Fiscal expansions affect unemployment, but they may increase it.

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Abstract

Evidence from structural VARs suggests that the unemployment rate significantly increases following increases in government expenditures in many OECD countries. Results hold for a variety of specifications and identification schemes. Fiscal expansions also tend to increase the participation rate, vacancies, real wages and employment while they do not affect significantly labor market tightness. Existing models have difficulties in generating such responses. We introduce insider and outsider workers and a labor force participation choice into a New Keynesian model with matching frictions and show that calibrated versions of the model can generate the empirical regularities.

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Key Words: unemployment, participation rate, VARs, matching frictions, insiders, outsiders.

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1 Introduction

In a recent article Farmer (2009) assures that "Fiscal Policy Can Reduce Unemployment." The argument of Farmer (2009) is theoretical and considers a generic view of fiscal policy. In a world of multiple equilibria, fiscal policy can affect the choice of equilibrium, although Farmer urges that there are better alternatives.

Our empirical analysis shows that actually not only fiscal policy is not the best instrument for reducing unemployment, but that it can also go against the original scope. In particular, we show that increases in government spending may increase unemployment. This result is very surprising. Yet, it is general, in the sense that it holds for a variety of OECD countries and a variety of VAR specifications and identification schemes that we use to extract fiscal shocks from the data.

Besides the difficulties in the identification of fiscal shocks, many economists have tried to characterize the responses of macroeconomic variables such as investment, consumption and output to such disturbances. Blanchard and Perotti (2002), Perotti (2004) and Gali et al. (2007) use the restriction that government spending does not contemporaneously react to changes in macrovariables to identify fiscal shocks. Ramey and Shapiro (1998), Edelberg et al. (1999), Burnside et. al. (2004) and Cavallo (2005) identify fiscal shocks in the US economy as episodes of significant exogenous and unforeseen increases in government spending in national defense.[1] Pappa (2009a) was the first to investigate the effects of fiscal shocks in labor market variables such as the real wage and employment using sign restrictions to identify the shocks.[2] However, labor markets include much more variables than the variables considered by Pappa (2009a).

In the present paper we expand the analysis of Pappa (2009a) and study the effects of government spending shocks on additional labor market variables. In particular, using the restriction that government spending cannot react contemporaneously to changes in the economic environment, we estimate the response of employment, real wages, participation rates and the unemployment rate to increases in government expenditure in 10 OECD countries (Australia, Canada, Finland, France, Italy, Japan, Norway, Sweden, the United

[1] Depending on the identification approach the results on the effects of governemnt spending on private consumption differ. Perotti (2007) critically reviews this literature.

[2] For the identification of fiscal shocks using sign restrictions see also Canova and Pappa (2007) and Mountford and Uhlig (2009).

Kingdom and the United States).

The unemployment rate increases in response to increases in government expenditures in all countries. The increase is significant in all countries but Italy and it is particularly large for Sweden and Finland. Results are robust to the usage of alternative identification schemes and control variables as well as different sub-periods. In particular, when we use war dummies to identify exogenous changes in expenditures in the US we still find that unemployment increases significantly to the increase in national defense spending. Besides the difference in the shape of the responses, when we use sign restrictions to identify the fiscal shock the essence remains the same. Fiscal expansions significantly increase unemployment in Canada, Japan, the UK and the US.[3] In addition, according to our SVAR evidence, fiscal expansions tend to increase the participation rate, employment and the real wage. We document furthermore using annual data and panel regressions that for the majority of the OECD countries considered an increase in government spending leads to a significant increase in job vacancies but an insignificant increase in labor market tightness.

Our empirical findings are difficult to reconcile with a theoretical model for several reasons. First, because analyzing the effects of government spending shocks on unemployment in standard RBC and NK models is out of the question given that standard versions of these models involve only voluntary movements in hours of work and employment. Second, even if we incorporate the Diamond-Mortensen-Pissarides search and matching model into the standard frameworks as it is suggested in Trigari (2006) or Walsh (2005), we cannot analyze the responses of the participation rate since in these models participation is constant. But, even disregarding the participation choice, generating increases in output, real wages, employment and unemployment at the same time in response to fiscal shocks is a difficult task.

To circumvent these difficulties following Ravn (2008) we introduce a participation margin in a New Keynesian model with labor market frictions and in the spirit of Lindbeck and Snower (1988) we model the presence of insiders and outsiders in the labor market. Outsiders are assumed to differ from the typical unemployed worker (insider) in their matching labor market prospects. We show which ingredients are necessary for successfully replicating the behavior of the variables in the data. The assumptions on workers´ heterogeneity

[3] The sign restriction approach requires data on tax revenues that we could obtain reliably for these four countries.

and price stickiness are crucial. Sticky prices are necessary for inducing an increase in demand that outdoes the crowding out of vacancies due to the increase in government absorption, while the existence of outsiders guarantees an increase in total unemployment after a government expansion besides the fact that both employment and the real wage increase.

In a recent article Monacelli et al. (2010) study contemporaneously and independently the response of unemployment for the US economy. They show that increases in government spending reduce unemployment. The differences in the results are due to the different sample periods used in the two analyses. Series before 1975 for the US deliver decreases in unemployment after a fiscal expansion, but series after 1975 deliver the opposite result. Yet, government spending induces an increase in unemployment when the Ramey Shapiro dummies are used to identify the fiscal shock even for the longer US sample. We do not want to make a strong case in favor of our results for the US – there is the issue of how to deal optimally with the Vietnam war. However, our empirical work shows that for many other OECD countries increases in government spending were also accompanied by increases in the unemployment rate. Thus, such a phenomenon is plausible. The theoretical model incorporates assumptions that can generate both increases and decreases in unemployment coupled with increases in output, employment and the real wage after a fiscal expansion while the model presented by Monacelli et al. (2010) is missing such features.

The remainder of the paper is organized as follows. Section 2 describes the econometric framework. Section 3 presents the main empirical results. The theoretical model is presented in Section 4. Section 5 describes the dynamics of the benchmark economy and highlights the features that are crucial for replicating qualitatively the empirical results and Section 6 concludes.

2 Data and Estimation Methodology

We obtain quarterly data on GDP, private consumption, investment, government consumption expenditures, wages, the short-term interest rate, the labor force and the unemployment rate from OECD statistics. Total central government tax revenues are obtained for Canada from Statistics Canada, for Japan from Datastream, for the UK from the Office of National Statistics, and for the US from the Bureau of Economic Analysis. All variables are in real

per capita terms (except for the interest rate), and are seasonally adjusted. The 10 OECD countries that we focus on in our empirical analysis are Australia, Canada, Finland, France, Italy, Japan, Norway, Sweden, the UK, and the US. We have chosen these countries because of the availability of sufficiently long time series data. The maximum time period covered for our 10 OECD is: Australia (1984:2, 2009:1); Canada (1961:1, 2009:1); Finland (1990:1, 2009:1); France (1978:1, 2009:1); Italy (1980:1, 2009:1); Japan (1980:1, 2009:1); Norway (1979:1, 2009:1); Sweden (1982:1, 2009:1); UK (1978:1, 2009:1); US (1975:1, 2009:1).

