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Hiring Stimulus and Precautionary Savings in a Liquidity Trap *

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Abstract

This paper assesses the ability of hiring subsidies to stimulate employment. I build a New Keynesian model with equilibrium unemployment and incomplete markets. Quantitatively, I find that an increase in hiring subsidies reduces unemployment more at the zero lower bound than it does during normal times. Central to this result is a precautionary savings channel. By stimulating labor demand, hiring subsidies reduce unemployment risk and precautionary savings. This increases the demand for consumption goods and generates inflationary pressures. At the zero lower bound, higher inflation expectations reduce the real interest rate, further stimulating consumption and hence amplifying the hiring stimulus.

Keywords: Unemployment risk, precautionary savings, hiring subsidies, zero lower bound

JEL Codes: E62, E21, E52

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1 Introduction

The current environment of low interests rates poses a challenge for monetary policy, since the presence of the zero lower bound limits the ability of central banks to lower nominal rates. This means that complementary stabilization policies may be needed. Hiring subsidies paid to firms have been widely used by advanced economies, including during the last financial crisis (OECD (2010)). The current paper assesses the ability of such hiring subsidies to stabilize employment. Doing so, it accounts for both their demand and supply-side effects.

Towards this end, I build a tractable New Keynesian model with equilibrium unemployment, sticky real wages (Hall (2005)), and incomplete markets as in Ravn and Sterk (2017). Firms, owned by perfectly-insured entrepreneurs, post vacancies to hire workers in a frictional labor market (Mortensen and Pissarides (1994)). Workers either earn labor income or receive unemployment benefits. Employed workers seek to self-insure against unemployment risk through inside risk-free bonds. A no-borrowing constraint means that, in equilibrium, every worker consumes her own current income. This renders the model analytically tractable.

In this framework, I assess the effects of a persistent increase in hiring subsidies. On the supply side, the hiring subsidies reduce firms' marginal costs and inflation. At a time when monetary policy is constrained, this channel alone would increase the real interest rate, reducing the effectiveness of the hiring stimulus. This finding is in line with the literature, which finds strong crowding-out effects of supply-side policies when monetary policy is constrained.[1] The demand-side effects, instead, are ambiguous. Two channels are at work. To the extent that wages rise but unemployment risk persists, employed workers wish to save more to smooth consumption. This consumption growth channel, through intertemporal substitution, depresses aggregate demand and employment rather than raising it. On the other hand, there is a precautionary savings channel. Namely, hiring subsidies reduce an employed worker's unemployment risk which stimulates

[1] For example, Eggertsson (2011) finds that labor tax cuts are contractionary at the zero lower bound in a representative agent framework.

demand. Quantitatively, I find that the precautionary demand-side channel dominates. This increase in aggregate demand raises inflation expectations, in spite of lower hiring costs, rendering hiring subsidies particularly effective when monetary policy is constrained.

More in detail, in order to transparently analyze the transmission mechanism of hiring subsidies and its interaction with precautionary savings I proceed in three steps. First, I consider a scenario with flexible prices. I find that the natural interest rate – the real interest rate prevailing with flexible prices – rises after the hiring stimulus. The increase in the natural interest rate results from the desire of households to reduce savings and increase consumption, showing that the precautionary savings channel dominates. In a second step I introduce sticky prices, such that aggregate demand affects equilibrium employment dynamics. I consider an increase in hiring subsidies during normal times, with an unconstrained central bank. In this case, I find that the fall in precautionary savings renders hiring subsidies inflationary, and that the higher demand for goods amplifies the employment expansion relative to the case with flexible prices. In a final step, I consider a liquidity trap experiment. I find that the inflationary pressures generated by the decline in precautionary savings reduce the real interest rate, further stimulating consumption and amplifying the hiring stimulus.

The previous logic suggests that absent the precautionary savings channel, hiring subsidies are less effective and deflationary. I verify this intuition in a representative agent economy. In normal times, absent the counteracting force of the decline in precautionary savings, the consumption growth channel significantly dampens the hiring stimulus. Yet, the central bank cuts the nominal interest rate in response to the deflationary pressures, reducing the real rate and hence sustaining the demand for consumption goods. At the zero lower bound, however, the deflationary forces raise the real interest rate. A higher real interest rate crowds-out consumption and renders hiring subsidies contractionary. [2]

The tractability of the model allows me to trace back this large disagreement between models to a second feature of incomplete markets: the intertemporal substitution motive

[2]This finding is in line with previous literature that has found that, in a complete markets framework, countercyclical supply policies can be contractionary in a liquidity trap (Eggertsson (2011)).

triggered by the hiring stimulus is substantially weaker with incomplete markets. The reason is as follows. The representative family internalizes in its budget constraint that temporarily more members are working. A single employed worker in the incomplete markets economy does not, as she is constrained by her *own* current income – the real wage. As a result, the income of the representative family increases more than that of a single worker when unemployment falls. Thus, the representative agent has a stronger desire to increase savings to smooth consumption and the consequent drop in demand and inflation is sharp. I show this by considering a perfect insurance benchmark where unemployment risk is absent owing to a generous unemployment insurance scheme, but maintains the same income volatility as in the imperfect insurance economy. In this perfect insurance model, the hiring stimulus is substantially dampened at the zero lower bound, as precautionary savings are absent, but far from the contraction predicted by the representative agent, since the current income of an employed worker moves little.

Related Literature

This paper relates to several strands of the literature. First, I contribute to the literature studying fiscal policies at the zero lower bound. Most of this research has been carried out in a complete markets framework, and hence entirely abstracting from the main channel highlighted in this paper. Woodford (2011) shows analytically how the government spending multiplier exceeds one under an interest rate peg, owing to the increase in inflation expectations. Christiano et al. (2011) quantify the government spending multiplier in a rich quantitative model. More broadly, Correia et al. (2013) show how to optimally circumvent the zero lower bound with sufficiently flexible taxes. More related to this paper, Eggertsson (2011) shows that supply-side policies, in particular labor tax cuts, are contractionary at the zero lower bound with a representative agent. I also find that, with complete markets, hiring subsidies can be detrimental at the zero lower bound, but show how precautionary savings can overturn this result. An exception to the previous papers is Kekre (2021). That paper shows how unemployment benefit extensions can be expansionary at the zero lower bound owing to a higher marginal propensity to consume of unemployed workers. Contrary to Kekre (2021), I focus on a precautionary savings channel and abstract from policies that directly redistribute income.

Second, my paper is related to the literature incorporating equilibrium unemployment into New Keynesian models. Examples are Blanchard and Galí (2010), Thomas (2008), Ravenna and Walsh (2011), and Faia (2009). These papers have predominantly focused on studying how frictional labor markets affect the optimal conduct of monetary policy in a complete markets framework. I contribute to this literature by showing that the interaction of unemployment and incomplete markets affects the transmission of other policies, hiring subsidies, in a New Keynesian framework.

Third, I contribute to literature focusing on heterogeneous agents with nominal rigidities. This literature has mainly analyzed how heterogeneity may shape and amplify demand disturbances. I, instead, show that accounting for incomplete markets is crucial to assess the effects of supply policies. Ravn and Sterk (2017) show how the feedback between precautionary savings and output can propagate labor market shocks, but they abstract from the zero lower bound and do not analyze supply-side policies. Ravn and Sterk (2020) study the equilibrium properties of the same model that I use in this paper. Importantly, they show analytically that contractionary TFP shocks can be deflationary in the presence of uninsured unemployment risk. They, however, abstract from hiring subsidies and their effects at the zero lower bound. Challe (2020) asks how monetary policy should be conducted when the same transmission mechanism is present. That paper finds that the optimal monetary policy response is to cut nominal rates after a contractionary productivity shock if there is imperfect insurance against unemployment, contrary to the result with complete markets. Relative to Challe (2020) I focus on the zero lower bound and explain how, in addition to precautionary savings, an intertemporal substitution channel shapes the differences between incomplete and complete markets. McKay and Reis (2021) find that uninsured unemployment risk calls for stronger automatic stabilizers in form of higher unemployment benefits. Relative to McKay and Reis (2021), I show how hiring subsidies can be used to insure workers as well by ensuring that job finding rates are high. Bayer et al. (2019) show how exogenous increases in idiosyncratic risk can lead to a recession, owing to a portfolio rebalancing channel from illiquid physical capital to liquid government bonds. I abstract from the portfolio choices of households, but allow the changes in idiosyncratic risk to be endogenous to labor market conditions and, hence, to policy. Gornemann et al. (2016) show in a richer model than the one that I consider how wealthy households favor an inflation-targeting monetary policy, in contrast to poorer households that are better off under a central bank that targets more unemployment volatility. Den Haan et al. (2018) shows how the presence of precautionary savings and sticky nominal wages can amplify business cycles. That paper also shows that unemployment benefits can help to stabilize the economy, but abstracts from supply policies as considered here.

