends upon whether the exhaustion or deterrence effect dominates. With a low (high) perceived probability of detection, the exhaustion (deterrence) effect dominates and informal sector participation declines (increases) during UP. This compounds (offsets) the increase in job-finding as exhaustion approaches.[19] The practical implication of this result is that the model is flexible enough to replicate F3, namely that the job-finding rate declines over the duration of unemployment.

[18] This result was first stated by Mortensen [1977]. A large literature has followed since. See, e.g., Lentz and Tranæs [2005], Card et al. [2007b], Chetty [2008].

[19] These results are shown analytically in Appendix B.

3.2 Decisions outside UI

If the worker exhausts UI her problem is stationary. She has two decisions: her job-finding probability in the formal sector and whether she accepts her current informal income opportunity. Taking a_t as given, her optimal conditional job-finding rate, $p^{out}(a_t)$, satisfies:

$$\beta\left(V^e - \mathbb{E}V^{out}\right) = c_p\left[a_t, p^{out}(a_t)\right]. \tag{11}$$

The intuition is very similar to that of (6). The marginal benefit of search derives from the utility gain associated with formal employment, $V^e - \mathbb{E}V^{out}$.

The decision to undertake informal work similarly depends upon her likelihood of receiving a formal job offer. She will accept χ_t if and only if it offers a higher discounted utility:

$$\begin{aligned} &u(\chi_t) - c\left[1, p^{out}(1)\right] + \beta\left\{p^{out}(1)V^e + \left[1 - p^{out}(1)\right]\mathbb{E}V^{out}\right\} \\ &\quad \geq u(0) - c\left[0, p^{out}(0)\right] + \beta\left\{p^{out}(0)V^e + \left[1 - p^{out}(0)\right]\mathbb{E}V^{out}\right\} \qquad (12) \\ &\iff \chi_t \geq \chi^{out}. \qquad (13) \end{aligned}$$

As in (9), the worker only accepts informal opportunities above a reservation level, χ^{out}. In this case, however, the opportunity must only compensate the worker for the lower conditional job-finding probability associated with informal work.

Equation (11) and inequality (13) jointly solve the worker's problem outside the UI programme. She accepts a proportion $1-F(\chi^{out})$ informal opportunities, and finds a job with an average, unconditional job-finding rate:

$$p^{out} = \left[1 - F(\chi^{out})\right]p^{out}(1) + F(\chi^{out})p^{out}(0). \tag{14}$$

3.3 Leaving UI

The worker can leave UI for two main reasons. She might have reached benefit exhaustion or be detected working in the informal sector. Regardless of the reason, leaving alters the worker's incentive to accept informal work. She now no longer receives UI payments. This makes informal opportunities more valuable:

Proposition 1 (Payment effect) *If the worker is still formally unemployed after her UI payments are exhausted, her informal sector participation strictly increases:*

$$1 - F\left(\chi_T^{ui}\right) < 1 - F\left(\chi^{out}\right).$$

The worker is subject to diminishing marginal utility: $u''(y_t) < 0$. As she no longer receives UI payments, her marginal utility of consumption thus increases. A given informal opportunity provides her with greater utility, helping to compensate for a lower conditional job-finding rate. Her willingness to accept informal work strictly increases immediately after leaving. As this result is driven by the level of UI payments, we call it the *payment effect*. We observe

that it would hold even if the worker enters or SA, so long as benefit payments decline.

Accepting more informal opportunities, of course, comes at a cost. It is more difficult to search for a formal job:

Corollary 1 (Job-finding after leaving) *The worker's unconditional job-finding rate may decrease after leaving the UI programme.*

Conditional on informal work, the worker's job-finding rates are higher outside the programme than inside: $p^{out}(0) \geq p_t^{ui}(0)$ and $p^{out}(1) > p_t^{ui}(1)$ for all $t \leq T$. Without UI payments, the marginal benefit of search has increased in (11) relative to (6). This is driven by the standard *moral hazard effect* arising in the canonical model. However, the worker undertakes more informal work. She is thus more likely to choose the job-finding rate $p^{out}(1) < p^{out}(0)$. As (14) makes clear, this has the potential to lower her unconditional job-finding rate outside of the UI scheme.

In the final period of UI receipt, $p_T^{ui}(0) = p^{out}(0)$ and $p_T^{ui}(1) \cong p^{out}(1)$. The payment effect thus results in a fall in the unconditional job-finding rate. This enables the model to replicate F1: once informal opportunities are accounted for, the re-employment spike is no longer a permanent phenomenon.

In the canonical model, the worker leaves UI before she exhausts benefits only if she finds a formal job. In our model, the worker may also leave without having found a job for two reasons. She may be detected working informally and excluded from the scheme (with probability $\delta[1 - F(\chi_t^{ui})] > 0$ in each period).

In summary, informal sector participation and formal job search are subject to non-stationary and opposite effects over the duration of unemployment. In particular, the relative importance of the payment versus the moral-hazard effect is mainly driven by the level of benefits and changes as workers move across different programmes while being unemployed. Whether the exhaustion or the deterrence effect dominate ultimately depends on the detection probability and sanctions. The relative magnitude of these effects and their ultimate impact on workers' decisions can only be ascertain quantitatively. We undertake this task in the next section.

4 Quantitative analysis

For the quantitative analysis, the model is extended to account for three salient features of the labour market in a developed economy: the full structure of UI, and SA programmes over the duration of unemployment; the type of sanctions for being caught working informally; worker skill heterogeneity (by varying re-employment earnings). The enriched model quantifies endogenously how informality is concentrated (i) over the duration of unemployment, (ii) across different social security programmes and (iii) across wage brackets. In particular, the skill heterogeneity allows us to capture the empirical finding that informal work tends to be concentrated among lower-skilled workers, who receive relatively low wages upon employment (ILO 2018). The model calibration is based

on data for Spain, as motivated in the Introduction. The algorithm to derive the aggregate equilibrium is described in Appendix D.

4.1 Functional forms

Instantaneous utility from consumption is CRRA with parameter σ: $u(y_t) = y_t^{1-\sigma}/(1-\sigma)$.