To identify the impact that government expenditure shocks have on labor market outcomes we use a structural VAR approach. The variables entering our baseline VAR specification are: the logs of real per capita government expenditures, GDP, consumption, investment, the interest rate, the log of the real CPI wage, and the unemployment rate. We compute the impulse response functions using a Cholesky decomposition. Hence, the underlying identification assumption in our baseline model is that government expenditures are contemporaneously unaffected by all variables in the model. This assumption appears plausible to us because fiscal policy usually reacts with a lag to changes in the economic environment (see for instance Blanchard and Perotti, (2002); Perotti, (2004)). The lag length of our VAR model is based on information criteria and set equal to one.[4] All variables in the VAR model enter as log-deviations from a constant and a time trend.

3 Main Empirical Results

Figure 1 presents impulse responses for the baseline VAR model that includes government expenditures, GDP, consumption, investment, the interest rate, wages, and the unemployment rate.[5] For all OECD countries there is a significant positive response in the unemployment rate following increases in government expenditures. The countries where government expenditure increases have quantitatively the strongest effects on unemployment are Finland and Sweden, followed by the UK, the US, Norway, and Australia. A typical estimate from the impulse responses implies that a 10% increase in government expenditures increases the

[4] We have also checked the robustness of our results using a VAR with up to 8 lags using Bayesian techniques. For example, the shape of the impulse responses for the 4 lag VAR model are very similar to our parsimonious 1 lag specification, but confidence bands become larger. Nevertheless, we obtain a significant positive response in the unemployment rate for six out of the ten OECD countries covered (results are available by the authors upon request).

[5] The reported impulse response functions are for the longest possible sample.

unemployment rate at peak by around 0.2-0.5%. Responses are persistent, indicating that government expenditure increases may have effects on the unemployment rate that are of rather long-term nature, which is in line with the hypothesis that there is some hysteresis in the unemployment rate (see for instance Blanchard and Summers, (1987); Blanchard and Wolfers, (2000)).

We repeat the above analysis by including tax revenues in our VAR model for those countries with available data on total tax revenues. In Figure 2 we show the impulse responses for the unemployment rate due to government expenditure shocks for Canada, Japan, the UK, and the US. Similarly to our baseline regressions above we find that the largest response in unemployment occurs in the UK. For Canada and the US we also find that the response in the unemployment rate due to government expenditure increases is positive and statistically significant at the 95% confidence level. While for Japan responses of unemployment are insignificant but positive over the whole range.

Given that different identification schemes might have different implications for the behavior of private consumption in the US economy, in the next step we check whether identifying fiscal shocks as unforeseen increases in government expenditure on defense, following the approach of Ramey and Shapiro (1998), changes the impact of fiscal expansions on unemployment. In Figure 3 we keep the VAR specification that includes tax revenues but substitute the government expenditure series for the Ramey-Shapiro war dummies. As can be seen, in this case we also obtain a significant positive response in the unemployment rate for the US that has its peak effect after about 2 quarters. Thereafter, the response in the US unemployment rate declines until eventually turning negative after about 10 quarters.

In contrast to our results, Ravn and Simonelli (2007) and Monacelli et al. (2010) find that for the US unemployment significantly decreases after a fiscal shock. We investigated the reasons for this discrepancy between ours and their results. We found that the reason for the difference in results is the sample period used for the estimation exercise. Ravn and Simonelli (2007) use data from 1959 to 2004, and Monacelli et al. (2010) use data from 1954 to 2006 which includes the Vietnam war. The Vietnam war was of an exceptional size for the US economy. More than 3 million US men and women served in the Vietnam war during 1963-1975; and more than 100 billion US dollars were spent by the US government on the Vietnam war, which amounts to almost 700 billion US dollar in current US dollars. If we exclude the Vietnam period from their data, then unemployment responses to fiscal

expansions are significantly positive at the 95% confidence level. Perotti (2004) finds that the effects of fiscal shocks change between the pre 80s and the post80s period. It could very well be that the differences in results are due to the different samples considered. In order to investigate this possibility we have split the sample before and after the 1980s for the US and Canada (the two countries that we have long enough data to cover both periods). Figure 4 presents the impulse responses of unemployment to a government spending shock for the two countries. Unemployment decreases significantly after a shock to government spending in the pre 80s period and increases significantly in the post80s period, while in Canada unemployment increases in response to the government expansion in both subperiods. This indicates that our results are not driven by a potential structural break for all the countries. Obviously, the US is a special case. According to the Ramey Shapiro dummy approach unemployment increases after a shock to government spending in the whole sample, while the SVAR approach indicates differences in the responses in the pre and the post80s period. We believe that the Vietnam war is responsible for these differences, but we do not investigate this issue further.

In order to ensure that our results are not driven by cross-country differences in the time-period covered and in order to exclude the break that occurred for some countries in the beginning of the 1980s, we repeat our analysis for the baseline VAR specification for the period 1990:1-2008:4. The impulse response functions displayed in Figure 5 show that there continues to be a significant positive response in the unemployment rate due to government expenditure increases for the time period that is commonly shared by all countries. Moreover, we still find that the largest responses in the unemployment rate due to increases in government expenditures occur in Finland and Sweden.

So far, the ordering of our variables in the VAR model implied that government expenditures do not react contemporaneously to changes in the other variables specified in the VAR (that is, government expenditures do not react to changes in the economic environment on impact). In Figure 6 we relax this assumption by re-specifying the ordering of the variables in our VAR so that the government expenditure series enters the VAR last.[6] Such an assumption can be justified by claiming that automatic stabilizers work at any point in time in a real economy. The orthogonalized impulse responses displayed in

[6] That is, the ordering of the variables in the VAR is GDP, consumption, investment, the interest rate, wages, the unemployment rate, and government expenditures.

Figure 6 clearly show that there continues to be a positive response in the unemployment rate due to government expenditure increases: for nine out of the ten OECD countries the unemployment rate increases; and significantly so at the 95% confidence level for eight of those countries.

In Figure 7 we present the response of the real wage. For most of our countries we find that the real wage increases due to government expenditure increases. For Finland and Sweden we find on the other hand that the real wage significantly decreases due to government expenditure increases. In Figures 8 and 9 we also present the response of employment and the labor force participation.[7] Consistent with the findings in Pappa (2009b) we find that employment significantly increases due to government expenditure increases in the US and Canada. We also find a significant response in employment due to government expenditure increases in the UK. For these countries also the labor force participation significantly increases. On the other hand, for Finland and Sweden we find that both the labor force participation and employment significantly decrease due to government expenditures increases. The behavior of these two countries is particular since also the increases in output after the fiscal expansion are small compared with the other countries and insignificant.

To reinforce our results we use yet another identification scheme to recover fiscal shocks from the data. In particular, we use sign restrictions on the responses of deficits, output, tax revenues and government expenditures to identify fiscal shocks. Following Pappa (2009b) we use an eight variable VAR and identify fiscal shocks using the restriction that contemporaneously government expenditures, output and deficits are positively correlated, while tax revenues are not allowed to be negatively or highly correlated with the shock.[8] In Figure 10 we plot impulse responses for the four countries where we have data available on tax revenues (Canada, Japan, the UK, and the US). The unemployment rate significantly increases due to government expenditure increases even when we identify the shocks using sign restrictions. Also, output, employment (except in the UK and Japan) and the real wage tend to increase significantly after the fiscal expansion. We also find for all four countries

[7] The impulses are generated from a VAR where we replace the unemployment rate by the labor force and employment (both variables are in per capita terms).