Finally, I add to the literature studying labor market policies over the business cycle. Most of it has abstracted from nominal rigidities. For example, Jung and Kuester (2015) compute the optimal labor market policy-mix over the business cycle under flexible prices. They find that hiring subsidies should be increased in recessions. I show how the interaction of precautionary savings and sticky prices amplify the positive effects of this hiring stimulus. An exception is Campolmi et al. (2011), they study hiring subsidies with nominal rigidities and under an operating Taylor rule, with a representative agent. That paper finds that hiring subsidies can display larger multipliers than government spending, owing to the fact that the deflationary forces of the former induce a decline in the real rate in normal times. I show that these same deflationary forces can, with complete markets, render hiring subsidies contractionary at the zero lower bound. Cahuc et al. (2018) provide empirical evidence of the effectiveness of hiring subsidies enacted by France during the Great Recession.

The rest of the paper is organized as follows. Section 2 describes the economic environment. Section 3 calibrates the model. Section 4 presents the main quantitative results and mechanism. Section 5 concludes.

2 Model

The model builds on Ravn and Sterk (2017).[3] The main features are incomplete markets, nominal rigidities in the form of price stickiness and search and matching frictions in labor markets. There is some ex-ante heterogeneity, and by assumption there are perfectly-insured entrepreneurs, who own firms but do not work, and workers. As a result of incomplete financial markets there is heterogeneity ex-post, between employed and unemployed workers, giving rise to precautionary savings against unemployment risk. Because this risk depends on the measured slackness in the labor market, the need to self-insure fluctuates with economic activity and, consequently, it will be affected by policy.

2.1 Labor Market

There is a continuum of worker households of measure 1 indexed by i. At the beginning of the period there is a mass of N_{t-1} employed workers. Of these, an exogenous fraction δ separate from the firm and instantaneously join the pool of unemployed workers, at which point it becomes $1-(1-\delta)N_{t-1}$, ready to be hired within the same period. The labor market is frictional. Firms must open vacancies V_t in order to be matched with a currently unemployed worker. New matches are denoted by M_t and are formed according to the function:

$$M_t = \chi V_t^{1-\eta} \left(1 - (1-\delta) N_{t-1}\right)^{\eta}, \tag{1}$$

where $\eta \in (0,1)$ is the elasticity of matches with respect to unemployment and χ represents matching efficiency.

Labor market tightness is defined as the ratio of vacancies over unemployment $\theta_t \equiv V_t/(1-(1-\delta)N_{t-1})$. An unemployed worker finds a job with probability $f_t \equiv M_t/(1-(1-\delta)N_{t-1})$ and a vacancy is filled with probability $q_t \equiv f_t/\theta_t$. Therefore, the law of

[3]For similar frameworks see McKay and Reis (2021), Challe (2020), and Ravn and Sterk (2020).

motion for employment is given by:

$$N_t = (1-\delta) N_{t-1} + f_t (1 - (1-\delta) N_{t-1}) . \tag{2}$$

2.2 Households

The household sector is composed by two type of agents, entrepreneurs and workers. Workers can be either employed or unemployed $N_{i,t} \in \{1, 0\}$. Entrepreneurs have mass λ and are the shareholders of firms, but do not participate in the labor market. All households can save in a risk-free bond, subject to a no-borrowing constraint. In addition, firm-owners participate in the equity market and can trade firm shares with each other.

The problem of a worker is to choose consumption $C_{i,t}$ and savings $A_{i,t}$ subject to the budget constraint and the no-borrowing constraint:

$$V(N_{i,t}, A_{i,t-1}) = \max_{C_{i,t}, A_{i,t} \geq 0} \frac{C_{i,t}^{1-\sigma^{-1}} - 1}{1-\sigma^{-1}} + \beta_t \mathbb{E}_t V(N_{i,t+1}, A_{i,t}) \tag{3}$$

subject to

$$C_{i,t} + A_{i,t} = N_{i,t} W_t + (1 - N_{i,t}) B_t + A_{i,t-1} \frac{1+i_{t-1}}{1+\pi_t}, \tag{4}$$

where β_t is the, potentially time-varying, time discount factor. $1+i_t$ denotes the gross nominal interest rate paid on real risk-free bonds $A_{i,t}$, set by the monetary authority. $1+\pi_t = P_t/P_{t-1}$ is the gross inflation rate and P_t the price level of the consumption good. If employed, a worker receives a real wage W_t. On the other hand, when a worker falls into unemployment she receives unemployment benefits $B_t < W_t$ provided by the government.

The surplus of a worker is hence given by:

$$\Delta_{u,t}^{e} = V(1, A_{i,t-1}) - V(0, A_{i,t-1}) . \tag{5}$$

I denote by $C_{F,t}$ and $A_{F,t}$ the consumption and saving choices of the representative entrepreneur, who solves:

$$V\left(A_{F,t-1},X_{t-1}\right)=\max_{C_{F,t},A_{F,t}\geq 0}\frac{C_{F,t}^{1-\sigma^{-1}}-1}{1-\sigma^{-1}}+\beta_t\mathbb{E}_tV\left(A_{F,t},X_t\right) \tag{6}$$

subject to

$$\lambda C_{F,t}+\lambda A_{F,t}+P_{X,t}X_t=\left(P_{X,t}+D_t\right)X_{t-1}+\xi-\lambda A_{F,t-1}\frac{1+i_{t-1}}{1+\pi_t}-T_t, \tag{7}$$

where D_t are real dividends paid out by firms, to be specified below, ξ is home production and T_t a lump-sum tax paid to the fiscal authority. X_t denotes firm shares and $P_{X,t}$ their price.

The division between firm-owners and workers is motivated by the uneven distribution of income sources and equity holdings observed in the data. Whereas the majority of households earn mostly labor income, only a few have a significant share of financial income in their total income (see e.g. Gornemann et al. (2016)). This is not inconsequential, as the cyclicality of dividends affects the volatility of income and hence the consumption-saving choices of households in response to aggregate shocks.[4] Yet, in Appendix A.1, I show that the main conclusions of this paper are robust to allowing workers to receive financial income.

2.3 Firms

The supply side of the economy has three layers of production: competitive final good producers, that produce a final consumption good; wholesale good producers, that operate in monopolistic competition and face nominal rigidities; and competitive labor good firms, that hire workers in a frictional labor market.

[4] Broer et al. (2020) discuss the role of profits for the transmission of monetary policy shocks in a similar worker-capitalist framework.

Final Good Producers

Final good producers buy differentiated wholesale inputs $Y_{j,t}$ at price $P_{j,t}$ and bundle them into a homogeneous final consumption good Y_t using a CES technology $Y_t = \left(\int_0^1 Y_{j,t}^{\frac{\varepsilon-1}{\varepsilon}} dj\right)^{\frac{\varepsilon}{\varepsilon-1}}$, where $\varepsilon > 1$ measures the elasticity of substitution across goods. The final good is sold to households at competitive price P_t. The problem of the representative final good producer delivers a set of isoelastic demand functions:

$$Y_{j,t} = \left(\frac{P_{j,t}}{P_t}\right)^{-\varepsilon} Y_t, \tag{8}$$

and a price index $P_t = \left(\int_0^1 P_{j,t}^{1-\varepsilon} dj\right)^{\frac{1}{1-\varepsilon}}$.

Wholesale Good Firms

Wholesale good producers operate under monopolistic competition. They buy homogeneous labor goods at a competitive price P_t^J, expressed in terms of the consumption good. Using a linear technology, they convert them into differentiated wholesale goods. I denote by $Q_{t,t+1} = \beta_t \left(\frac{C_t^F}{C_{t+1}^F}\right)^{\sigma^{-1}}$ the discount factor of firms.

A typical wholesale firm j has per period real profits:

$$D_{j,t}^W = Y_{j,t}\left[\frac{P_{j,t}}{P_t} - P_t^J\right], \tag{9}$$

These firms face nominal rigidities à la Calvo. In particular, every period only a fraction $(1-\alpha)$ of firms is able to reset its price. In equilibrium, conditional on resetting their prices, all firms are alike and will behave in the same way, so we can drop the j subscript to summarize their optimal decisions. I denote by P_t^* the optimal price chosen by optimizing firms, in terms of final goods' price. This is given by:

$$P_t^* = \frac{\varepsilon}{\varepsilon - 1}\frac{P_t^A}{P_t^B} \tag{10}$$

where

$$P_t^A = Y_t P_t^J + \alpha \mathbb{E}_t \left(1 + \pi_{t+1}\right)^{\varepsilon} Q_{t,t+1} P_{t+1}^A, \tag{11}$$

$$P_t^B = Y_t + \alpha \mathbb{E}_t \left(1 + \pi_{t+1}\right)^{\varepsilon - 1} Q_{t,t+1} P_{t+1}^B. \tag{12}$$

Note in particular that in the limit of flexible prices $\alpha \to 0$, all firms set the same price every period, implying that the price for labor goods is constant $P_t^J = \frac{\varepsilon - 1}{\varepsilon}$. Next, using the price index we can express inflation as a function of P_t^*:

$$1 + \pi_t = \left[\frac{1}{\alpha} + \frac{\alpha - 1}{\alpha} \left(P_t^*\right)^{1-\varepsilon}\right]^{\frac{1}{\varepsilon - 1}}. \tag{13}$$

Finally, using the optimality conditions from the final good firms, together with its zero-profit condition, we can write total dividends paid to firm-owners by wholesale firms as:

$$D_t^W = \int_0^1 D_{j,t}^W dj = Y_t \left(1 - P_t^J \Delta_t\right), \tag{14}$$

where $\Delta_t = \int_0^1 \left(\frac{P_{j,t}}{P_t}\right)^{-\varepsilon} dj \geq 1$ measures price dispersion.