The effort cost of job search, $c(a_t, p_t)$ is derived in two stages, employing commonly used functional forms (see, for example, Hopenhayn and Nicolini 1997). First, suppose that the worker chooses search effort, $s_t \geq 0$. This comes at an instantaneous cost of $\hat{c}(a_t, s_t) = \frac{1+a_t\alpha}{\gamma} s_t^{\gamma}$, with $\gamma > 1$ to ensure convexity. Accepting informal work ($a_t = 1$) increases the cost of job search if and only if $\alpha > 0$. Search effort is then transformed into a job-finding probability through the search technology, $p(s_t) = 1 - \exp(-\rho s_t)$.[20]

The distribution of available informal income opportunities is log-normal, $\ln N\left(\mu, \nu^2\right)$, over a discrete grid. The probability of each opportunity is determined by rescaling the densities to ensure that they sum to one.[21]

We now need to be explicit about the continuation values of being sanctioned, V^{es} and V^{us} from (3). Recipients of Spanish UP who are caught engaging in informal work are excluded and have to repay any benefit payments to which they were not entitled [Spanish Public Employment Service, 2017a,b]. They can still accept offers of formal employment. This structure can be nested in a system of Bellman equations, outlined below. For each programme, $up \in \{ui, ua, sa\}$, let $V^{us,up}$ be the continuation value of being sanctioned without a job offer whilst being part of that programme:

$$V^{us,up}(\chi_t) = \max_{a_t, p_t} \left\{ u(a_t\chi_t) - c(a_t, p_t) + \beta \left[p_t V^{es,up} + (1-p_t)\mathbb{E}V^{us,up} \right] \right\}. \quad (15)$$

Such a worker still choose whether to accept informal opportunities and exert effort engaging in formal job search. With no benefit payments or savings, she only consumes the income she receives from accepting informal work, $a_t\chi_t$. Her job search cost is $c(a_t, p_t)$, as before. Transitioning to the next period, she generates a job offer with probability p_t, receiving continuation payment $V^{es,up}$, described below. Otherwise, with probability $1 - p_t$, she remains unemployed and sanctioned, receiving $\mathbb{E}V^{us,up}$ on average.

Upon accepting a formal job offer, a sanctioned worker receives:

$$V^{es,up} = u\left(w - b^{up} - \phi b^{up}\right) + \beta\zeta[\lambda\mathbb{E}V_1^u + (1-\lambda)V^e] + \beta(1-\zeta)[\lambda\mathbb{E}V^{u,inelig} + (1-\lambda)V^{e,inelig}]. \quad (16)$$

[20] Skill heterogeneity opens the possibility that low skilled workers, who receive lower wage offers, are also intrinsically less capable of finding a job; that their γ, α and ρ are different from high skilled workers. While allowing for this has no qualitative effects on the policy predictions of our analysis, it may help sharpening the quantitative results. We discuss this further in Appendix I.

[21] For robustness, we also calibrated the model using an exponential distributions. This yielded very similar results.

In the first period of re-employment, she earns a wage, w, but are required to repay the benefit payment to which she was not entitled b^{up}. We also allow for the possibility that she pays an additional fine. In countries where fines are used, they are usually a proportion ϕ of the repayment. This leaves the worker with a net income of $w - b^{up} - \phi b^{up}$ for consumption.

Having repaid, the worker still endures a period of ineligibility for UP. To avoid introducing further non-stationarity into the model, we assume that this period ends stochastically. Transitioning to the next period, with probability ζ the worker requalifies for UP. If she simultaneously becomes unemployed, she entering UP and receives $\mathbb{E}V_1^u$ defined by (3). If she keeps her job, she receives V^e defined by (4). Otherwise, with probability $1-\zeta$, she remains ineligible and, depending on whether she maintains her job, receives:

$$V^{e,inelig} = u(w)+\beta\zeta[\lambda\mathbb{E}V_1^u+(1-\lambda)V^e]+\beta(1-\zeta)[\lambda\mathbb{E}V^{u,inelig}+(1-\lambda)V^{e,inelig}],$$

or:

$$V^{u,inelig}(\chi_t) = \max_{a_t,p_t}\left(u(a_t\chi_t) - c(a_t,p_t) + \beta\left\{p_t\left[\zeta V^e + (1-\zeta)V^{e,inelig}\right] + (1-p_t)\mathbb{E}V^{u,inelig}\right\}\right).$$

If she does keep her job, she receives $V^{e,inelig}$. This is identical to $V^{es,up}$, except for the fact that the worker has already repaid her benefit payment, along with any fine, and so can consume her entire wage. If she becomes unemployed, she receives $V^{u,inelig}$. This is similar to V^{out}, given by (4), but allows that she may not be eligible for UP if she receives another job offer, thereby receiving $V^{e,inelig}$ rather than V^e.

4.2 Calibration

The model is calibrated on a monthly basis. Data on informal income earned by unemployed workers comes from European Commission [2014], which refers to 2013. Given this and for consistency, the remaining model parameters and moments are calibrated to this year. Table E.1 in Appendix E reports the parameter values for which data is available and their sources.

Three behavioural parameters are calibrated using data from Álvarez-Parra and Sánchez [2009]: the discount factor is $\beta = 0.994$, the coefficient of relative risk aversion is $\sigma = 2$ and the effort cost parameter is $\gamma = 2$.

To account for skill heterogeneity, and its impact upon UI payments, we segment the formal labour market by wages (as in Uren 2018). Formal wages are measured using data on wage deciles in 2013 from the Instituto Nacional de Estadística. We consolidate the available empirical wage distribution into quintiles and normalise the average wage to 100. This yields five wages: $w^j \in \{32.81, 64.79,\ 85.78, 116.20, 200.38\}$. As noted above, we interpret these wage differential as reflecting differences in productivity among workers. Alternatively, they can also be interpreted as reflecting sectoral heterogeneity. The job-destruction rate λ is set equal to 0.0153 based on the average job-destruction rate in Spain in 2013 (European Commission).

Informal opportunities are drawn from a grid of 200 equally-spaced values centred around the average formal sector wage. Using a larger grid has little effect, as the additional opportunities are received with a very low probability.

Sanctions are calibrated using data from Spanish Public Employment Service [2017a,b]. Those caught accepting informal work lose eligibility for UP for a maximum of twelve months, are required to repay undue benefits, but are not subject to fines. We therefore set the eligibility rate $\zeta = 0.0833$ $(= 1/12)$, and the fine rate $\phi = 0$. Whilst the Spanish system allows for partial repayments, we assume that the UP payment is always returned in full for tractability of the numerical algorithm.[22]

According to the OECD [2014a], the Spanish UP system consists of two programmes, UI and UA, with maximum duration of 24 and 18 months, respectively. UI is not mean-tested and provides payments at a replacement ratio of $rr_1^{ui} = 70\%$ of pre-unemployment earnings for the first six months, reducing to $rr_2^{ui} = 50\%$ afterwords. There is no waiting period. We assume that pre-employment earnings match the wage, w^j, received by a worker when re-employed. The payment is subject to maximum, $\overline{b}^{ui}$, and minimum, $\underline{b}^{ui}$, limits that depend upon the family composition of the recipient. The UI recipient's payment is thus:

$$b_k^{ui,j} = \begin{cases} \underline{b}^{ui}, & rr_k^{ui} w^j < \underline{b}^{ui} \\ rr_k^{ui} w^j, & \underline{b}^{ui} \leq rr_k^{ui} w^j < \overline{b}^{ui} \\ \overline{b}^{ui}, & rr_k^{ui} w^j \geq \overline{b}^{ui} \end{cases}$$

for $j = 1, ..., 5$ and $k = 1, 2$. Using as reference the figures for single individuals, UI payments are bounded between 497€ and 1087.20€ per month. As we normalise the average formal wage to 100, we set $\overline{b}^{ui} = 51.25$, $\underline{b}^{ui} = 23.43$. Thus UI payments are equal to $\underline{b}^{ui}$ for the first wage quintile, 45.35 for the second and $\overline{b}^{ui}$ for the remaining quintiles.