[8] Given that in the theoretical model of the next section output might not react contemporaneously to the shock we also use restrictions on the second period after the shock to identify the fiscal disturbances. Results do not differ substantially.

that real wages significantly increase.

A complete study for the responses of the labor market variables to fiscal shocks should also include variables like vacancies, labor market tightness and the job finding rate. Unfortunately, obtaining comparable quarterly series for these variables for the OECD countries of our sample is not possible. To get a taste of how the responses of those variables to fiscal expansions look like, we estimate the effect that government spending has on job vacancies and labor market tightness based on a dynamic panel regression that accounts for unobservable cross-country heterogeneity, as well as unobservable year-specific shocks using annual data on job vacancies and labor market tightness from the CEP-OECD database (see Nickell (2006)) and government expenditure data from the OECD statistics.[9] In column (1) of Table 1 we document the response of job vacancies to increases in government spending. We find that for all countries except Canada the response is positive and statistically significant at least at the 5% level. Quantitatively, the increase in job vacancies due to government expenditure increases is largest for the US and the UK, and smallest for Canada, Japan, and Norway. On the other hand, column (2) shows that with the exception of Japan, government expenditure increases do not significantly affect labor market tightness.

To summarize: our VAR analysis suggests fiscal expansions tend to increase employment, the real wage, output, the labor force participation and the unemployment rate for the majority of the OECD countries we consider. Dynamic panel regressions also suggest significant increases in vacancies after fiscal expansions and insignificant increases in labor market tightness. This evidence is hard to reconcile with a standard model. We explore this possibility in the next section.

4 The Model

Analyzing the effects of government spending shocks on unemployment, or the participation rate in standard RBC and NK models is out of the question given that standard versions of these models involve only voluntary movements in hours of work and employment. To analyze unemployment fluctuations researchers found it natural to incorporate the Diamond (1982) and Mortensen and Pissarides (1994) (henceforth DMP) search and matching model

[9] Appendix 8.1 explains in detail the estimation method.

into the standard frameworks. In the DMP set up frictionless unemployment arises because the matching between workers that look for jobs and firms that post vacancies takes time. As a result, in the DMP framework it is natural to study labor market variables and their importance for the transmission of shocks. In the business cycle literature many researchers have studied the consequences of introducing the DMP search frictions into the standard model.[10] Such tendency was extended to New Keynesian models.[11]

However, with the exception of Ravn (2008), these studies assume that the labor market participation rate is constant. The empirical analysis of the previous section revealed that government spending shocks do affect labor force participation. Hence, in order to explain the empirical results, it is central to introduce a participation margin in our theoretical model. Following Ravn (2008), we model the labor market participation choice in terms of a trade-off between giving up leisure time to participate in the labor market search and giving up the benefits associated with the prospect of finding a new job when searching. Labor market non-participants are modelled as agents that are unmatched and that do not look for a job, while unemployed are unmatched agents that actively look for a job.

The traditional macroeconomic literature on unemployment (see Layard et al. (1991) for a literature review) includes other reasons for why unemployment may occur in equilibrium. Lindbeck and Snower (1988) propose a model of insiders and outsiders for explaining unemployment. In their framework, unemployment occurs because some agents (the outsiders) cannot sell as much labor services as they wish to supply. We find this perspective attractive, since in reality many agents, such as married wives, long-term unemployed, students, or elderly workers may be viewed as outsiders in the sense of Lindbeck and Snower (1988). These agents are often non-participants in the labor market and they might differ from the typical unemployed worker in their matching market prospects. This may indicate that the expected payoff from engaging in search activities is smaller for labor market non-participants (outsiders) than for search active agents (insiders). Hence, to incorporate the notion of insiders and outsiders in our model we introduce heterogeneity in the matching function of the two types of agents. In particular, we assume that there are two types of unemployed workers that differ in their prospect of being matched with vacancies. Out-

[10] See, e.g., Andolfatto (1996), den Haan, Ramey and Watson (2000), Hall (2005), Merz (1995), Shimer (2005) and Ravn (2008).

[11] See, e.g., Trigari (2006), Walsh (2005), Campolmi and Faia (2006), Thomas (2008) and Blanchard and Gali (2008).

siders face a less efficient matching technology than insiders and this group of agents may decide to become non-participants in equilibrium.

Finally, we will assume that prices are sticky in the short run, since we need to generate a demand effect that pushes wages up after a government spending shock in equilibrium.[12] In what follows we will discuss how the heterogeneity in matching functions, the labor force participation margin and the assumption of price stickiness help to generate positive responses of unemployment, output, employment, the participation rate and the real wage after a government spending disturbance.

Overall, the economy consists of households that have employed, unemployed and non-participants members. Some of the households members are insiders and have a more efficient matching function than some other members that we call outsiders. There are two types of firms in the economy: (i) competitive intermediate firms that use capital and labor to produce a good, and (ii) monopolistic competitive retailers that use all intermediate varieties to produce the final good which is used for consumption, investment and government spending. Price rigidities arise at the retail level, while search frictions occur in the intermediate goods sector.

4.1 Preferences

There is a measure one of households. Households consist of a continuum of agents and it is assumed that households pool the idiosyncratic labor income risk of their members. In other words, the number of individuals in the household is large enough to guarantee insurance over consumption.

At any point in time a fraction n_t of the household´s members are employed, while a fraction u_t are unemployed and another fraction l_t are labor market non-participants. The difference between non-participants and unemployed is that the latter are actively looking for a job.

$$1 = n_t + u_t + l_t \tag{1}$$

The preferences of the representative household are defined by:

$$u(c_t, l_t) = \frac{c_t^{1-\eta}}{1-\eta} + \phi \frac{l_t^{1-\zeta}}{1-\zeta} \tag{2}$$

[12] See, Pappa (2009a) for the differential effect of shocks to government spending on the real wage depending on the assumption about the price dynamics.

where c_t, denotes consumption, $1/\eta$ is the intertemporal elasticity of substitution, $\phi > 0$ is a preference parameter and ζ is the inverse of the elasticity of labor supply. That is, households obtain utility from consumption and from the fraction of households that do not participate in market activities and enjoy leisure.[13] Notice that each household member´s consumption is the same independently of their labor market status due to pooling. For this to hold the separability between consumption and leisure is necessary. Notice also that a member of a household that searches for a job or that is employed suffers the same disutility. That is, search effort is as costly in terms of utility as a full time job.

4.2 Matching

The process through which workers and firms find each other is represented by a matching function that accounts for the imperfections and transaction costs in the labor market. Given that in our economy there are two types of unemployed that differ in their prospect of finding a job, we need to introduce heterogeneity in the matching functions of insiders and outsiders.