Labor Good Firms

Labor good firms are composed by a single worker and use a linear technology to produce labor goods. The value of a firm with a worker is denoted by J_t and given by the sum of operating profits, $P_t^J - W_t$, and the continuation value of the job:

$$J_t = P_t^J - W_t + (1 - \delta) \mathbb{E}_t Q_{t,t+1} J_{t+1}. \tag{15}$$

In order to produce, firms must hire a worker. Hiring a worker involves opening vacancies at a cost per vacancy κ_v. The government subsidizes vacancy posting at rate τ_t^v, such that by providing hiring subsidies it reduces the cost of posting vacancies. Free entry implies that, in equilibrium, a firm posts vacancies until the expected gains from not doing so are zero, that is:

$$\kappa_v (1 - \tau_t^v) = q_t J_t. \tag{16}$$

It is well-known that search and matching models as described here tend to deliver far too little unemployment volatility when wages are bargained according to a standard Nash protocol, featuring the so-called "Shimer Puzzle" (Shimer (2005)). A possible solution, consistent with the observed patters in the data, is to assume that real wages are sticky and fall to adjust sufficiently in recessions. I follow this approach and use a wage mechanism similar to Hall (2005) and Challe (2020), where the prevailing real wage is given by:

$$W_t = \left(W_t^{\text{Nash}}\right)^{1-\zeta} \left(W_{ss}\right)^{\zeta}, \tag{17}$$

where W_{ss} is the constant steady state wage and W_t^{Nash} is the solution to the Nash bargain problem between the firm and the worker:

$$W_t^{\text{Nash}} = \arg\max_{W_t} J_t^{\gamma} \left(\Delta_{u,t}^{e}\right)^{1-\gamma}, \tag{18}$$

where γ denotes the bargaining power of the firm and $\Delta_{u,t}^{e}$ is the surplus of a worker, defined in (5). Hence ζ controls the rigidity of the real wage.

Total dividends from labor good firms are given by total operating profits net of after-subsidies vacancy posting costs:

$$D_t^J = N_t \left(P_t^J - W_t\right) - (1 - \tau_t^v) \kappa_v V_t. \tag{19}$$

2.4 Government

The government is composed by a monetary and a fiscal authority. The monetary authority sets the nominal interest rates according to a Taylor rule that targets inflation deviations and is constrained by the zero lower bound. That is:

$$1 + i_t = \max \left\{ (1 + \bar{i}) \frac{\bar{\beta}}{\beta_t} (1 + \pi_t)^{\phi_\pi}, 1 \right\}, \tag{20}$$

where $\phi_\pi > 1$ is the endogenous response of the central bank to inflation, satisfying the Taylor principle, and $1 + \bar{i}$ is the gross nominal interest rate in steady state. $\bar{\beta}$ is the steady state value of the discount factor and β_t its time t value.

The government provides hiring subsidies to firms and unemployment benefits to unemployed workers, financed by levying lump-sum taxes on firm-owners:

$$T_t = \tau_t^v \kappa_v V_t + (1 - N_t) B_t. \tag{21}$$

2.5 Market Clearing

Equilibrium in the asset market requires that bonds are in zero net supply $\int_0^{1+\lambda} A_{i,t} di = 0 \; \forall t$ and the equity market clears $X_t = 1$ every period. Labor goods market clearing implies that $Y_t \Delta_t = N_t$. Finally, using the budget constraints of households and the government, we can write the resource constraint as:

$$N_t C_{e,t} + (1 - N_t) C_{u,t} + \lambda C_{F,t} = Y_t - \kappa_v V_t + \lambda \xi. \tag{22}$$

2.6 Equilibrium Implications

Since bonds are in zero net supply and borrowing is not allowed, the equilibrium allocation coincides with financial autarky. That is, in equilibrium no agent holds bonds and, as a consequence, every household consumes its *own* income period by period. In particular, employed workers consume the real wage $C_{e,t} = W_t$, unemployed the unemployment benefits $C_{u,t} = B_t$ and firm-owners $\lambda C_{F,t} = D_t + \xi - T_t$.

Consistency with a zero net demand for bonds, in turn, requires that the real interest rate is sufficiently low, so that every agent optimally chooses to not save. In order to characterize such equilibrium interest rate, it is convenient to spell out the Euler equations characterizing the optimal saving choices of employed workers, unemployed workers and firm-owners, respectively:

$$1 \geq \mathbb{E}_t \beta_t \frac{1+i_t}{1+\pi_{t+1}} \left\{ [1-\delta(1-f_{t+1})] \left(\frac{C_{e,t}}{C_{e,t+1}} \right)^{\frac{1}{\sigma}} + \delta(1-f_{t+1}) \left(\frac{C_{e,t}}{C_{u,t+1}} \right)^{\frac{1}{\sigma}} \right\}, \tag{23}$$

$$1 \geq \mathbb{E}_t \beta_t \frac{1+i_t}{1+\pi_{t+1}} \left[f_{t+1} \left(\frac{C_{u,t}}{C_{e,t+1}} \right)^{\frac{1}{\sigma}} + (1-f_{t+1}) \left(\frac{C_{u,t}}{C_{u,t+1}} \right)^{\frac{1}{\sigma}} \right], \tag{24}$$

$$1 \geq \mathbb{E}_t \beta_t \frac{1+i_t}{1+\pi_{t+1}} \left(\frac{C_{F,t}}{C_{F,t+1}} \right)^{\frac{1}{\sigma}}, \tag{25}$$

where the above equations hold with strict inequality if the no-borrowing constraint is binding.

Focusing on the steady state, note that employed workers have the strongest savings motive as they face the downward idiosyncratic risk of falling into unemployment. Unemployed workers, however, may become employed and hence would like to borrow against their higher future income. Consequently, they would be only willing to hold bonds at a higher steady-state real interest rate than employed workers. More formally, evaluating (23) and (24) at the steady state, and denoting by r^{eq} the equilibrium interest rate at which every agent optimally chooses to not save we obtain:

$$\frac{1}{1+r^{eq}} \geq \frac{1}{1+r*} = \beta \left\{ 1 + \delta(1-f) \left[\left(\frac{C_e}{C_u} \right)^{\frac{1}{\sigma}} - 1 \right] \right\} > \beta \left\{ 1 - f \left[1 - \left(\frac{C_u}{C_e} \right)^{\frac{1}{\sigma}} \right] \right\}, \tag{26}$$

where I have denoted by r^* the real interest rate that leaves employed workers indifferent between holding or not holding bonds, and where the second inequality follows from $C_e > C_u$. It follows that, at the equilibrium interest rate r^{eq}, currently unemployed workers would like to borrow and consequently will be off their Euler equation.

On the other hand, firm-owners face no idiosyncratic risk as they do not participate in the labor market. Hence, they are unwilling to save at any steady-state real interest rate below their time preference rate $1/\beta$. Again, evaluating their Euler equation for the bond (25), we obtain:

$$\frac{1}{1+r^{eq}} \geq \frac{1}{1+r*} = \beta \left\{ 1 + \delta(1-f) \left[\left(\frac{C_e}{C_u} \right)^{\frac{1}{\sigma}} - 1 \right] \right\} > \beta, \tag{27}$$

and, as consequence, firm-owners will be off their Euler equation as well. [5]

It follows, hence, that the agents willing to save at the lowest interest rate are employed workers, owing to their precautionary savings motive. In particular, note that any real interest rate below r^* is consistent with a zero net demand for bonds. However, any $r^{eq} < r^*$ is not robust to the introduction of an arbitrarily small amount of positive supply of liquidity, for which there must be at least one agent willing to hold it.[6] Therefore, I focus on the equilibrium defined by $r^{eq} = r^*$, implying that employed workers price the bond and their Euler equation (23) holds with equality.

Following much of the literature, I will focus on fluctuations around this steady state as result of small aggregate shocks, and hence assume that the relevant equilibrium condition is still given by the Euler equation of employed workers.

2.7 Benchmark Economies

In order to illustrate the transmission mechanism of hiring subsidies to employment in the imperfect insurance economy previously described, I confront its predictions with two benchmark economies.