After exhausting UI, the worker receives UA. This pays a flat amount, b^{ua}, measured as 80% of the *Indicador Público de Renta de Efectos Múltiples* (IPREM). The IPREM in 2013 is 532.51€ per month. Normalising, $b^{ua} = 20.08$. In general, the duration of UA is 6 months, so we set $T^{ua} = 6$.[23] The SA programme, known as *Renta Mínima de Inserción* (MII), provides recipients

[22] Partial UP – reductions in benefits following declaration of paid work – is designed to encourage reporting of waged- or self-employment. Excluding these from the quantitative model is equivalent to assuming that the bureaucratic cost of declaring temporary jobs while unemployed exceeds the benefit for the worker. Incorporating partial UP would involve keeping track of 597 additional states, as the amount a worker caught engaging in informal work would need to repay would depend upon both her benefits history and informal opportunities accepted.

[23] UA is means-tested, but the condition to receive the benefit is that there are no individual earnings in the family over 75 per cent of the minimum wage. As for UI, our calibration is based on the assumption that recipients are single individuals. In some cases, this may be extended beyond six months depending on the contribution history and family composition of the claimant.

with a subsistence income. Upon exhausting UA, workers move into SA, receiving b^{sa} until they find a formal job. According to the OECD [2014a], the average monthly payment of the MII is 327.71€. We normalise this to $b^{sa} = 15.44$.

The remaining eleven parameters, see Table E.2, are calibrated by matching first moments of the data. The first five refer to the population weights, ψ^j, capturing in equilibrium the wage heterogeneity observed in the data, since ψ^j is calibrated to match the corresponding quintile in the empirical wage distribution. In the data, 20% of employed workers receive each wage, w^j. Since workers who receive low wages have less incentive to find a job than those who receive higher wages, employment rates vary across quintiles. If unweighted, this would lead to an uneven distribution of employed workers in each wage bracket in equilibrium (for example, more than 20% of employed workers receiving w^5, and less than 20% of workers receiving w^1). The population weights, ψ^j, are therefore calibrated to ensure the equal distribution of workers across wage quintiles.

The other six parameters, the effective (maximum) duration of UI T^{ui}, the behavioural parameters α and ρ, the perceived detection rate δ, and the two parameters controlling the distribution of informal opportunity, μ and ν, are difficult to measure directly due to the lack of data. The maximum duration of UI in Spain depends jointly upon continuing to meet eligibility criteria and the worker's history of contributions whilst employed. However, these do not represent the average recipient's experience. There is no data on the contribution record of unemployed workers that we could use to vary the UI duration across different wage brackets. Consequently, T^{ui} measures the aggregate effective duration across all workers. There is no information available on the fraction of fraudulent UP claims, that would help identifying δ. At the same time there is no information on individual earnings from the informal sector and job finding rates by unemployment duration and informality status that would help measuring directly μ and ν.

These six parameters are jointly calibrated to minimise the sum of the squared proportional distances between six simulated and empirical aggregate moments: the unemployment rate; the total cost of UI; the coverage of UI; the coverage of UA; the informal sector income generated by the unemployed as a proportion of GDP; and the informal participation rate of the unemployed.[24] The unemployment rate is taken from OECD [2014b] while data on UI cost and coverage is from European Commission [2016]. Informal income as a percentage of GDP is calculated multiplying the informal sector size in the economy as a percentage to GDP (18.6), using data from Schneider [2013], by the share of informal sector income pertinent to unemployed as a proportion of the total informal sector income across the employed, unemployed and inactive respondents (21.5), using data in European Commission 2014.[25] Participation is measured from survey data of the European Commission (ESS ERIC 2012, 2014), as the proportion of individuals whose main activity over the week prior to the survey

[24] Appendix D provides a summary description of how the aggregate moments are calculated.

[25] This surveyed around 27,000 individuals across 27 EU countries regarding undeclared work they had done in the previous twelve months, providing details on the type and frequency of activities, as well as income earned.

Table 1: Estimated and empirical moments

Moment	Model	Empirical
Unemployment rate	25.47	26.09
UI coverage	20.36	21.17
UA coverage	18.49	19.51
UI cost	1.98	1.85
Informal income	3.83	3.99
Participation rate	17.65	17.24

Notes: Rates are reported as a percentage. Incomes and costs are reported as a percentage of GDP. See main text for the sources of the empirical moments.

was job-seeking, but who also reported paid work.

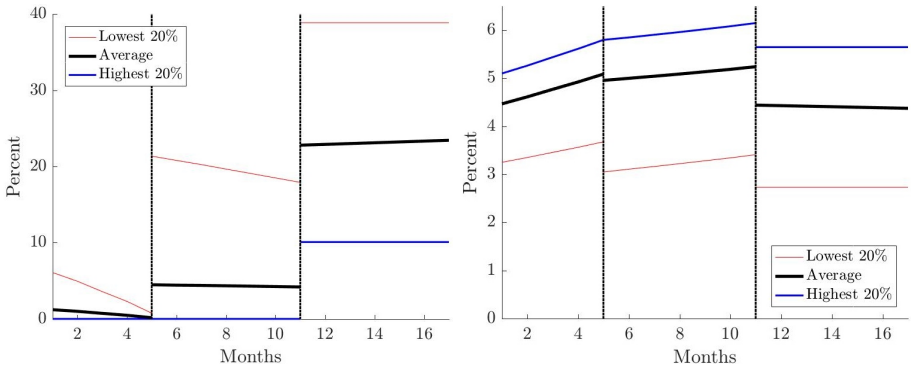
There are four observations about the parameters in Table E.2 that are worth highlighting. First, in calibrating the model, we allowed for the possibility that informal work could enhance formal job-finding, $\alpha < 0$, the so-called stepping stone effect. However, the value of α consistent with the best match of the aggregate targets is positive, $\alpha = 4.782$. This suggests that informal work significantly increases the cost of search and corroborates the assumption in (7). Second, the estimated detection rate of 0.44%, is towards the lower end of the existing range of estimates (Fugazza and Jacques 2004, Boeri and Garibaldi 2007, Bosch and Esteban-Pretel 2012, 2015, Di Porto et al. 2017). This perhaps reflects the greater difficulty of monitoring individuals engaged in temporary casual work relative to waged- or self-employment, to which existing estimates typically refer. Third, the average effective duration of UI is found to be below the statutory maximum ($T^{ui} = 5$), reflecting agents' heterogeneous employment histories and family circumstances. Thus the calibrated T^{ui} suggests that on average unemployed workers leave the UI before switch to the lower tier rate. Fourth, the estimated parameters for the informal opportunity distribution imply that, after rescaling, the mean available informal opportunity is 37% of the average wage. Álvarez-Parra and Sánchez [2009] obtain instead 41.5%, using data for Spain in 1997. In that year, the size of the informal sector as a percentage of GDP was 23% (Schneider 2013). As noted above, the size of the informal sector in Spain in 2013 had declined to 18.6%. Our lower estimate is largely driven by this change.