We model this aspect as follows. Every period a constant fraction σ of the currently employed worker-job matches is destroyed and a measure of M new matches are formed. Workers that experience a termination of their match are characterized as insiders and they enter into a period of unemployment. An insider may either remain unemployed, or find a new job match, or become an outsider. Insiders move to long term unemployment and become outsiders with probability $\mu \in [0, 1]$. The number of new matches between vacant jobs and unmatched agents will depend on both the labor market tightness and on the structure of unemployment. The aggregate number of matches is given by:

$$\begin{aligned} M(v_t, u_t^O, u_t^I) &= m_I(v_t, u_t^I) + m_O(v_t, u_t^O), \quad \text{with} \\ m_I(v, u) &> m_O(v, u) \ \text{ for } \ \forall\ v, u > 0 \end{aligned} \tag{3}$$

where v denotes vacancies, u^I denotes the measure of insiders in unemployment, while u^O denotes the measure of outsiders looking for a job. We assume that the efficiency

[13] Such a utility function can be rationalized by the production of home goods. That is, it is equivalent to assuming that households derive utility from market and home goods, c_t^h whereas the home goods are produced by the following production function: $c_t^h = \frac{l_t^{1-\zeta}}{1-\zeta}$.

of the matching process of unemployed insiders is higher than the respective efficiency of unemployed outsiders. Thus, the matching function for the two groups of individuals is assumed to satisfy:

$$m_i(v, u^j) = \varrho_m^j v^\alpha (u^j)^{1-\alpha} \text{ with } \ j = I, O \quad \text{and} \varrho_m^I > \varrho_m^O > 0 \tag{4}$$

The matching function is assumed to have constant returns to scale. The probability that a vacant job is matched with a worker is going to depend on the overall labor market tightness, $\theta_t = \frac{v_t}{u_t}$, as in the standard framework, but also on the relative size of insiders and outsiders. If we denote by γ_t^f this probability, we have:

$$\gamma_t^f = \frac{m_t}{v_t} = \theta_t^{\alpha-1} \left[\varrho_m^I \left(\frac{u_t^I}{u_t} \right)^{1-\alpha} + \varrho_m^O \left(\frac{u_t^O}{u_t} \right)^{1-\alpha} \right] \tag{5}$$

where $u = u_I + u_O$, and the ratio $\frac{u^j}{u}, j = I, O$, defines the share of unemployment for the each type of agent. So an increase in the unemployment rate for both type of agents reduces the probability that a vacancy will be filled. However, an increase in the unemployment rate for insiders has a stronger impact on this probability than an increase in the unemployment rate of outsiders. The probability for an unemployed worker (insider or outsider) to find a job is given by:

$$\gamma_t^h = \frac{m_t}{u_t} = \theta_t^\alpha \left[\varrho_m^I \left(\frac{u^I}{u} \right)^{1-\alpha} + \varrho_m^O \left(\frac{u^O}{u} \right)^{1-\alpha} \right] \tag{6}$$

Again the relative size of the two types of unemployed workers in the economy matters. Hence, an additional outsider searcher creates less of a negative externality for the total sum of individuals looking for a job.

The employment transition equation is given by:

$$n_{t+1} = (1 - \sigma) n_t + m_{It} + m_{Ot} \tag{7}$$

The transition equation for unemployment among insiders is given by:

$$u_{t+1}^I = (1 - \mu) u_t^I + \sigma n_t - m_{It} \tag{8}$$

Notice that in this framework the participation choice is relevant for outsiders. Insiders are more often (that is for many parameter specifications) better off searching since they are faced with a better matching technology. Outsiders instead have to decide whether they

should participate in the labor market and their decision should take into account the fact that they are less advantageous in matching with firms.

4.3 The problem of the household

The household except from offering labor to firms owns the economy´s capital stock. The capital stock evolves over time according to:

$$k_{t+1} = (1-\delta)k_t + i_t + \xi(\frac{k_{t+1}}{k_t})k_{t+1} \tag{9}$$

where, δ is the capital´s depreciation rate, i_t is gross investment and $\xi(.)$ is a function that regulates capital adjustment costs. We adopt a quadratic specification of the form:

$$\xi(\frac{k_{t+1}}{k_t}) = \frac{\omega}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 \tag{10}$$

where the parameter ω regulates the importance of capital adjustment costs for the accumulation of capital.

The representative household maximizes its expected utility given by:

$$E_t \sum_{t=0}^{\infty} \beta^t u(c_t, l_t) \tag{11}$$

choosing sequences of consumption, c_t, the number of insiders in the next period, u_{t+1}^I, and the number of outsiders , u_t^O, employment for next period, n_{t+1}, next period´s bond holdings, B_{t+1} and capital, k_{t+1}, subject to (1), (7), (8), (9) and its budget constraint given by:

$$c_t + i_t + \frac{B_{t+1}}{p_t R_t} \leq r_t k_t + w_t n_t + b u_t + \frac{B_t}{p_t} + \Pi_t + T_t \tag{12}$$

where p_t is the price level, w_t is the real wage, r_t is the real return to capital, b denotes some non-tradable value to being unemployed expressed in terms of unit output, R_t is the gross nominal interest rate, Π_t are the profits of the monopolistic competitive firms and T_t are transfers from the government. The first order conditions for the household are given below:

$$c_t^{-\eta} = \lambda_{ct}$$

$$\lambda_{ct}\left(1 + \omega\left[\frac{k_{t+1}}{k_t} - 1\right]\right) = \beta E_t \lambda_{ct+1}\left(1 - \delta + r_{t+1} + \frac{\omega}{2}\left(\frac{k_{t+2}}{k_{t+1}} - 1\right)^2\right)$$

$$\phi l_t^{-\zeta} = \gamma_t^{Oh}\lambda_{nt} + b\lambda_{ct}$$

$$\lambda_{ut} = \beta E_t[\lambda_{nt+1}\gamma_{t+1}^{Ih} + \lambda_{ct+1}b + \lambda_{ut+1}((1-\mu) - \gamma_{t+1}^{Ih}) - \phi l_{t+1}^{-\zeta}]$$

$$\lambda_{nt} = \beta E_t[\lambda_{ct+1}w_{t+1} + (1-\sigma)\lambda_{nt+1} + \sigma\lambda_{ut+1} - \phi l_{t+1}^{-\zeta}]$$

$$\lambda_{ct}\pi_{t+1} = \beta E_t\lambda_{ct+1}R_t$$

where $\gamma_t^{Ih} = \frac{m_t^I}{u_t^I}$ and $\gamma_t^{Oh} = \frac{m_t^O}{u_t^O}$ are the probabilities for an unemployed insider and an outsider to find a job, respectively.

4.4 Intermediate good firms and job creation

Intermediate goods firms employ the household's labor and capital to produce intermediate goods. The production function for intermediate goods is given by:

$$y_t = F(Z_t, k_t, n_t) = k_t^{\varphi}(Z_t n_t)^{1-\varphi} \tag{13}$$

where Z_t is aggregate productivity.