[5]Note that, as emphasized in Ravn and Sterk (2020), the equilibrium allocation resulting in this model, where consumption equals income, does not necessarily imply that all agents have a marginal propensity to consume (MPC) of one. In partial equilibrium, firm-owners can use their equity holdings to smooth transitory income fluctuations. The model can be easily extended to reduce the MPC of employed workers as well, while obtaining the same equilibrium implications. Suppose that agents could borrow up to a fraction ϑ of their labor income, $A_{i,t} \geq -\vartheta W_t$, such that only employed workers could borrow. This formulation also implies that, in equilibrium, every agent in the economy consumes her own current income. However, the presence of debt would imply that only unemployed workers have an MPC of one, as in partial equilibrium employed workers can now borrow to smooth transitory income shocks.

[6]See Werning (2015) and Krusell et al. (2011).

2.7.1 Representative Agent Economy

First, I consider an economy populated by a representative agent, or alternatively with complete markets and no ex-ante heterogeneity. The Euler equation of the representative household reads:

$$C_t^{-\sigma^{-1}} = \mathbb{E}_t \beta_t \frac{1 + i_t}{1 + \pi_{t+1}} C_{t+1}^{-\sigma^{-1}}, \tag{28}$$

where C_t denotes aggregate consumption. The aggregate resource constraint states that total consumption must equal aggregate production net of resources spent on hiring:

$$C_t = Y_t - \kappa_v V_t. \tag{29}$$

The imperfect insurance economy differs from the representative agent along two key dimensions that, as I will show, shape the effects of hiring subsidies on employment. Both are related to the presence of incomplete financial markets.

With incomplete markets, the lack of risk-sharing implies that the consumption of a worker is constrained by her *own current income*. This has two consequences. First, the income drop upon unemployment should be absorbed to some extent by consumption, which implies that workers have a precautionary savings motive. Second, conditional on being employed, she only consumes her income – the real wage. Consequently, the budget constraint of an employed worker is not directly affected by the fact that, during a hiring stimulus, more households may be working.

Complete markets break both features. Perfect risk-sharing in the economy is analogous to all workers pooling their own current income within the representative family. Hence, each worker consumes a constant fraction of *current aggregate income*, regardless of her employment status. Consequently, the precautionary savings motive vanishes, rendering the representative agent economy a natural benchmark to test the predictions of the imperfect insurance model. Second, owing to this income pooling result of full risk-sharing, the representative household internalizes in its budget constraint that more family's members may be working during a hiring stimulus. This implies that its income fluctuates through the number of workers and not only through the the real wage. Thus, even abstracting from precautionary savings, the saving choices of a single worker in the incomplete markets economy might differ substantially from that of the representative family owing to their different income volatility.

2.7.2 Perfect Insurance Economy

In order to tell these two dimensions apart – precautionary savings and income volatility – I consider a second benchmark, that I label perfect insurance. In this perfect insurance model, I keep the worker-entrepreneur structure of the imperfect insurance model and incomplete financial markets, but I set unemployment benefits B_t very close to the current real wage W_t in the calibration.[7] Effectively, this high level of unemployment benefits eliminates the precautionary savings motive, but precludes the income pooling arising in the representative agent model. This allows me to break down the disagreement between complete and incomplete markets into two pieces. First, comparing the perfect insurance economy with the imperfect insurance model I will be able to pin down the implications of unemployment risk for the transmission of hiring subsidies. Second, confronting the representative agent model with the perfect insurance economy allows me to discern the consequences of the different income volatility previously discussed.

3 Calibration

I calibrate the model to the U.S. economy. One period of the model refers to one quarter. The values of parameters are collected in Table 1. These, in the incomplete markets economy with imperfect insurance, are chosen as follows. Regarding the labor market, I set the separation rate δ to 0.10, as in e.g. Gornemann et al. (2016). I set the matching efficiency χ to target an employment rate in steady state of 94%, implying $\chi = 0.66$. The elasticity of new matches with respect to unemployment η is set to 0.5, in the ballpark

[7] A similar benchmark economy is used in Challe (2020).

of estimates of Petrongolo and Pissarides (2001). The bargaining power of firms γ is set to target steady state operating profits of 1%, compare to Hagedorn and Manovskii (2008) and Shimer (2005). This implies $\gamma = 0.40$. I calibrate the vacancy posting cost κ_v to target a vacancy filling rate in steady state of 71%, as in Den Haan et al. (2000). Regarding the New Keynesian block of the model, I set the probability of not readjusting prices α to 0.80, implying that on average firms readjust their prices every five quarters, similar to e.g. Gornemann et al. (2016). The elasticity of substitution across goods ε is set to 6, implying a steady state markup of 20%, a common value in the literature. The response of nominal rates to inflation ϕ_Π is set to 1.5. As regards the household side, I set the relative risk aversion parameter $1/\sigma$ to 1.5 as in Ravn and Sterk (2017). I choose a value for the relative risk aversion parameter somewhat lower than that used in the heterogeneous agents literature (e.g. Bayer et al. (2019), Kaplan and Violante (2014)) in order to mitigate the impact of the absence of positive liquidity in my framework. The steady-state time discount factor $\bar{\beta}$ is chosen to match an annualized real interest rate of 3% in the steady state.

A crucial parameter that determines the strength of precautionary savings is the consumption drop upon unemployment, given by the gap between the real wage W_t and unemployment benefits B_t. This matters along two dimensions. First, how large the income drop is at a given point in time. Second, how this income drop changes over the business cycle. I shut down the latter effect by assuming that the unemployment insurance scheme is defined by a constant replacement rate b over the real wage. That is, the government provides unemployment benefits according to $B_t = bW_t$. This allows me to transparently isolate the change in precautionary savings arising only from the amount of slackness in the labor market. In Appendix A.1, I explore the consequences of relaxing this assumption and show that the main results remain unaffected.

Chodorow-Reich and Karabarbounis (2016) find that consumption on non-durable goods and services declines by about 21% during an unemployment spell. On the other hand, Ganong and Noel (2019) report that the consumption drop on the onset of an

Param.	Description	Imperfect Insurance	Perfect Insurance	Rep. Agent	Source/Target
η	Elasticity of M_t wrt V_t	0.50	0.50	0.50	Standard value
δ	Separation rate	0.10	0.10	0.10	Gornemann et al. (2016)
ε	Elasticity of subs.	6.00	6.00	6.00	Markup 20%
ϕ_π	Taylor rule	1.50	1.50	1.50	Standard value
b	Replacement rate	0.90	0.99	0.90	Cons. drop upon unempl.
$1/\sigma$	Risk aversion	1.50	1.50	1.50	Ravn and Sterk (2017)
β	Discount factor	0.98	0.99	0.99	Interest rate s.s. 3%
α	Price stickiness	0.80	0.80	0.80	Mean price duration of 5q.
κ_v	Vacancy posting cost	0.06	0.06	0.06	$q = 0.71$
χ	Matching efficiency	0.66	0.66	0.66	$N = 0.94$
γ	Bargaining power of firm	0.40	0.88	0.43	Operating profits of 1%
ξ	Home prod. entr.	1.20	1.20	0.00	Income share of top 20%
ζ	Wage rigidity	0.54	0.55	0.55	Elasticity of real wage

Table 1: Calibrated parameters.

Notes: The table shows the calibrated parameters. See the main text for a discussion of the calibration targets.

unemployment spell is approximately 6%. I target an intermediate value and set $b = 0.90$, implying a consumption drop of 10% upon unemployment in the baseline calibration. [8]

I identify the group of entrepreneurs or firm-owners with the top 20% of the income distribution. I choose their home production level ξ to match their income share $\lambda C_{F,t}/(\lambda C_{F,t} + N_t C_{e,t} + (1 - N_t)C_{u,t})$. I target an income share of 61.4% (Rios-Rull and Kuhn (2016)), leading to $\xi = 1.20$.

Finally, I calibrate the parameter controlling wage rigidity ζ to match an elasticity of real wages with respect to productivity shocks and flexible prices of 0.45, following Hagedorn and Manovskii (2008). This delivers $\zeta = 0.54$.

In order to be as transparent as possible, I recalibrate the representative agent and perfect insurance models to ensure that they share the same steady state and wage cyclicality of the baseline imperfect insurance economy. In the perfect insurance model

[8] In Appendix A.1 a provide I sensitivity analysis with respect to this parameter. Results are robust unless that the consumption drop upon unemployment is substantially below the empirical estimates.

I set the replacement rate b equal to 0.99 as to quantitatively shut down the effect of precautionary savings. This implies that the discount factor $\bar{\beta}$ increases to 0.992, as in the representative agent economy, in order to match the targeted steady state real rate. Given that the higher replacement rate implies a lower surplus of working, the bargaining power of firms increases to $\gamma = 0.88$. In the representative agent economy, with $b = 0.90$, I set $\gamma = 0.43$ to target the same operating profits as in the baseline imperfect insurance model. The wage rigidity parameter ζ slightly increases to 0.55 in the perfect insurance model and in the representative agent case.