Table 1 presents the model's performance in matching the targeted empirical moments under the baseline calibration, which returns an overall distance of 0.012.[26]

The proposed baseline calibration is robust to a wide battery of checks,

[26]The quantitative model could be extended along several dimensions. We discuss in Appendix I some of those that we see as being most relevant, and the issues associated with their implementation.

Figure 3: Informal participation and job-finding over the duration of unemployment



(a) Informal sector participation rate (b) Formal sector job-finding rate

including: the ability of the empirical moments to identify the parameters; variation in the behavioural parameters; the sign of the cost search coefficient; the duration of informal work; the model's ability to match moments other than those directly targeted. We further investigated how labour market aggregates respond to changes in the value of employment (due for example to on-the-job search and/or severance costs) and in the job separation rate of the formal sector (due for example to labour market reforms that reduce the statutory duration of contracts and/or severance costs). Appendix F discusses these results in detail.

5 Baseline results

Figure 3 shows the dynamics of informal participation and job-finding over the duration of unemployment, for the aggregate economy (black lines) and unemployed workers in the bottom and top wage quintiles (red and blue lines, respectively).[27]

Panel (a) shows that informal sector participation for all workers increases as they switch from UI, to UA and to SA, due to the reduction in benefit payments, as in Proposition B.1 in Appendix B. Informal sector participation within each programme and across workers varies significantly. Those in the top quintile have no incentive to work informally until they reach SA. This is both because they receive relatively high levels of UP payments and their value of employment is relatively high so that accepting informal work carries an high opportunity cost. In contrast, lower-skilled workers have opposite incentives and start accepting informal work immediately upon becoming unemployed.

[27]The dynamics for the remaining quintiles are in between those for the top and bottom quintiles. Reporting them would add little to the intuition, while making the figures difficult to interpret. This additional data are available upon request from the authors.

Informal sector participation declines for these workers within UI and UA since the exhaustion effect dominates due to the low perceived detection rate (0.4%). Once in SA, informal sector participation becomes stationary, being about 4 times larger for lower-skilled workers than higher skilled.

Panel (b) shows that the unconditional job-finding rates vary significantly across programmes and workers. These are increasing during UI and UA for all workers as they all have an incentive to search more intensively as exhaustion approaches, despite the UP authority's inability to monitor search effort (moral hazard). For lower-skilled workers, the increase in job finding during any given programme is compounded by the decline in their informal participation, whereas the drop as they switch to UA is driven by corresponding jump in informal sector participation. No such a jump is observed for higher-skilled workers as they switch from UI to UA, given their informal sector participation is unchanged at this point. During SA, the reduction in benefit payment makes all workers more dependent on informal work to supplement their income, in turn increasing the marginal cost of search.

In both panels, the aggregate rates follow a similar pattern to those of lower-skilled workers because informal work tends to be concentrated towards the bottom of the wage distribution. The dynamics, however, appear much flatter than those for lower-skilled workers. Partly, this reflects the decision of higher-skilled workers to reject informal work. But it also reflects the changing identity of the representative worker. As the duration of unemployment increases, a disproportionate number of higher-skilled workers find formal jobs. As such, the proportion of lower-skilled workers in the unemployed population increases. It is for this change in the composition of the labour market over time, that during SA the average participation rate is marginally increasing and the average job finding rate is marginally decreasing.

Figure 3 also shows that the model dynamics are consistent with F1-F3. The job-finding rate tends to drops as workers transition between programmes (F1). Informal sector participation crowds out job-finding rates (F2). As higher-skilled workers leave unemployment, the average job-finding rate declines towards that of lower-skilled workers, thereby reducing over time (F3).

Table 2 reports the aggregate values for the monthly informal participation and formal job-finding rates presented in Figure 3, as well as the underlying informal/formal wage ratio, calculated as the average monthly informal income generated by workers who accept at least one opportunity within a programme normalised by the average formal wage. This is different from the mean of the available opportunities distribution described in Section 4.2, for two reasons. Firstly, it refers only to accepted opportunities, and workers reject those below a reservation level. Secondly, it averages across months where workers reject informal work.

The monthly participation rate increases over unemployment duration across programme, since the increase due to the payment effect between programmes dominates the reductions within programmes associated with the exhaustion effect, as also visible from Figure 3.

The informal/formal wage ratio declines from UI to UA, before increasing

Table 2: Informal participation, earnings, and job-finding of unemployed

	Informal participation rate	Informal/formal wage ratio	Formal job-finding rate
		Aggregate	
Average	17.65	31.00	4. 48
		By programme	
UI	0.74	66.43	4. 76
UA	4.32	25.14	5. 11
SA	25.47	26.65	4. 16

Notes: All moments are reported as% per month. To calculate the informal/formal wage ratio, we first take the average accepted informal opportunity in each programme and multiply it by the average number of accepted opportunities over the duration of a programme, conditional on a worker accepting at least one (i.e. conditional on informal participation). This gives an estimate of the total amount earned informally over the duration of the programme. We then divide this by the effective duration and the average formal wage.

slightly in SA. Whilst greater participation increases informal income, the fall in benefit payments reduces workers' reservation opportunity. When the latter effect dominates, the informal/formal wage ratio falls. Bosch and Esteban-Pretel [2015] who also find a similar result using a stationary general equilibrium model calibrated to Mexico. The intuition is very different, however, as they consider waged-informal employment and raising benefit payments enables workers to negotiate for higher wages.[28]

The aggregate job-finding rate varies non-monotonically across programmes, reflecting the temporary nature of the re-employment spike (F1) and negative duration dependence (F3).

More broadly, these results show that the model's predictions are consistent with three dimensions of informal work. It is concentrated amongst the poorest in society, the long-term unemployed, and those with little or no social security support (ILO 2016, 2018). Informal work also exacerbates differences in job-finding rates across workers. If we were to remove the informal sector from the baseline calibration, all workers' job-finding rates would increase. However, the largest increase would be for lower-skilled workers.

[28]Our estimate of the informal/formal wage ratio is lower than those typically used in developing countries (Albrecht et al. 2009), in part reflecting our model's focus on a segment of the informal sector rather than the whole. It is also lower than the informal/formal wage ratio used by Álvarez-Parra and Sánchez [2009], for the reason highlighted at the end of Section 4.2: since they have a single informal wage rather than a distribution, there is no distinction between the value of available and accepted informal work in their model.