Intermediate firms maximize the discounted value of future profits. Firms adjust employment by varying the number of workers (extensive margin) rather than the number of hours per worker. According to Hansen (1985) most of the employment fluctuations arise from movements in this margin. The firm takes as given the number of workers currently employed and its employment decision concerns the number of vacancies that it posts in the current period, v_t. Firms open as many vacancies as necessary to employ the desired number of workers next period and there is a utility cost from posting a vacancy, $\varkappa$. Firms also need to decide on the size of the capital stock that they need for production. The problem of a firm with n_t currently employed workers consists of choosing capital and vacancies to maximize:

$$Q(n_t) = \max x_t F(Z_t, k_t, n_t) - w_t n_t - r_t k_t - \varkappa v_t + E_t\Lambda_{t+1}Q(n_{t+1}) \tag{14}$$

where x_t is the relative price of intermediate goods and $\Lambda_{t+s} = \frac{\beta^s U_{ct+s}}{U_{ct}}$, is the discount factor constructed in terms of relative marginal utility. The maximization takes place subject to the production function, the law of motion for aggregate productivity and the job transition function which links the future number of filled jobs to the current stock of filled jobs plus net hiring.

$$n_{t+1} = (1-\sigma)n_t + \gamma_t^f v_t \tag{15}$$

The first order conditions for the firm are given by:

$$x_t F_{kt} = r_t$$

$$\frac{\varkappa}{\gamma_t^f} = \beta E_t \left(\frac{c_t}{c_{t+1}}\right)^{\eta} \left[x_{t+1} F_{nt+1} - w_{t+1} + (1-\sigma)\frac{\varkappa}{\gamma_{t+1}^f}\right]$$

4.5 Bargaining over wages

Workers and firms split rents through Nash bargaining and the part of the match surplus they receive depends on their bargaining power. If we denote by $\vartheta \in (0,1)$ the firms bargaining power, the Nash bargaining problem maximizes the weighted sum of log surpluses:

$$\max_{w_t} (1-\vartheta) \ln V_t^W + \vartheta \ln V_t^F$$

where $V_t^W = w_t - b + (1 - \sigma - (\gamma_t^{Ih} + \gamma_t^{Oh}))E_t \Lambda_{t+1} V_{t+1}^W$, is the worker's surplus and $V_t^F = x_t(1-\varphi)\frac{y_t}{n_t} - w_t + \beta E_t \Lambda_{t+1} V_{t+1}^F$, is the firm's surplus of the match.

The solution of the bargaining problem defines the wage as:

$$w_t = (1-\vartheta)\left[(1-\varphi)x_t \frac{y_t}{n_t} + \frac{\varkappa(\gamma_t^{Oh} + \gamma_t^{Ih})}{\gamma_t^f}\right] + \vartheta b \tag{16}$$

4.6 Retailers and price setting

There is a continuum of monopolistically competitive retailers indexed by i on the unit interval. Retailers buy intermediate goods from firms and differentiate them with a technology that transforms one unit of intermediate goods into one unit of retail goods. Retail goods are then used for consumption, government spending and investment. Note that the relative price of intermediate goods, x_t, coincides with the real marginal cost faced by the retailers. Let y_{it} be the quantity of output sold by retailer i. Final goods can be expressed as the composites of individual retail goods:

$$y_t = \left[\int_0^1 y_{it}^{\frac{\varepsilon-1}{\varepsilon}} di\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{17}$$

where $\varepsilon > 1$ is the constant elasticity of demand for intermediate goods. The retail good is sold at its price, $p_t = \left(\int_0^1 p_{it}^{1-\varepsilon} di\right)^{\frac{1}{1-\varepsilon}}$. The resulting demand for its aggregator depends

on the relative price and aggregate demand:

$$y_{it} = \left(\frac{p_{it}}{p_t}\right)^{-\varepsilon} y_t \tag{18}$$

Following Calvo (1983) we assume that in any given period each retailer can reset its price with a fixed probability $1-\psi$. Hence, the price index is given by:

$$p_t = \left[(1-\psi)p_t^{*1-\varepsilon} + \psi p_{t-1}^{1-\varepsilon}\right]^{1/(1-\varepsilon)} \tag{19}$$

The firms that are able to reset their price, p_t^*, choose it so as to maximize expected profits given by:

$$E_t \sum_{t=0}^{\infty} \psi^s \Lambda_{t+s} \left[\frac{p_{it}^*}{p_{t+s}} - x_{t+s}\right] y_{it+s} \tag{20}$$

The optimal price solves:

$$p_{it}^* = \frac{\varepsilon}{\varepsilon - 1} \frac{E_t \sum_{t=0}^{\infty} \psi^s \Lambda_{t+s} x_{t+s} y_{it+s}}{E_t \sum_{t=0}^{\infty} \psi^s \Lambda_{t+s} y_{it+s}} \tag{21}$$

4.7 Fiscal policy

The government consumes exogenously part of the retail goods and finances its expenditures via lump sum taxes.

$$G_t = T_t$$

4.8 Monetary Policy

There is an independent monetary authority which sets the nominal interest rate as a function of current inflation, according to the rule:

$$R_t = \overline{R} \exp(\zeta_\pi \pi_t + \epsilon_t^R) \tag{22}$$

where ϵ_t^R is a monetary policy shock and π_t measures inflation in deviation from the steady state.

4.9 Closing the model

Aggregate production must equal private and public demand:

$$y_t = c_t + i_t + G_t + \varkappa v_t \tag{23}$$

We solve the model by approximating the equilibrium conditions around a non-stochastic steady state in which all prices are flexible.

4.10 Parameterization

We use parameter values that have been used in calibration exercises for the US economy. A full list of our choices is given in Table 2.

Without loss of generality we set $Z = 1$. The quarterly discount factor is set to 0.99, which implies a quarterly real rate of interest of approximately 1 percent. The risk aversion parameter is set to $\eta = 2$ and the utility of leisure has elasticity $\zeta = 2$. These values are common in the literature.

Following Blanchard and Diamond (1989) we set $\alpha = 0.6$ and using Hosios condition we also set the bargaining parameter equal to the elasticity of matching, i.e., $\alpha = \vartheta$.

Davis, Haltiwanger and Schuh (1996) compute a quarterly worker separation rate of about 8 percent, while Hall (1995) reports this rate to be between 8 and 10 percent. Accordingly, we set the overall separation rate σ to 0.08. The probability of moving from short to long term unemployment is set to 0.3 and the values of ρ_m^O and ρ_m^I so that the outsiders unemployment rate is around 8%. This number corresponds roughly to the average unemployment of women and the young population in our sample. Finally, the vacancy to output ratio is set equal to 0.05.

The depreciation rate is set equal to 0.01 and the capital share is set equal to 0.36. Capital adjustment costs are included to moderate the response of investment with respect to the monetary and fiscal shocks. We set parameter ω to match the ratio of the investment to output variance for the US economy. The probability that a firm does not change its price within a given period, ψ, is set equal to 0.75, implying that the average period between price adjustments is around 4 quarters. The values used for the technology and the monetary shock are standard, while the ones of the government spending shock are the average values for the various shocks we have recovered in the empirical part of the exercise.

Our parameterization implies that the participation rate is equal to 75% which is close to the average for the sample of countries we use in the empirical section. The unemployment rate for outsiders equals 8% and the one of insiders is 5%. In the standard model with homogeneous workers the labor market tightness takes values around 0.25. The labor market tightness for outsiders is 0.19 and the one of the insiders is 0.31. Finally, the probability for finding a job for the outsiders equals 0.18, while insiders probability to find a job is twice as much. The results we obtain in the benchmark model for the effects of fiscal shocks are stable to the exact parameterization of the labor market.