4 Quantitative Analysis

In order to clarify the transmission of hiring subsidies to employment, and how this is shaped by precautionary savings, I proceed in three steps. First, I show the impact of subsidizing hiring with flexible prices. Second, I consider the case of sticky prices and an unconstrained central bank. Finally, I show the effects of a hiring stimulus in a liquidity trap.

Owing to the non-linearity introduced by the zero lower bound, standard solution methods are not well-suited for the liquidity trap analysis. As such, I follow McKay et al. (2016) and consider perfect-foresight shocks, solving the model non-linearly. Similar approaches are used in the literature (e.g. Christiano et al. (2011)). In order to enhance comparability between exercises, I use the same solution method even when I consider the flexible prices scenario and the sticky prices case away from the zero lower bound.

The shock that I consider is as follows. At time $t-1$ the economy is in the non-stochastic steady steady state, where hiring subsidies are zero. At time t the government unexpectedly increases hiring subsidies τ_t^v to 10% on impact.[9] They decline exponentially with persistence of $\rho_\tau = 0.85$.[10] That is, at time $t+k$, the hiring subsidy is $\tau_{t+k}^v = \rho_\tau^{t+k}\tau_t^v$.

[9] The size of the initial increase is chosen such that figures in the analysis are visually informative. Results are unaffected by considering alternative magnitudes of the initial increase in hiring stimulus.

[10] The persistence of the stimulus in line with the persistence of government spending shocks (e.g. Nakamura and Steinsson (2014)). Appendix A.1 provides a sensitive analysis with respect to this parameter.

I will consider the same path for hiring subsidies, in terms of size and persistence, in all exercises.

4.1 Flexible Prices

Figure 1 shows the impulse responses to a hiring stimulus with flexible prices in the imperfect insurance economy and the two benchmark models, the perfect insurance model and the representative agent economy. The fall in hiring costs generated by the government induces firms to post more vacancies. As a consequence, aggregate employment increases, observe the first column of Figure 1. Since prices are flexible, the possible differences in consumption-savings decisions of households between the three economies do not feedback into output and hence the increase in employment is symmetric across all three models.

The second column of Figure 1 shows that the behavior of the natural interest rate – the real interest rate prevailing with flexible prices – notably differs across models. In the imperfect insurance economy, first row of Figure 1, the natural interest rate increases significantly. In sharp contrast, the natural interest rate persistently falls in the two benchmark economies, observe the last two rows of the second column in Figure 1. Yet, the magnitude of the drop of the natural interest rate is substantially larger under the representative agent model than in the perfect insurance economy.

As firms post more vacancies and labor market tightness increases, the outside option of the worker improves. Consequently, as shown in the last column of Figure 1, the real wage increases. Since the increase in employment, and hence in labor market tightness, is similar in the three economies, so it is the rise in the real wage.

In the imperfect insurance economy and the perfect insurance model, employed workers only consume the real wage in equilibrium. Accordingly, the consumption of a single worker increases in lockstep with the real wage in these economies, compare the third and fourth column in the first two rows in Figure 1. The increase in consumption of a single worker stands in sharp contrast with that of the representative agent, compare to the third panel of last row in Figure 1. The reason is that the representative agent internalizes in its budget constraint that more family members are working. Consequently,

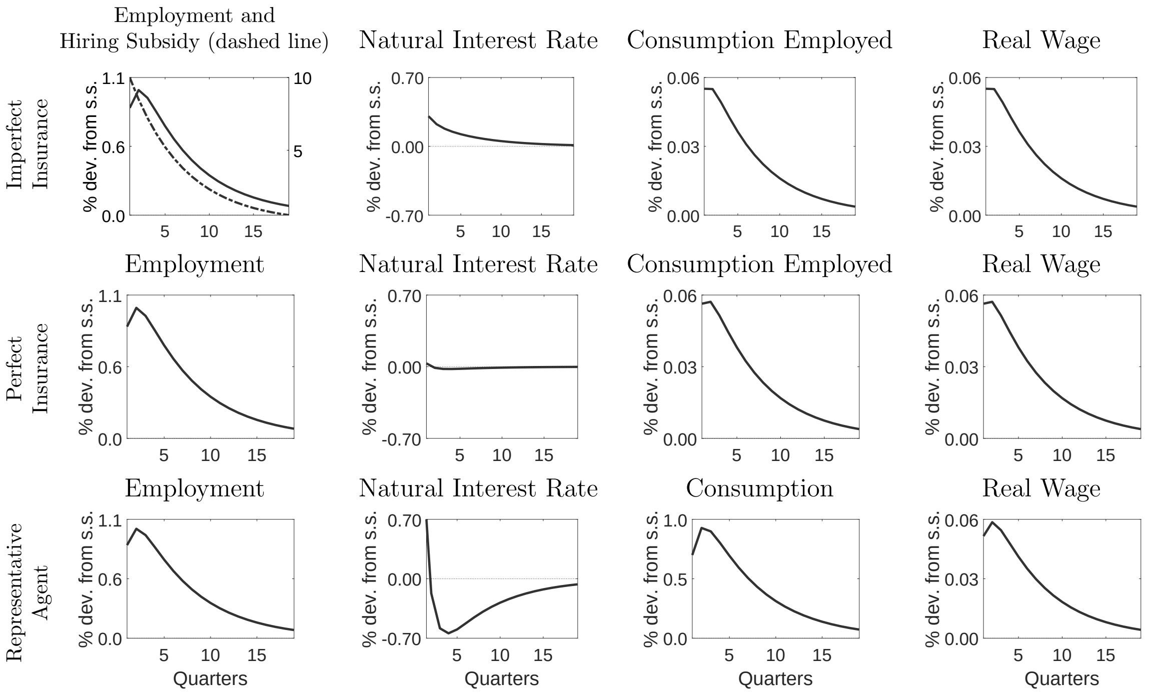

Figure 1: Effect of an Increase in Hiring Subsidies with Flexible Prices

Notes: Impulse responses to an increase in hiring subsidies with flexible prices. The path for the hiring subsidy is depicted in the first panel of the first row with a dashed line. The first row shows impulse responses in the imperfect insurance economy. The second row displays the results in the perfect insurance economy. The last row plots the impulse responses in the representative agent model. In the imperfect insurance and perfect insurance economies, "Consumption Employed" refers to the impulse response of the consumption of a single employed worker. The natural interest rate is the real interest rate prevailing with flexible prices and is reported in annualized level deviations.

its consumption closely tracks aggregate employment, compare the first and third panel of the last row in Figure 1.

In sum, Figure 1 shows that although the response of aggregate employment with flexible prices does not depend on the details of the household side, the behavior of the natural interest rate crucially does. The natural interest rate, in turn, adjusts to ensure that the asset market clears without further adjustments in income. As such, it constitutes a useful summary statistic to understand households' savings decisions in each economy. In order to build intuition and understand the large disagreement in the behavior of the natural interest rate found in Figure 1 it is instructive to log-linearize the Euler equation (23) with flexible prices:

$$\sigma \underbrace{\widehat{R}_t^n}_{\text{Natural Rate}} = \underbrace{\mathbb{E}_t \left(\widehat{c}_{e,t+1} - \widehat{c}_{e,t}\right)}_{\text{Consumption Growth}} + \underbrace{\sigma\Gamma\mathbb{E}_t\widehat{f}_{t+1}}_{\text{Precautionary Savings}} \tag{30}$$

with

$$\Gamma = \beta(1+\bar{r})f\delta(b^{-\frac{1}{\sigma}} - 1) \geq 0,$$

where letters with hats denote percentage deviations from steady-state values.[11] Equation (30) states that the natural interest rate is shaped by two forces.[12]

First, there is a *consumption growth channel*. Temporarily higher income – hence, in equilibrium, consumption –, implying that the first term on the right-hand side is negative, puts downward pressure on the natural interest rate. This force triggers intertemporal substitution, inducing households to increase savings to smooth consumption and leading to a drop in the real interest rate. Second, there is a *precautionary savings channel*, the main focus of this paper.[13] This channel states that higher future job-finding rates reduce unemployment risk, inducing households to cut back on precautionary savings, and hence raising the natural rate. The strength of this channel is governed by Γ. In particular, this channel disappears in the two benchmark economies where the consumption drop upon unemployment vanishes.

To understand how the previous two channels interact in equilibrium, suppose that the government temporarily raises hiring subsidies. As firms hire more, the labor market gets tighter, increasing real wages. Temporarily higher real wages induces households to increase savings, putting downward pressure on the natural interest rate. However, as the job-finding rate increases, workers expect to find jobs quickly, and hence unemployment

[11]For expositional clarity I abstract here from a time-varying discount factor β.

[12]Challe (2020) offers the same decomposition to show how the presence of precautionary savings affects the behavior of the natural interest rate in face of productivity and cost-push shocks.