6 Policy experiments

The results of the previous section highlight the importance of accounting for informal participation when quantifying job search incentives in economies that provide UP. In our model we can disentangle these incentives over the duration of unemployment and across wage brackets, and therefore evaluate how to exploit them to increase the effectiveness of UP provision.

The dynamics of informal participation and job search depend on the parameters determining UP, as captured by the duration (T^{ui} and T^{ua}) and the generosity of benefit payments (b^{ui} and b^{ua}). It is therefore of interest to quantify the implications of changes in these key policy parameters.

We conduct two types of experiment. First, we perform comparative statics exercises to evaluate the effects of changing duration and payment generosity qualitatively and gauge intuition. We then quantify the impact of self-financing policy changes, i.e. policies that involve reallocating resources within UP, whilst leaving its overall cost unchanged.

The comparative statics results are described in detail in Appendix G. These experiments highlight that it may be possible to simultaneously reduce unemployment and informal participation by redistributing resources within UP recipients. There are two viable channels. The first is cross-sectional, redistributing from parts of the system that disproportionately benefit higher-skilled workers, to those that benefit lower-skilled workers. The second channel is across programmes, redistributing from more generous parts of the UP system to those that are less generous. These trade off different incentives. Since higher-skilled workers tend to participate less in the informal sector, reducing UP mainly encourages them to search more intensively. In contrast, increasing the generosity of UP for lower-skilled workers reduces mainly their dependence on informal work to supplement their income. Similarly, since recipients of generous benefits have a relatively low marginal utility of income, reducing their payments does not result in particularly large increases in informal participation. In contrast, increasing payments to recipients of less generous benefits causes relatively large reductions in informal participation. As job-finding tends to be inversely related to informal participation, unemployment falls in both cases.

Despite being outside the scope of the paper, in Appendix G.1 we also study the sensitivity of labour market outcomes to changes in the three components of the sanction system, i.e. the fine rate, (ϕ), the detection rate (δ), and the re-entry rate (ζ). The results show that, in the aggregate, increasing sanctions through either of these three components typically leads to lower informal participation and higher job finding rate. The effects are larger when increasing the detection rate. The breakdown across benefit recipients suggests that fines and monitoring should concentrate on those in the early stage of UA and/or those who are not eligible for UP, as these are the groups with a larger incentive to work informally.

Table 3: Elasticities for self-financing duration changes

	Policy experiment	
	(1)	(2)
Increase in	T^{ua}	T^{ui}
Financed by a reduction in	T^{ui}	T^{ua}
Informal income	-0.100	0.163
Participation rate:	-0.103	0.182
UI	0.861	-1.076
UA	0.132	-0.165
SA	0.022	-0.004
Unemployment rate	-0.007	0.012
Average job-finding rate:		
UI	-0.025	0.037
UA	-0.050	0.069
SA	-0.015	0.016
UP coverage	0.316	-0.463

Notes: Results in the table are computed for one period increases and decreases in the duration of interest. Spline interpolation is used to calculate the necessary change in the other duration that keeps the cost of UP constant, as well as the impact of the policy change on each moment. Elasticities are then computed using the average percentage change in each moment between the two experiments.

6.1 Self-financing changes in UP provision

We estimate the impact of altering the structure of UP by reallocating existing resources within the system. In each experiment, we consider the effect of increasing a less generous element of the UP system, financed by a reduction in a more generous element, which leaves the overall cost of the system as a proportion of GDP unchanged. In this respect, we only consider revenue neutral changes in policy which do not require explicit specification of the government budget.

6.1.1 Duration

Table 3 shows how self-financing policy changes to the effective durations of each UP programme impact on the aggregate unemployment rate, average job-finding rates within each benefit programme, the coverage of UP, the informal income earned by the unemployed relative to GDP, and participation in the informal sector.

Experiment (1), in the second column of Table 3, shows the effect of a one%

increase in the duration of UA, financed by a reduction in the duration of UI. This effect is quantified in terms of elasticity. For a detailed description of this calculation, see Appendix H. The results need careful interpretation. Because a proportion of unemployed workers find a job in each period, the mass of workers in the final period of UA receipt is mechanically smaller than the mass of individuals in the final period of UI at any point in time. Moreover, UA payments are lower than UI payments. Consequently, extending UA duration requires a smaller reduction in UI duration to finance it. The overall duration of UP, $T^{ui} + T^{ua}$, increases. This has two notable effects. First, it increases the value of unemployment for UP recipients. Second, it postpones unemployed workers' transition to SA. The coverage of UP increases by about 0.3%. Since the value of unemployment is higher within each programme, the opportunity cost of accepting informal work falls. This leads to higher participation rates within UI, UA, and SA. However, by postponing the transition to SA, there exists a cohort of unemployed workers who would, before the policy change, have participated in the informal sector at SA rates (accepting roughly 25% of opportunities) who now participate at UA rates (accepting roughly 4% of opportunities). This dominates the within programme increases in participation, lowering both informal participation, and income, of the unemployed by 0.1%.

Similar arguments explain workers' job-finding dynamics. Within each benefit programme, job-finding declines, reflecting the higher value of unemployment caused by the longer duration of UP. Simultaneously, and perhaps counter-intuitively, the unemployment rate falls. Since SA recipients search less intensively than UI or UA recipients, postponing unemployed workers' transition into SA keeps job-finding rates high for longer than previously (roughly 5.1% versus 4.1%). This dominates the within-programme declines in job-finding rates, causing the overall reduction in unemployment by 0.01%.

As a robustness exercise, experiment (2) considers the effect of increasing UI duration, funded by a reduction in UA duration. As expected, the effects are opposite to those of reducing T^{ui} to fund an increase in T^{ua}. Similarly, job-finding within programmes increases, but so to does the overall unemployment rate. The magnitudes of the elasticities are different, however, reflecting both nonlinearities in the model, as well as the fact that a one period increase in T^{ua} requires a less than one period reduction in T^{ui}, whereas a one period increase in T^{ui} requires a more than one period reduction in T^{ua}.

6.1.2 Payments

Table 4 shows the impact of self-financing changes to benefit payments. As shown in Appendix G, UP payments can be changed by considering the effect of a subsidy (tax) paid to (levied on) all recipients in proportion to their benefit payment. UI payments can also be changed by altering either the replacement ratio rr^{ui}, or the maximum limit $\overline{b}^{ui}$ or minimum limit $\underline{b}^{ui}$. Each of these affects unevenly recipients in different wage brackets. Changing rr^{ui} affects payments for those in the middle wage brackets, whilst changing $\overline{b}^{ui}$ or $\underline{b}^{ui}$ affects payments for higher-skilled and lower-skilled workers respectively.