5 How fiscal shocks can increase unemployment

The current section investigates the properties of the benchmark model and examines which mechanisms are necessary for the derivation of the results.

5.1 The benchmark model

The model performs pretty well in generating reasonable dynamics for all the shocks considered.[14] Figure 11 presents the effects of a shock to government expenditure on output, employment, unemployment (total and for the two types of workers), the real wage, the participation rate, consumption and investment.

In the benchmark economy an increase in government spending induces a negative wealth effect that makes households increase their labor supply. As a result, the participation rate increases. Also, the increase in government absorption is crowding out private consumption and investment and hiring. On the other hand, the increase in demand induced by the government expansion in combination with sticky prices increases labor demand, and, in turn, wages and employment increase. But, it is the insiders that get the extra jobs and instead the unemployment rate of the outsiders increases. As a result, total unemployment dynamics display a kink. On impact total unemployment increases because of the increase in participation and the increase in the unemployment rate of outsiders. As insiders are hired by the firms to face the increased demand total unemployment decreases, but when the demand effect fades away total unemployment starts rising again. In line with the empirical results, the effects of the shock in unemployment are very persistent.

[14] The effects for the other two shocks are available from the authors upon request.

5.2 The role of price stickiness

Notice that price stickiness is necessary for obtaining our results. In Figure 12 we present the responses of an economy which is otherwise identical to the benchmark except for the assumption of price stickiness.[15] With flexible prices, the increase in government absorption would crowd out vacancy posting since it would decrease the resources available for filling vacancies. Although the wealth effect would increase participation and the labor supply in equilibrium, the decrease in vacancy posting would decrease demand for employment and output and increase the unemployment of both types of agents, generating responses which are in contrast with the empirical evidence on the positive effects that government spending has on output.

5.3 The role of the participation margin and worker's heterogeneity

We have initially modeled the participation margin in order to be able to analyze the behavior of labor force participation in reaction to fiscal shocks. However, the assumption of the participation margin might be important in generating the results. In Figure 13 we plot the responses of the variables in an economy in which agents are homogeneous, prices are sticky and there is no participation margin versus an economy in which agents are homogeneous with sticky prices and a participation margin.[16] The fact that there is a pool of non-participants that move into the labor force when the negative wealth effect from the increase in the government absorption kicks in maybe all one needs to generate the increase in unemployment after a government spending shock. The figure suggests that the labor force participation choice is not enough. If labor force participation were the only additional feature relative to the standard model that would not be enough to generate an increase in unemployment and in fact the two models with or without the participation decision would be almost identical. Workers heterogeneity is crucial for generating the increase in total unemployment after the spending shock. If agents were homogeneous, an increase in government spending under sticky prices would increase labor demand and unemployment would be reduced[17]. It is the fact that outsiders have a hard time to find a job that makes total unemployment increase in equilibrium in the benchmark model.

[15] To obtain the case of flexible prices we set the Calvo parameter close to zero.

[16] The appendix describes how the benchmark model is modified to analyze these cases.

[17] The homogeneous agents model is actually very similar to the benchmark model used by Monacelli et al. (2010), except for the participation choice decision. For that reason results are very similar.

5.4 Sensitivity analysis

To summarize, price stickiness and workers' heterogeneity are the two crucial assumptions to replicate the empirical facts. We performed a number of sensitivity analyses to investigate the robustness of our conclusions with respect to the remaining parameters of the model. The most crucial parameters in the model are the cost of posting a vacancy as a percentage of GDP, $\varkappa$, and the labor supply elasticity, ζ.

The size of the vacancy cost is important to determine how much the government expansion crowds out the creation of vacancies. If the cost associated with the creation of vacancies is very small (for $\varkappa < 0.02$) an increase in government spending does not affect job creation and the model becomes standard in the sense that the wealth and the demand effects increase employment and vacancies, decreasing unemployment for both types of workers.

On the other hand, when the labor supply elasticity decreases (for values of $\zeta > 6$), the wealth effect of the increase in government absorption does not increase that much labor force participation. As a result, the unemployed of both types can be employed in firms that face increased demand for their products due to the price stickiness and unemployment decreases after the fiscal expansion in equilibrium.

Finally the relative size of insiders and outsiders in total unemployment should also affect our results. Our results hold if the share of outsiders in total unemployment varies between (0.4 and 0.7). The absence of closed form solutions for our steady state and the restrictions on parameter values deters us from studying more rigorously this effect.

6 Conclusions

In the current study we examine empirically the effect of fiscal shocks on labor market variables and, in particular, on unemployment for 10 OECD countries. We find that for the majority of the countries considered a fiscal expansion leads to a significant increase in total unemployment. Our results are robust to the identification used to extract fiscal shocks from the data and the sample period considered. For the rest of the labor market variables, according to VAR evidence, fiscal expansions increase employment and labor force participation, while dynamic panel regressions which are based on annual data suggest that fiscal expansions are accompanied by significant increases in vacancies and insignificant

increases in labor market tightness.

The empirical evidence is hard to reconcile with an existing model. Following a recent trend in the business cycle literature we suggest a new Keynesian model with search frictions to explain the findings. The introduction of workers' heterogeneity is crucial for deriving our results. When the economy is populated by insiders and outsiders which are characterized by different matching prospects in the labor market, it is possible to obtain increases in total unemployment after a fiscal expansion. This is because the negative wealth effect induced by the increase in government absorption increases labor force participation for both types of workers. Outsiders unemployment increases more than the fall in insiders unemployment, due to the increased demand generated by the sticky prices, and total unemployment increases in equilibrium.

The model introduced in this paper should provide a guide for future research on the modeling of the labor market in DSGE models. Our aspiration was to show that it is possible under reasonable assumptions to generate an increase in total unemployment after a fiscal expansion. However, the proposed model fails to account for all the empirical regularities concerning the effects of fiscal shocks.

For example, in the model private consumption decreases after the fiscal expansion. Most empirical findings (including our own) suggest an increase in private consumption after the fiscal shock. Given that the scope of the model is to reproduce the dynamics of the labor market after a fiscal expansion, we have not included in the analysis mechanisms, such as complementarity between government and private goods (Linnemann and Schaubert (2003)) that would overcome this shortcoming.[18]

The model has also difficulties in explaining the behavior of Finland and Sweden. In these countries increases in government expenditures are accompanied by significant increases in unemployment, insignificant increases in output; but significant decreases in the real wage, the labor force participation and employment. The benchmark model for low degrees of price rigidities can generate insignificant increases in output and significant increases in unemployment, but it cannot at the same time produce decreases in employment, real wages and the participation rate. It is well known that the Scandinavian labor market

[18] Also complementarity between consumption and leisure (see Hall and Milgrom (2005)) could in principal generate increases in private consumption after a fiscal shock. This assumption cannot be incorporated in our framework since consumption risk can be pooled only under the assumption of separability between consumption and leisure in the utility function.

and welfare state are special. Scandinavian countries rely on a mix of local autonomy and national controls to constrain local taxation and expenditure. Future work should try to address the Scandinavian model of fiscal federalism and examine its implications.