[13]It is worth emphasizing at this point that "precautionary savings" in this paper are understood as the increased desire of the household to hold savings in response to an increase in household income risk, driven by a drop in the job-finding rate. Note that this event has a first-order effect due to the presence of borrowing constraints and, therefore, would be present even if preferences exhibited no "prudence" (Kimball (1990)). See Challe and Ragot (2016) for a similar point.

risk falls. As a consequence, households reduce precautionary savings, bidding up the natural interest rate. In sum, after an increase in hiring subsidies, the consumption growth channel and the precautionary savings channel operate in opposite directions, and the net effect on the natural interest rate depends on relative strength of each of them.

As shown in Figure 1, the natural interest rate increases in the imperfect insurance economy. This implies that the precautionary savings channel dominates. Absent precautionary savings, as in the two benchmark economies, the consumption growth channel illustrated in equation (30) leads to a persistent fall in the natural interest rate.

The strength of the consumption growth channel, in turn, explains the quantitative difference in the fall of the natural interest rate between the two benchmark economies. The reason is as follows. The representative agent, owing to full risk-sharing that results from complete financial markets, internalizes in its budget constraint that more family members are working after the hiring stimulus. A single worker in the perfect insurance economy – as well as in the imperfect insurance model – does not. Owing to incomplete financial markets, she is constrained by her *own* current income – the real wage. As a consequence, the income of the representative agent rises significantly more than that of a single worker. Therefore, the desire to increase savings of the representative family is larger, the consumption growth channel stronger, and the fall of the natural interest rate deeper.[14]

The interaction between a weak consumption growth channel and a significant fall in unemployment risk explains the large disagreement in the behavior of the natural interest rate between the imperfect insurance economy and the representative agent model found in Figure 1. Of this gap, the importance of the precautionary savings channel is given by the difference between the perfect insurance and imperfect insurance economies – compare the second panel of the first two rows in Figure 1 – as both economies share the

[14]Exercises provided in Appendix A.1 further illustrate this channel. In particular, I show that when real wages are perfectly flexible the consumption growth channel becomes stronger, dampening the precautionary savings channel, but the latter effect still dominates. Furthermore, I show that the weaker consumption growth channel in the incomplete markets economy is not a consequence of dividends being allocated to firm-owners, but rather a result of more family members working in the representative agent model.

same consumption growth channel, compare the third panel of the first two rows. The remaining difference between the imperfect insurance model and the representative agent is accounted by the distinct consumption growth channel, which can be approximated as the difference between the representative agent economy and the perfect insurance model – compare the second panel of the last two rows in Figure 1 – since none of these two economies feature precautionary savings and they only differ in their income volatility.

4.2 Sticky Prices

The different optimal saving choices of households did not feed back into employment and output with flexible prices. I introduce next sticky prices, such that aggregate demand affects equilibrium employment dynamics. I start by considering the effects of an increase in hiring subsidies with an unconstrained central bank. Figure 2 shows the results in the three economies. The first row shows the results in the imperfect insurance economy. The second row displays the impulse responses in the perfect insurance model, and the third row shows the results in the representative agent economy.

The increase in hiring subsidies reduces firms' marginal costs and stimulates aggregate supply. This channel, alone, would reduce inflation. The effects on aggregate demand, instead, are ambiguous, as discussed in the previous section. In the imperfect insurance economy, as shown previously, the precautionary savings channel dominates. Therefore, the hiring stimulus induces households to increase their demand for consumption goods. With sticky prices, the higher demand for goods generates inflationary pressures in the economy, observe the third panel of the first row in Figure 2. In response to higher inflation, the central bank raises the nominal interest rate, increasing the real rate, as shown in the second panel of the first row.

The behavior of inflation in the imperfect insurance economy stands in sharp contrast with the deflationary forces witnessed in the two benchmark models, observe the third panel of the last two rows in Figure 2. Absent the precautionary savings channel, the decline in firms' hiring costs reduce inflation. Furthermore, the consumption growth channel contains aggregate demand, reinforcing the deflationary pressures. According

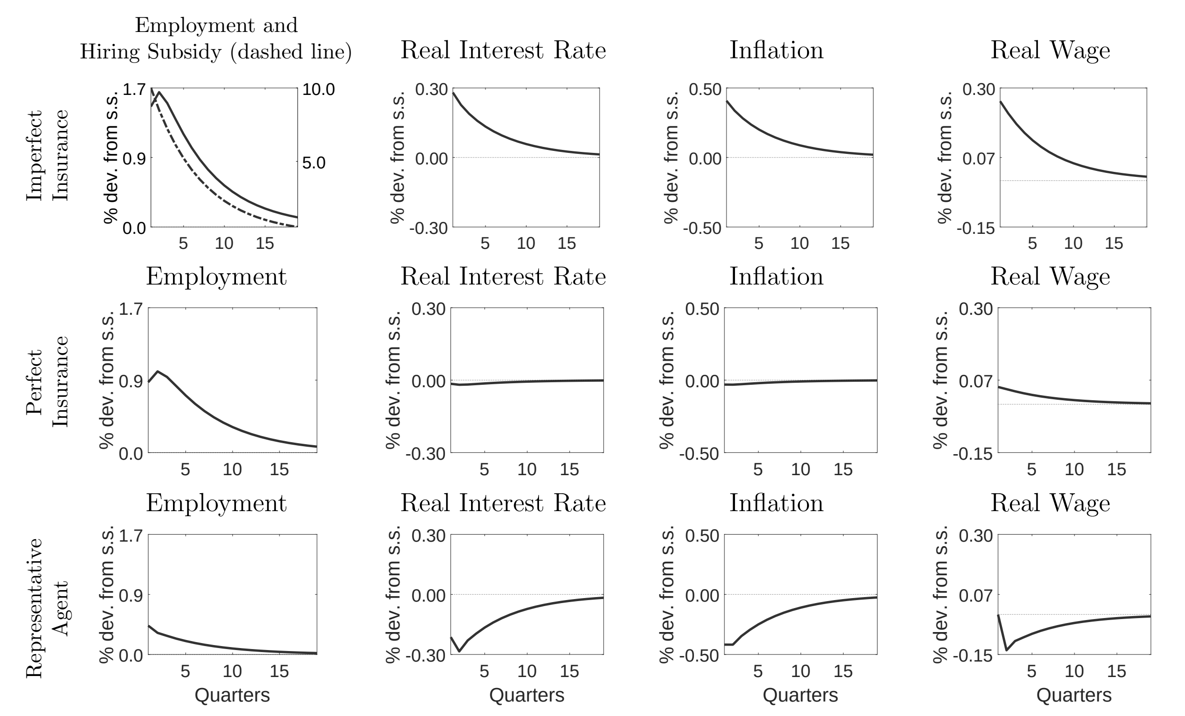

Figure 2: Effect of an Increase in Hiring Subsidies with Sticky Prices

Notes: Impulse responses to an increase in hiring subsidies with sticky prices and away from the zero lower bound. The path for the hiring subsidy is depicted in the first panel of the first row with a dashed line. The first row shows impulse responses in the imperfect insurance economy. The second row displays the results in the perfect insurance economy. The last row plots the impulse responses in the representative agent model. In the imperfect insurance and perfect insurance economies, "Consumption Employed" refers to the impulse response of the consumption of a single employed worker. The real interest rate and inflation are reported in annualized level deviations.

to the Taylor rule (20), the central bank cuts the nominal interest rate, inducing the real interest rate to fall, observe the second panel of the last two rows. In annualized terms, inflation drops about 0.42 percent in the representative agent economy, whereas it increases by roughly the same magnitude in the imperfect insurance model. In the perfect insurance framework, it barely falls by 0.03 percent. Similar to the previous section, the large quantitative difference between the imperfect insurance economy and the perfect insurance model underscores the relevance of the precautionary savings channel.