Table 4: Elasticities for self-financing payment changes

	Policy experiment							
	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Increase in	b^{ua}	b^{ua}	b^{ua}	b^{ua}	b^{ui}	rr^{ui}	$\overline{b}^{ui}$	$\underline{b}^{ui}$
Financed by	b^{ui}	rr^{ui}	$\overline{b}^{ui}$	$\underline{b}^{ui}$	b^{ua}	b^{ua}	b^{ua}	b^{ua}
Informal income	-0.118	-0.355	-0.457	1.649	0.757	0.378	0.517	-0.913
Participation rate:								
UI	24.245	9.369	4.443	100.000	-54.263	-2.062	-5.563	-42.826
UA	-5.074	-5.190	-5.277	-3.995	9.809	2.298	7.779	0.756
SA	-0.630	-0.641	-0.643	0.068	2.499	0.628	0.655	-0.571
Unemployment rate	-0.060	-0.067	-0.079	0.125	0.253	0.078	0.069	-0.115
Job-finding rate:								
UI	-0.277	-0.215	-0.190	-0.591	0.652	0.091	0.305	0.230
UA	0.064	0.071	0.068	-0.008	-0.100	-0.041	-0.101	0.009
SA	0.221	0.211	0.230	-0.062	-0.804	-0.203	-0.238	0.175
UP coverage	0.126	0.126	0.140	-0.077	-0.454	-0.122	-0.146	0.121

Notes: Elasticity estimates for each moment are derived from the average percentage change following a one% increase and a one% decrease in the payment parameter of interest, except for (6) which is based only on a one% decrease in b^{ua} to finance an increase in $\underline{b}^{ui}$.

The first four columns, experiments (3)-(6), show the effect of increasing UA generosity, funded by various components of UI payments. The remaining four columns, experiments (7)-(10), are robustness checks, showing the impact of increasing each component of UI generosity, funded by reductions in UA payments. As with changes in duration, the direction of change of each variable of interest reverses, although the magnitude may increase or decrease.

The intuition explaining experiments (3)-(5) is identical. In each case, the reduction in UI generosity increases the marginal utility of income for UI recipients, causing an increase in informal participation in UI. Under experiment (5), which sees a reduction in the maximum UI payment, the increase is muted – only 4.4% versus around 24% in experiment (3) – as only higher-skilled unemployed workers are affected. Their UI payments are still relatively generous, leading to a smaller increase in informal participation.

The savings in UI are then used to fund an increase in UA generosity. This reduces the marginal utility of income equally for all recipients, leading to a fall in informal participation of around 5.2%. Since workers have exhausted UI by the time they receive the higher UA payments, reductions in informal participation under UA are almost identical across experiments.

Under SA, participation also falls due to the so-called entitlement effect. The redistribution increases the value of unemployment at the point a worker loses her job. For a SA recipient this, in turn, increases the value of employment,

as if they find a job and subsequently lose it, they will be better off. Informal participation falls, as the opportunity cost of accepting informal work is higher.

Overall, the reductions in informal work amongst UA and SA recipients dominate the increase for UI recipients. Both the overall informal participation rate and income decline. The declines are more pronounced when the policy is funded by a reduction in $\overline{b}^{ui}$ as there is a relatively modest increase in participation during UI to offset the falls in UA and SA.

Turning to the effect on formal activities, changes in unconditional job-finding rates mirror the changes in informal participation. Increases in informal participation amongst UI recipients, combine with a higher value of unemployment to suppress job-finding. In contrast, lower informal participation amongst UA and SA recipients enables them to search more intensively. Job-finding increases. Overall, the unemployment rate falls. Once again, the reduction is larger when the policy is financed by a reduction in $\overline{b}^{ui}$ as smaller increases in informal participation under UI result in smaller falls in job-finding for UI recipients to offset the gains for those on UA or SA.

The results for experiment (6) differ from the previous three. Whilst the underlying mechanisms are the same, the magnitude of the effects are very different. By targeting the minimum UI payment to fund increases in UA generosity, lower-skilled workers are disproportionately affected. These workers are the most active informal participants in the UI programme. Reducing their UI payments thus results in a relatively large increase in informal participation (it doubles) and a relatively large decrease in job-finding under UI (a fall of 0.6%). In contrast to the previous experiments, these changes dominate lower informal participation and higher job-finding in UA and SA, resulting in increases in informal income and participation, and the unemployment rate of 1.6, 0.8 and 0.13% respectively.

We complete this section with four remarks. First, our analysis suggests that there is significant scope for reducing informal participation and the unemployment rate by increasing SA payments, possibly redistributing away from UI recipients. We did not pursue this experiment explicitly for two reasons. SA is a broad-based income support programme that targets low-income groups in general rather than job-seekers specifically. Further, the increase in UA duration in Table 3 is equivalent to increasing SA payments for one month, as it allows unemployed workers to receive UP for longer rather than relying on income support. Second, the results in Table 3 relating to changes in duration need careful interpretation. UP duration is endogenously derived and is not directly under the control of the policymaker. Our model is silent on how eligibility criteria for UP should be changed to alter the effective duration. Third, the model allows for workers to be inactive because job search effort is endogenous, but no worker chooses zero search effort since we abstract from saving and human capital accumulation. Nevertheless the quantitative analysis accounts for SA recipients, which will include groups such as inactive and long-term unemployed workers. Fourth, the finding that increasing benefit generosity in UA increases job search contrasts with the literature on optimal UI, which advocates the front-loading

of benefits to reduce the problems associated with moral hazard (see Shavell and Weiss 1979, Hopenhayn and Nicolini 1997). It further suggests that informal sector participation may play a significant role in determining job-finding rates. In our model, by back-loading, or extending the duration of, benefit payments, informal sector participation is deterred, thereby increasing formal job search.

6.1.3 Temporary contracts

A number of recent papers have highlighted that labour market reforms in many countries are resulting in different degrees of employment protection for workers in the formal sector. According to the data of Bentolila et al. [2019] the share of employees with fixed-term contracts has been increasing by about 5% in Europe between 1983 and 2017. In 2013, the reference year for our calibration, this share was 23.1% of total dependent employment in Spain. The study on informality of Di Porto et al. [2017] distinguishes between permanent and temporary contracts in formal employment, showing that it is possible to trade off the different incentives of those on permanent employment and those in the informal sector to achieve joint reduction of informality and unemployment. We have simulated the effects of shortening formal job duration by increasing the job separation rate in the robustness analysis in Appendix F, showing that, ceteris paribus, this reduces the value of employment, thereby increasing both informality and unemployment. Of course, the redistribution results highlighted above in Tables 3 and 4 still hold even if a share of formal employment receives contracts of shorter duration. We would expect however, that the gains from the redistribution of unemployment benefits would be lower as formal employment reduces in value relative to informal employment. To check whether this intuition holds in our model, we have have repeated the policy experiment in Tables 3 and 4 after increasing the job separation rate by 10%. To elucidate the main results, we extracted from these simulations the effects on informality and unemployment. These are reported in Table 5. The results show that the effects of the redistribution experiments in most cases are the same as those observed from 3 and 4, though the magnitude of the distribution gains (in terms of reduction of informality and unemployment) reduces due to the decline in the value of formal employment. The only discordance is in the outcome of experiments (3a) and (7a) that in Table 5, have the same sign as experiments (6a) and (10a), respectively, but opposite sign compared to the corresponding experiments in Table 4. This reflects the fact that changes in b^{ui} affect $\underline{b}^{ui}$, rr^{ui} and $\bar{b}^{ui}$ simultaneously. Experiment (3a), for example, can be viewed as a composite of experiments (4a), (5a), and (6a). In Table 4, the increases in unemployment and informality from experiments (4) and (5) dominated the decreases found in experiment (6). In Table 5, since the value of employment is now lower, the opposite is true.