Finally, our empirical results are subject to the criticism that any VAR exercise is subject to (see for example, Chari et al.(2007) and Ramey (2009) among others). We feel comfortable by using the simple Choleski decomposition since according to Mertens and Ravn (2009) it might deliver nearly correct impulse responses even if shocks are anticipated by the private sector. However, since there remain factors that can render our results questionable we state in the title that fiscal expansions *may* increase unemployment although our evidence leaves no room for doubt.

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8 Appendix

8.1 Panel data estimates

We estimated the effect that government spending has on job vacancies and labor market tightness using a dynamic panel regression that accounts for unobservable cross-country heterogeneity as well as unobservable year-specific shocks. Specifically, we estimated the model:

$JobV(LMT)_{c,t} = a_c + b_t + \phi_c JobV(LMT)_{c,t-1} + g_c G_{c,t-1} + u_{c,t}$

where $JobV$ stands for job vacancies, LMT stands for labor market tightness and G stands for government expenditures, a_c are country fixed effects, b_t are year fixed effects, and $u_{c,t}$ is an error term that is clustered at the country level. Note that the above model explicitly allows for differences in convergence dynamics across countries and also for differences in the marginal effect that government spending has on job vacancies (labor market tightness). The method of estimation of the above model is system-GMM (Blundell and Bond, 1998). Estimates are computed based on annual data and all variables are in real per capita terms and in logs of the level. The annual data on job vacancies and labor market tightness are from the CEP-OECD database (Nickell (2006)); and the government expenditure data are from OECD statistics.

8.2 Steady state

The steady state is one with no employment, or unemployment growth and zero inflation.

$$\sigma n = \gamma^{Ih} u_I + \gamma^{Oh} u_O \tag{24}$$

$$\mu u_I = \gamma^{Oh} u_O \tag{25}$$

$$1/\beta = 1 - \delta + r \tag{26}$$

$$1/\beta = R \tag{27}$$

$$\phi l^{-\zeta} = \gamma^{Oh} \lambda_n + bc^{-\eta} \tag{28}$$

$$\lambda_u = \beta[\lambda_n \gamma^{Ih} + \lambda_u((1-\mu) - \gamma^{Ih}) - \phi l^{-\zeta} + bc^{-\eta}] \tag{29}$$

$$\lambda_n = \beta[c^{-\eta}w + (1-\sigma)\lambda_n + \sigma\lambda_u - \phi l^{-\zeta}] \tag{30}$$

$$r = \varphi x\frac{y}{k} \tag{31}$$

$$\frac{i}{k} = \delta \tag{32}$$

$$y = Zk^{\varphi}(n)^{1-\varphi}, Z = 1 \tag{33}$$

$$1 = l + u_I + u_O + n \tag{34}$$

$$y = c + i + g + \varkappa v \tag{35}$$

$$\theta_O = v/u_O, \qquad \theta_I = v/u_I \tag{36}$$

$$\begin{aligned} \gamma^{Ih} &= \rho_m^I\theta_I^{\alpha}, & \gamma^{Oh} &= \rho_m^O\theta_O^{\alpha} \\ \gamma^{If} &= \gamma^{Ih}/\theta_I & \gamma^{Of} &= \gamma^{Oh}/\theta_O \end{aligned} \tag{37}$$

$$\frac{\varkappa}{\gamma^{If}+\gamma^{Of}}(1-\beta(1-\sigma)) = \beta\left[\frac{y}{n}x(1-\varphi) - w\right] \tag{38}$$

$$w = (1-\vartheta)\left[(1-\varphi)x\frac{y}{n} + \frac{\varkappa(\gamma^{Oh}+\gamma^{Ih})}{\gamma^{If}+\gamma^{Of}}\right] + \vartheta b \tag{39}$$

$$x = \frac{\varepsilon - 1}{\varepsilon} \tag{40}$$

Substituting (24) and (25) and the fact that $\frac{\theta_I}{\theta_O} = \frac{u_O}{u_I}$ in the remaining equations we get:

$$n = u_O\frac{\rho_m^O\theta_O^{\alpha}}{\mu\sigma}[\rho_m^I\left(\frac{\mu}{\rho_m^O}\right)^{\alpha}\theta_O^{\alpha(1-\alpha)} + \mu] = B(\theta_O)u_O \tag{41}$$

$$\lambda_n = \frac{c^{-\eta}(w-b)}{\frac{1}{\beta} - (1-\sigma) + \rho_m^O\theta_O^{\alpha} - \frac{\beta\sigma(\rho_m^I\theta_I^{\alpha} - \rho_m^O\theta_O^{\alpha})}{1-(1-\mu)\beta+\beta\rho_m^I\theta_I^{\alpha}}} = \frac{c^{-\eta}(w-b)}{T(\theta_O)} \tag{42}$$

$$\theta_I = \left(\frac{\mu}{\rho_m^O}\right)\theta_O^{(1-\alpha)} \qquad \text{that is } \theta_I(\theta_O) \tag{43}$$

$$\lambda_u = \lambda_n \frac{\beta(\rho_m^I \theta_I^\alpha - \rho_m^O \theta_O^\alpha)}{1-\beta(1-\mu)-\beta\rho_m^I\theta_I^\alpha} \qquad \text{that is } \lambda_u(\theta_O) \tag{44}$$

$$\frac{y}{n} = \left[\frac{y}{k}\right]^{\frac{\varphi}{1-\varphi}} = \left[\frac{r}{\varphi}\frac{\varepsilon}{\varepsilon-1}\right]^{\frac{\varphi}{1-\varphi}} \tag{45}$$

from (34) we have

$$l = 1 - \left[1 + B(\theta_O) + \frac{\gamma^{Oh}}{\mu}\right] u_O \tag{46}$$

We can write the resource constraint as:

$$\frac{c}{y} = 1 - \frac{\delta}{\frac{y}{k}} + \frac{g}{y} - \frac{\varkappa}{y}\theta_O u_O \tag{47}$$

and $c = \frac{c}{y}y$, while $y = \frac{y}{n}n$.

from (42) we have:

$$w = c^\eta \lambda_n T(\theta_O) + b \tag{48}$$

Using (38) together with (39) we can write:

$$u_O = \frac{\beta\vartheta\left[1-\varphi)x\frac{y}{n} - b\right]}{1-\beta(1-\sigma)-(1-\alpha)\beta(\gamma^{Oh}+\gamma^{Ih})} \frac{(\gamma^{Of}+\gamma^{If})}{\frac{y}{n}T(\theta_O)\frac{\varkappa}{y}}$$

then using the equation for wages:

$$w = (1-\vartheta)\left[(1-\varphi)x\frac{y}{n} + \frac{\varkappa(\gamma^{Oh}+\gamma^{Ih})}{(\gamma^{Of}+\gamma^{If})}\right] + \vartheta b$$

and equation (48) we have one equation in one unknown θ_O and its solution solves for the steady state of the model.