The different consumption response of households has now, with sticky prices, real effects on aggregate employment. The first column of Figure 2 shows that the employment response sharply differs across economies. More precisely, the drop in precautionary

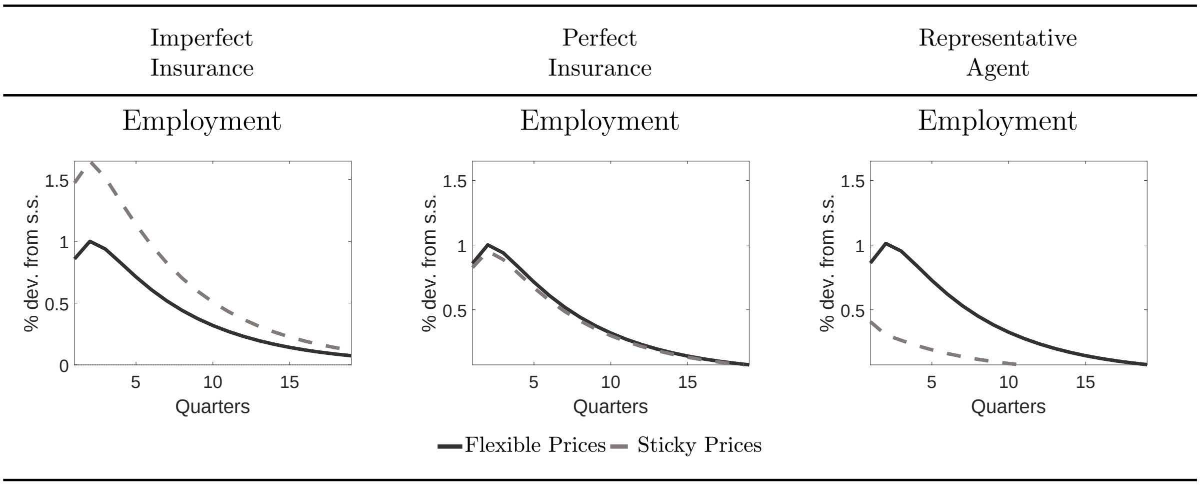

Figure 3: Flexible Prices vs. Sticky Prices

Notes: Black solid lines show the effects of increasing hiring subsidies when prices are flexible and gray dashed lines display the impulse responses to the same hiring subsidy shock when prices are sticky in the imperfect insurance economy (first panel), the perfect insurance model (second panel), and the representative agent economy (third panel).

savings and increase in demand for consumption goods implies that employment in the imperfect insurance economy increases three times as much as it does in the representative agent model. The perfect insurance model lies between these two, as the precautionary savings channel is absent, but lacks the strong consumption growth channel present in the representative agent economy.

Figure 3 compares the responses with sticky prices, displayed with solid black lines, and flexible prices, shown with dashed gray lines. The first panel in Figure 3 shows that sticky prices amplify the hiring stimulus in the imperfect insurance economy. This is a consequence of the increase in the demand for consumption goods generated by the fall in unemployment risk. Absent the precautionary savings channel, the hiring stimulus is dampened with sticky prices, observe the second and third panels in Figure 3. Again, the stronger consumption growth channel triggered by the hiring stimulus explains the substantial dampening observed with a representative agent, relative to the perfect insurance model.

Yet, as we can observe in Figure 2, hiring subsidies succeed in bringing down unemployment rates in all three economies. Crucially, I have assumed that the central bank could respond to the dynamics of inflation. In particular, absent precautionary savings, the monetary authority lowers the nominal rate more than one for one with inflation, reducing the real rate and sustaining the demand for goods. In the imperfect insurance model, it raises the nominal rate, therefore setting back the higher consumption demand that follows the decline in unemployment risk. Next, I ask what happens when the central bank is constrained and cannot freely adjust the nominal interest rate.

4.3 Liquidity Trap

Once that the transmission mechanism of hiring subsidies with flexible and sticky prices is clear, the effects at the zero lower bound will become straightforward. In order to generate a liquidity trap, I assume that the discount factor increases on impact from its steady state value $\bar{\beta}$ to $\beta_t = \bar{\beta} + 0.018$ and then reverts back to steady state with persistence 0.9.[15]

Figure 4 displays the results of the liquidity trap experiment. Solid black lines shows the impulse responses to the discount factor shock in isolation, absent any intervention from the fiscal authority. Dashed gray lines, instead, show the path for variables when, at the same times as the demand shock hits, the government provides hiring subsidies, as described in previous experiments. The first row shows the results in the imperfect insurance economy. The outcomes in the perfect insurance model are depicted in the second row. The third row captures the results in the representative agent economy.

Focusing first on the solid black lines, with no hiring stimulus, we observe that the discount factor shock leads to a large decline in employment, as shown in the first column of Figure 4. The discount factor shock induces households to be more patient, and therefore their current demand for consumption goods declines. As goods' demand falls, inflation drops and the central bank cuts the nominal interest rate until it hits the zero lower bound, observe the second and third column of Figure 4.

[15]The size and persistence of the discount factor shock are chosen such that the zero lower bound binds for several periods. The implications of the duration of the zero lower bound are discussed further below.

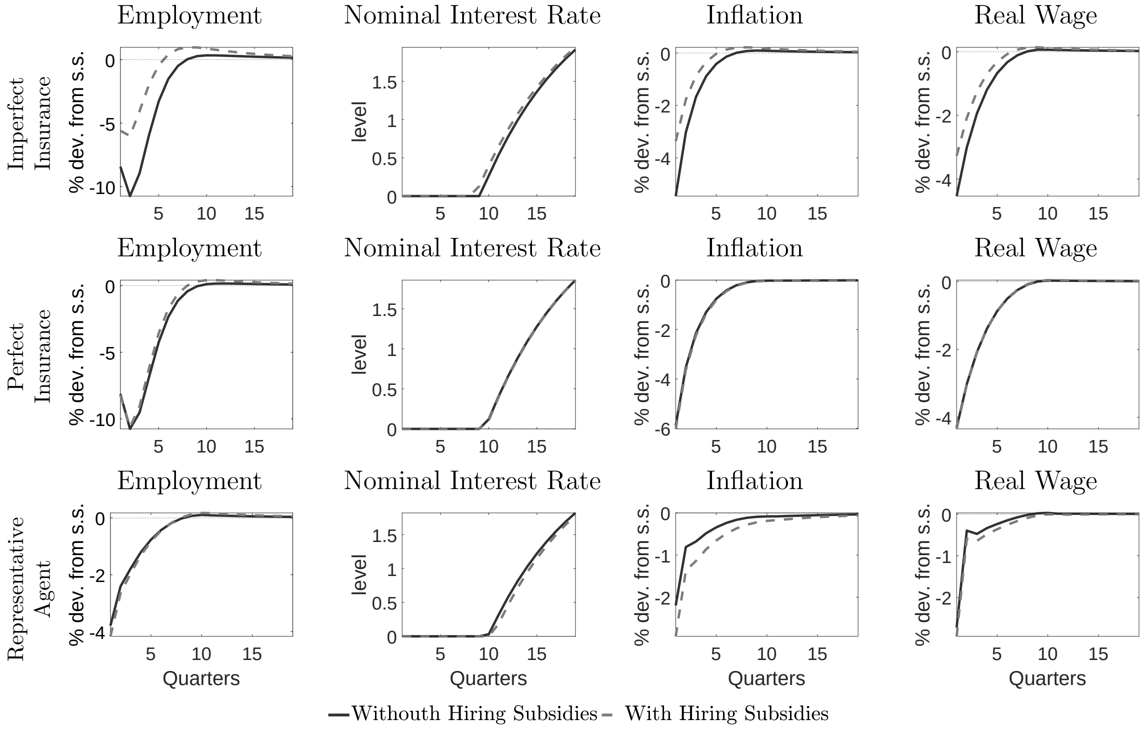

Figure 4: Liquidity Trap

Notes: Impulse responses to discount factor shock that makes the zero lower bound bind, as described in the main text, with and without hiring subsidies. Black solid lines show the effects of the discount factor shock absent any response from the fiscal authority. Gray dashed lines display the impulse responses when the discount factor shock is accompanied by the same increase in hiring subsidies as displayed in Figure 1 and Figure 2.

Comparing the three rows of the first column of Figure 4 we observe that the magnitude of the recession differs across the three economies. The zero lower bound prevents the central bank from providing enough accommodation. Hence, in order to ensure that the asset market clears, the current income of savers needs to decline. In the representative agent economy, this implies that employment must fall sufficiently. In the imperfect insurance and perfect insurance models, this requires the income of employed workers – the savers in these models – to fall. That is, the real wage must decline enough. Since the real wage is sticky, this requires the labor market tightness, and hence employment, to fall markedly. This explains the large differences in the employment contraction observed across economies.

Can hiring subsidies curb the large employment losses depicted in Figure 4? Dashed gray lines in the first column provide the answer to this question. Visual inspection reveals a sharp conclusion. As long as precautionary savings are present, hiring subsidies stimulate employment in a liquidity trap, observe the first panel of the imperfect insurance economy in Figure 4. Absent uninsured unemployment risk, instead, the hiring stimulus is entirely crowded-out in equilibrium, see the first panel of the perfect insurance and representative agent economies in Figure 4.

In the imperfect insurance economy, hiring subsidies reduce unemployment risk which increases aggregate demand. As a consequence, inflation rises, compare dashed and solid lines of the third panel in the first row in Figure 4. With the nominal interest rate stuck at zero, the real interest rate – not shown – drops. A lower real rate stimulates consumption and hence employment rises, compare the solid black line and the dashed gray line in the first panel of the first column in Figure 4.

At the zero lower bound, deflationary pressures increase the real interest rate in the two benchmark economies, where precautionary savings are absent. As a consequence of a higher real interest rate, households demand less goods and employment contracts, compare solid and dashed lines of first panel in the representative agent row in Figure 4. The dynamics in the perfect insurance economy, that lacks the precautionary savings channel but has a weaker consumption growth channel, lie in between those of the representative family and the imperfect insurance model.