Table 5: Elasticities for self-financing policy changes with a higher job separation rate

	(1a)	(2a)	(3a)	(4a)	(5a)
Increase	T^{ua}	T^{ui}	b^{ua}	b^{ua}	b^{ua}
Finance	T^{ui}	T^{ua}	b^{ui}	rr^{ui}	$\overline{b}^{ui}$
Informal Income	-0.093	0.141	0.156	-0.128	-0.205
Unemployment Rate	-0.004	0.007	0.021	-0.015	-0.015

	(6a)	(7a)	(8a)	(9a)	(10a)
Increase	b^{ua}	b^{ui}	rr^{ui}	$\overline{b}^{ui}$	$\underline{b}^{ui}$
Finance	$\underline{b}^{ui}$	b^{ua}	b^{ua}	b^{ua}	b^{ua}
Informal Income	2.481	-0.216	0.090	0.265	-0.678
Unemployment Rate	0.251	-0.020	0.003	0.013	-0.058

6.1.4 Further extensions

Appendix I discusses the likely implications of three further extensions to the quantitative analysis. The first is making formal wages endogenous. Briefly, the policies we identify increase the job-finding rate. As a result, this could increase wages and consequently the incentive to search for a job relative to working informally, amplifying the beneficial effects of the redistribution identified in Tables 3 and 4. The second is removing labour market segmentation. Allowing workers to move from low- to high-wage jobs, would not affect the qualitative dynamics of the model. So long as higher-skilled workers are more likely to receive high wage offers than lower-skilled workers, thereby having a greater (stationary) expected value of employment, we would expect greater informal participation amongst the lower-skilled. Thus the channels we identify for redistribution would still be beneficial. The third is changing the informal income distribution. In the model all unemployed workers draw informal opportunities from the same distribution. This could be relaxed, conditioning for example upon workers' skills if there were reliable data. It is unclear what the aggregate effect of this extension would be. However, since higher-skilled workers only accept relatively valuable informal opportunities compared to lower-skilled workers, we observe a positive correlation between earnings in the two labour markets. This suggesting that *ex post* access to the informal sector is heterogeneous.

7 Conclusion

Many workers in developed countries accept temporary informal work while searching for a formal job, despite unemployment protection being widely pro-

vided by social security systems. Motivated by this, we incorporate informal opportunities and the associated sanctions into a workhorse model of temporary unemployment insurance to assess their impact. The paper makes two main contributions. First, we develop a theoretical model that can deliver qualitative predictions in line with empirical evidence on job search during unemployment. Second, the quantitative analysis suggests that unemployment and informality could be simultaneously reduced by appropriate redistribution of UP funds either across workers or across programmes, without increasing the overall UP budget.

The results of the paper should be interpreted bearing in mind two important caveats. Firstly, data on informal work earnings in developed countries are still scarce. Despite capturing a range of empirically-observed phenomena, and sitting comfortably within a class of models that have previously been used to successfully analyse the structure of UP, the model that we specify remains highly stylised. In many cases, calibrating additional features that would improves the realism of the model would require data on informality that, to the best of our knowledge, is not available. Secondly, data on informal work participation also suffers from under-reporting. Whilst we rely on indirect measures of informal activity that bypass survey data where possible, our results are undoubtedly affected by the downward bias that under-reporting creates. Greater informal participation could make the beneficial effects highlighted by the redistribution experiments even larger. Bearing in mind these two caveats, we see the paper's results as indicative of channels through which the UP systems in many developed countries could be improved simply through the re-allocation of existing budgets.

Supplementary Material

Supplementary material is available on the OUP website. These are the data used in the calibration, replication files, and all online appendices.

Funding

No funding was received for the study.

Acknowledgements

We are grateful for their helpful comments to: John Hudson, Andy Henley, Ezgi Kaya, Samuli Leppälä, Antonio Mele, Nicola Pavoni, Javier Rivas, Maik Schneider, Bruno Van Der Linden, Mike Wickens, and Colin Williams as well as participants at seminars at the universities of Bath, Cardiff, Sheffield and Surrey and participants at the 2016 MMF conference, the 2017 Essex Economics

of Crime workshop, the 2018 CESifo conference on Employment and Social Protection, and the 2018 Royal Economic Society conference.

References

A. Alba, J. M. Arranz, and F. Muñoz-Bullón. Re-employment probabilities of unemployment benefit recipients. *Applied Economics*, 44(28):3645–3664, 2012.

J. Albrecht, L. Navarro, and S. Vroman. The effects of labour market policies in an economy with an informal sector. *The Economic Journal*, 119(539): 1105–1129, 2009.

F. Álvarez-Parra and J. M. Sánchez. Unemployment insurance with a hidden labor market. *Journal of Monetary Economics*, 56(7):954–967, 2009.

D. Bardey, F. Jaramillo, and X. Peña. Unemployment insurance in the presence of an informal sector. *The World Bank Economic Review*, 29:S126–S134, 2015.

S. Bentolila, J. J. Dolado, and J. F. Jimeno. Dual labour markets revisited. 2019.

T. Boeri and P. Garibaldi. Shadow sorting. In J. A. Frankel and C. A. Pissarides, editors, *NBER International Seminar on Macroeconomics 2005*, pages 125–163. MIT Press, June 2007.

M. Bosch and J. Esteban-Pretel. Job creation and job destruction in the presence of informal markets. *Journal of Development Economics*, 98(2):270 – 286, 2012.

M. Bosch and J. Esteban-Pretel. The labor market effects of introducing unemployment benefits in an economy with high informality. *European Economic Review*, 75:1–17, 2015.

O. Bover, M. Arellano, and S. Bentolila. Unemployment duration, benefit duration and the business cycle. *The Economic Journal*, 112(479):223–265, 2002.

D. Card and P. B. Levine. Extended benefits and the duration of ui spells: evidence from the new jersey extended benefit program. *Journal of Public Economics*, 78(1):107 – 138, 2000.

D. Card, R. Chetty, and A. Weber. The spike at benefit exhaustion: Leaving the unemployment system or starting a new job? *The American Economic Review*, 97(2):113–118, 2007a.

D. Card, R. Chetty, and A. Weber. Cash-on-hand and competing models of intertemporal behavior: New evidence from the labor market. *The Quarterly Journal of Economics*, 122(4):1511–1560, 2007b.