8.3 Loglinear conditions

State variables are 3: capital, employment and insider unemployment.

$$\widehat{n}_{t+1} = (1-\sigma)\widehat{n}_t + \frac{m_I}{n}\widehat{m}_{It} + \frac{m_O}{n}\widehat{m}_{Ot} \tag{A1}$$

$$\widehat{m}_{It} = \alpha\widehat{v}_t + (1-\alpha)\widehat{u}_t^I \tag{A2}$$

$$\widehat{m}_{Ot} = \alpha\widehat{v}_t + (1-\alpha)\widehat{u}_t^O \tag{A3}$$

$$\widehat{\gamma}_t^{Ih} = \widehat{m}_{It} - \widehat{u}_t^I \tag{A4}$$

$$\widehat{\gamma}_t^{Oh} = \widehat{m}_{Ot} - \widehat{u}_t^O \tag{A5}$$

$$\widehat{k}_{t+1} = (1-\delta)\widehat{k}_t + \delta\widehat{i}_t \tag{A6}$$

$$\widehat{u}_{t+1}^I = (1-\mu)\widehat{u}_t^I + \sigma\frac{n}{u^I}\widehat{n}_t - \frac{m_I}{u^I}\widehat{m}_{It} \tag{A7}$$

$$\widehat{ll}_t + n\widehat{n}_t + u^I\widehat{u}_t^I + u^O\widehat{u}_t^0 = 0 \tag{A8}$$

$$\frac{\eta}{\beta}\widehat{c}_t + \frac{\omega}{\beta}k_t = E_t\{\frac{\eta}{\beta}\widehat{c}_{t+1} - r\widehat{r}_{t+1} - \omega k_{t+2} + \frac{\beta\omega}{1+\beta}k_{t+1}\} \tag{A9}$$

$$\frac{\gamma^{Oh}\lambda_n}{\gamma^{Oh}\lambda_n + bc^{-\eta}}(\widehat{\gamma}_t^{Oh} + \widehat{\lambda}_{nt}) - \frac{\eta bc^{-\eta}}{\gamma^{Oh}\lambda_n + bc^{-\eta}}\widehat{c}_t = -\zeta\widehat{l}_t \tag{A10}$$

$$\lambda_u\widehat{\lambda}_{ut} = \beta E_t\{\gamma^{Ih}\lambda_n\widehat{\lambda}_{nt+1} + \gamma^{Ih}[\lambda_n - \lambda_u]\widehat{\gamma}_{t+1}^{Ih} + \lambda_u[(1-\mu) - \gamma^{Ih}]\lambda_{ut+1} + \phi\zeta l^{-\zeta}\widehat{l}_{t+1} - b\eta c^{-\eta}\widehat{c}_{t+1}\} \tag{A11}$$

$$\lambda_n\widehat{\lambda}_{nt} = \beta E_t\{wc^{-\eta}\widehat{w}_{t+1} - \eta wc^{-\eta}\widehat{c}_{t+1} + (1-\sigma)\lambda_n\widehat{\lambda}_{nt+1} + \sigma\lambda_u\widehat{\lambda}_{ut+1} + \phi\zeta l^{-\zeta}\widehat{l}_{t+1}\} \tag{A12}$$

$$\widehat{c}_t = E_t\widehat{c}_{t+1} - \frac{1}{\eta}(\widehat{R}_t - E_t\pi_{t+1}) \tag{A13}$$

$$\widehat{y}_t = \varphi\widehat{k}_t + (1-\varphi)[\widehat{z}_t + \widehat{n}_t] \tag{A14}$$

$$\widehat{\gamma}_t^{If} = \widehat{m}_{It} - \widehat{v}_t \tag{A15}$$

$$\widehat{\gamma}_t^{Of} = \widehat{m}_{Ot} - \widehat{v}_t \tag{A16}$$

$$\frac{1}{\gamma^{If}+\gamma^{Of}}\left[\gamma^{If}\widehat{\gamma}_t^{If}+\gamma^{Of}\widehat{\gamma}_t^{Of}\right]+\eta\widehat{c}_t=\eta E_t\widehat{c}_{t+1}+\frac{\gamma^{If}+\gamma^{Of}}{\varkappa}\beta(1-\varphi)x\frac{y}{n}E_t[\widehat{n}_{t+1}-\widehat{x}_{t+1}-\widehat{y}_{t+1}]+$$
$$\beta\frac{w(\gamma^{If}+\gamma^{Of})}{\varkappa}E_t\widehat{w}_{t+1}+\frac{1-\sigma}{\gamma^{If}+\gamma^{Of}}E_t\left[\gamma^{If}\widehat{\gamma}_{t+1}^{If}+\gamma^{Of}\widehat{\gamma}_{t+1}^{Of}\right]$$

$$w\widehat{w}_t = (1-\vartheta)(1-\varphi)x\frac{y}{n}\left[\widehat{x}_t+\widehat{y}_t-\widehat{n}_t\right]+(1-\vartheta)\frac{\varkappa}{\gamma^{If}+\gamma^{Of}}\left[\gamma^{Ih}\widehat{\gamma}_t^{Ih}+\gamma^{Oh}\widehat{\gamma}_t^{Oh}\right] \quad (49)$$
$$-(1-\vartheta)\frac{\varkappa(\gamma^{Ih}+\gamma^{Oh})}{\gamma^{If}+\gamma^{Of}}\left[\gamma^{If}\widehat{\gamma}_t^{If}+\gamma^{Of}\widehat{\gamma}_t^{Of}\right] \quad (50)$$

$$\pi_t=\beta E_t\pi_{t+1}+\frac{(1-\beta\psi)(1-\psi)}{\psi}\widehat{x}_t \quad (A19)$$

$$\widehat{R}_t=\xi_\pi\pi_t+\varepsilon_t^R \quad (A20)$$

$$\widehat{r}_t=\widehat{x}_t+\widehat{y}_t-\widehat{k}_t \quad (A21)$$

$$\widehat{y}_t=\frac{c}{y}\widehat{c}_t+\frac{i}{y}\widehat{i}_t+\frac{G}{y}\widehat{g}_t+\frac{\varkappa}{y}v\widehat{v}_t \quad (A22)$$

The model contains 22 equations in 22 unknowns ($n_t, m_{It}, m_{Ot}, v_t, u_{It}, u_{Ot}, \gamma_t^{Ih}, \gamma_t^{If}, \gamma_t^{Oh}, \gamma_t^{Of}$, $k_t, i_t, w_t, l_t, c_t, r_t, \lambda_{nt}, \lambda_{ut}, \pi_t, R_t, y_t, x_t$) and we solve it using the generalized Schur form.

8.4 Alternative models

8.4.1 Homogeneous agents and participation margin

For the homogeneous workers' model, there is one kind of unemployed workers. As a result, the variable u^I disappears and $u^O = u$. The matching function is given by: $m_t = \rho_m v^\alpha u^{1-\alpha}$ and agents maximize:

$$u(c_t,n_t)=\frac{c_t^{1-\eta}}{1-\eta}-\phi\frac{n_t^{1-\zeta}}{1-\zeta}$$

subject to (9), (7), and (12), and (1) becomes: $n_t + u_t = 1$.

With the participation margin, agents solve the same problem as in the benchmark economy with the only difference that $u^I = 0$. All models are parameterized to deliver comparable steady state values for the labor market variables.