O. Charlot, F. Malherbet, and C. Terra. Informality in developing economies: Regulation and fiscal policies. *Journal of Economic Dynamics and Control*, 51:1–27, 2015.

R. Chetty. Moral hazard versus liquidity and optimal unemployment insurance. *Journal of Political Economy*, 116(2):173–234, 2008.

D. Contini and M. G. Richiardi. Reconsidering the effect of welfare stigma on unemployment. *Journal of Economic Behavior & Organization*, 84(1):pp. 229–244, 2012.

E. Di Porto, L. Elia, and C. Tealdi. Informal work in a flexible labour market. *Oxford Economic Papers*, 69(1):143–164, 2017.

E. Espino and J. M. Sánchez. How does informal employment affect the design of unemployment insurance and employment protection? *Federal Reserve Bank of St. Louis Review*, (Second Quarter):159–72, 2015.

ESS ERIC. *ESS Round 6: European Social Survey Round 6 Data*. NSD - Norwegian Centre for Research Data, Norway – Data Archive and distributor of ESS data for ESS ERIC., data file edition 2.3 edition, 2012.

ESS ERIC. *ESS Round 7: European Social Survey Round 7 Data*. NSD - Norwegian Centre for Research Data, Norway – Data Archive and distributor of ESS data for ESS ERIC., data file edition 2.1 edition, 2014.

European Commission. Labour market (including lfs). [Online] Available from: `http://ec.europa.eu/eurostat/web/labour-market/overview` [Accessed 29th August 2017].

European Commission. *Special Eurobarometer 284 "Undeclared Work in the European Union"*. 2007.

European Commission. *Special Eurobarometer 402 "Undeclared Work in the European Union"*. 2014.

European Commission. *Labour market policy: Expenditure and participants*, volume Data 2013. Publications Office of the European Union, Luxembourg, 2016.

Federal Reserve Bank of New York. *Survey of Consumer Expectations - Survey of Informal Work Participation*. New York, 2015. [Online] Available from: `https://www.newyorkfed.org/microeconomics/databank.html` [Accessed 28th July 2017].

M. Feldstein. Rethinking social insurance. *The American Economic Review*, 95 (1):1–24, 2005.

M. Fugazza and J.-F. Jacques. Labor market institutions, taxation and the underground economy. *Journal of Public Economics*, 88(1):395 – 418, 2004.

D. L. Fuller, B. Ravikumar, and Y. Zhang. Unemployment insurance fraud and optimal monitoring. *American Economic Journal: Macroeconomics*, 7(2):pp. 249–90, 2015.

H. A. Hopenhayn and J. P. Nicolini. Optimal unemployment insurance. *Journal of Political Economy*, 105(2):412–438, 1997.

ILO. *Non-Standard Employment Around the World: Understanding challenges, shaping prospects*. International Labour Office, Geneva, 2016.

ILO. *Women and Men in the Informal Economy: A Statistical Picture*. International Labour Office, Geneva, 2018.

Instituto Nacional de Estadística. Wage of the main job. [Online] Available from: `http://www.ine.es/dynt3/inebase/en/index.htm?padre=2581&capsel=2662` [Accessed 5th April 2018].

L. F. Katz and B. D. Meyer. The impact of the potential duration of unemployment benefits on the duration of unemployment. *Journal of Public Economics*, 41(1):45 – 72, 1990.

K. Kroft, F. Lange, and M. J. Notowidigdo. Duration dependence and labor market conditions: Evidence from a field experiment. *The Quarterly Journal of Economics*, 128(3):1123–1167, 2013.

A. B. Krueger and A. Mueller. Job search, emotional well-being and job finding in a period of mass unemployment: Evidence from high-frequency longitudinal data. *Brookings Papers on Economic Activity*, 42(1 (Spring)):pp. 1–81, 2011.

A. B. Krueger and A. Mueller. The lot of the unemployed: A time use perspective. *Journal of the European Economic Association*, 10(4):pp. 765–794, 2012.

R. Lalive, J. van Ours, and J. Zweimüller. How changes in financial incentives affect the duration of unemployment. *The Review of Economic Studies*, 73 (4):1009–1038, 2006.

R. Lentz and T. Tranæs. Job search and savings: Wealth effects and duration dependence. *Journal of Labor Economics*, 23(3):467–489, 2005.

I. W. Long and V. Polito. Unemployment, crime and social insurance. *Cardiff Economics Working Papers*, (E2014/9), 2014.

L. Medina and F. Schneider. Shadow economies around the world: what did we learn over the last 20 years? 2018.

C. Meghir, R. Narita, and J.-M. Robin. Wages and informality in developing countries. *American Economic Review*, 105(4):1509 – 1546, 2015.

J. Mesén Vargas and B. Van Der Linden. Is there always a trade-off between insurance and incentives? the case of unemployment with subsistence constraints. *IZA DP*, (11034), 2017.

D. T. Mortensen. Unemployment insurance and job search decisions. *Industrial and Labor Relations Review*, 30(4):505–517, July 1977.

OECD. Benefits and wages: Country specific information, 2014a.

OECD. *OECD Labour Force Statistics 2013*. OECD Publishing, Paris, 2014b.

N. Pavoni. Optimal unemployment insurance, with human capital depreciation, and duration dependence. *International Economic Review*, 50(2):323–362, 2009.

N. Pavoni and G. L. Violante. Optimal welfare-to-work programs. *The Review of Economic Studies*, 74(1):283–318, 2007.

R. Rogerson, R. Shimer, and R. Wright. Search-theoretic models of the labor market: A survey. *Journal of Economic Literature*, 43(4):959–988, December 2005.

F. Schneider. Size and development of the shadow economy of 31 european and 5 other oecd countries from 2003 to 2013: A further decline. Working paper, April 2013.

F. Schneider and D. H. Enste. Shadow economies: Size, causes, and consequences. *Journal of Economic Literature*, 38(1):77–114, 2000.

S. Shavell and L. Weiss. The optimal payment of unemployment insurance benefits over time. *Journal of Political Economy*, 87(6):1347–1362, 1979.

Spanish Public Employment Service. *Contributory unemployment benefit: Unemployment protection*. Spanish Public Employment Service, Madrid, January 2017a.

Spanish Public Employment Service. *Unemployment allowance: Unemployment protection*. Spanish Public Employment Service, Madrid, January 2017b.

G. Ulyssea. Regulation of entry, labor market institutions and the informal sector. *Journal of Development Economics*, 91(1):87 – 99, 2010.

L. Uren. The redistributive role of unemployment benefits. *Journal of Economic Dynamics and Control*, 90:236 – 258, 2018.

C. C. Williams. *The Informal Economy and Poverty: Evidence and Policy Review*. Joseph Rowntree Foundation, 2014.

C. C. Williams and A. I. Horodnic. Reconceptualising undeclared work as paid favours: implications for community economic development. *Community Development Journal*, 53(4):732–750, 2018.