The previous results highlight that precautionary savings crucially shape the aggregate effects of the hiring stimulus in a liquidity trap. Figure 5 further illustrates this. Dashed gray lines show the effects of hiring subsidies when monetary policy is unconstrained and follows the Taylor rule (20). Solid black lines show, instead, the effects of the hiring stimulus in a liquidity trap, computed as the difference between dashed and solid lines in Figure 4.

The differences across models observed in Figure 5 are stark. In the presence of uninsured unemployment risk, hiring subsidies reduce unemployment substantially more in a liquidity trap than in normal times, observe the first panel in Figure 5. This is a

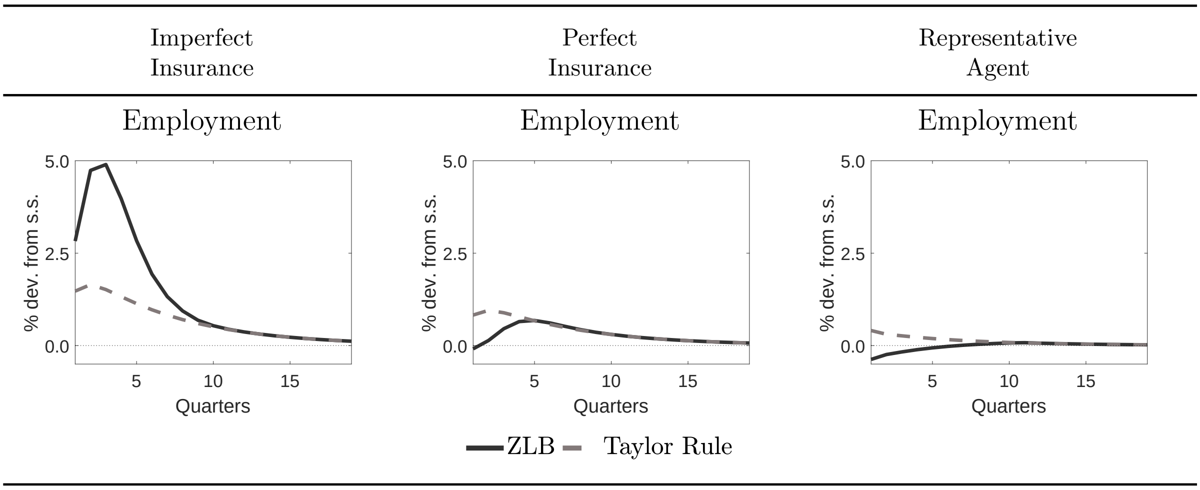

Figure 5: Zero Lower Bound vs. Taylor Rule

Notes: Effects of an increase in hiring subsidies, as depicted in Figures 1 and 2, at the zero lower bound (black solid lines) and away from the zero lower bound, under an operative Taylor rule (gray dashed lines) in the imperfect insurance economy (first panel), the perfect insurance model (second panel), and the representative agent economy (third panel). The black solid line is computed by taking the difference between the gray dashed lines and the black solid lines in Figure 4.

consequence of the fall in the real interest rate at the zero lower bound, which amplifies the effects of hiring subsidies.

This amplification of the hiring stimulus stands in sharp contrast with the strong dampening observed in the perfect insurance and representative agent models, observe the second and third panels in Figure 5. In the liquidity trap, with the nominal interest rate stuck at zero, the real interest rate increases. As a result, consumption contracts and the employment stimulus is dampened. Indeed, in the representative agent economy, this channel is sufficiently strong to render hiring subsidies contractionary in a liquidity trap, observe the third panel in Figure 5. This finding is in line with previous literature that has found that, in a complete markets framework, countercyclical supply side policies can be contractionary in a liquidity trap (Eggertsson (2011)).

In sum, the presence of precautionary savings renders hiring subsidies a powerful stabilizing tool in a liquidity trap. First, we have seen that with flexible prices the natural interest rate increases in the incomplete markets model. This is a consequence of the decline in precautionary savings induced by the fall in unemployment risk. Second, if

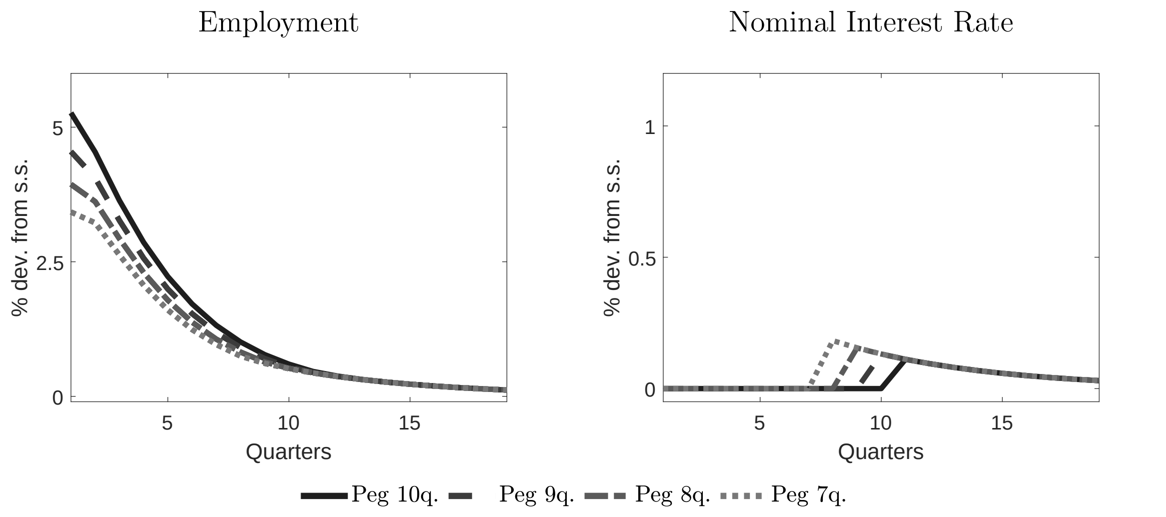

Figure 6: Duration of the ZLB

Notes: Effects of an increase in hiring subsidies, as displayed in Figures 1 and 2, under an interest rate peg in the imperfect insurance economy. The interest rate is assumed to remain its steady state level for 10, 9, 8, or 7 periods, as shown in the second panel. Thereafter, the nominal interest rate is set according to the Taylor rule (20).

prices are sticky, the fall in precautionary savings spurs aggregate demand for goods, inflation, and hence employment. At the zero lower bound, these inflationary pressures reduce the real interest rate, further stimulating consumption and amplifying the hiring stimulus. Absent precautionary savings, as in the representative agent model and the perfect insurance economy, hiring subsidies are deflationary. Consequently, the hiring stimulus is crowded-out in a liquidity trap.

4.4 Duration of the ZLB and Implementation Lags

4.4.1 Duration of the ZLB

A common finding of the literature is that the equilibrium effects of a policy stimulus depends on the duration of the zero lower bound (e.g. Christiano et al. (2011)). This is relevant as fiscal measures tend to typically arrive with some delay. In order to address this issue transparently I assume that the economy is in steady state when the government increases hiring subsidies and the nominal interest rate is exogenously fixed at its steady state value for a certain number of periods. Figure 6 shows the effects of a hiring stimulus in the imperfect insurance economy when the nominal interest rate is assumed to be pegged for 10, 9, 8, and 7 periods. Thereafter, the central bank follows the Taylor rule (20).

As in can be observed in the left panel of Figure 6, the hiring stimulus has a bigger effect on employment the longer the nominal interest rate is pegged. The reason is that the larger the duration of the trap, for more periods the higher inflation generated by the hiring stimulus maps into lower real interest rates, further stimulating demand and hence output.

4.4.2 Implementation Lags

A related but different concern is that there might be a lag between the announcement of the stimulus and its implementation, due for example to the political process. In order to address this concern I assume, as before, that the economy is in steady state and the nominal interest rate is pegged for 10 periods. At period 1 the government announces that it will provide a hiring stimulus in the future. I consider the cases where implementation takes place in period 1 – i.e. no implementation lags –, in period 2, 3 or 4. Figure 7 displays the results of this experiment in the imperfect insurance economy. The first row collects the effects on employment when prices are flexible. The second row shows, instead, the effects with sticky prices and a nominal interest rate peg.

Focusing first on the case with flexible prices we observe that, when there is an implementation lag, employment actually falls until hiring subsidies are increased. The reason is that forward looking firms decide to postpone hiring as they expect lower vacancy posting costs in the near future.

This result sharply contrasts with the effects found with sticky prices and an interest rate peg, depicted in the second row of Figure 7. In this case, not only employment does not fall when there are implementation lags, but it actually may increase on impact more than when there are no implementation lags. The reason is that, in addition to firms, households are forward looking too. As consequence of the future stimulus,

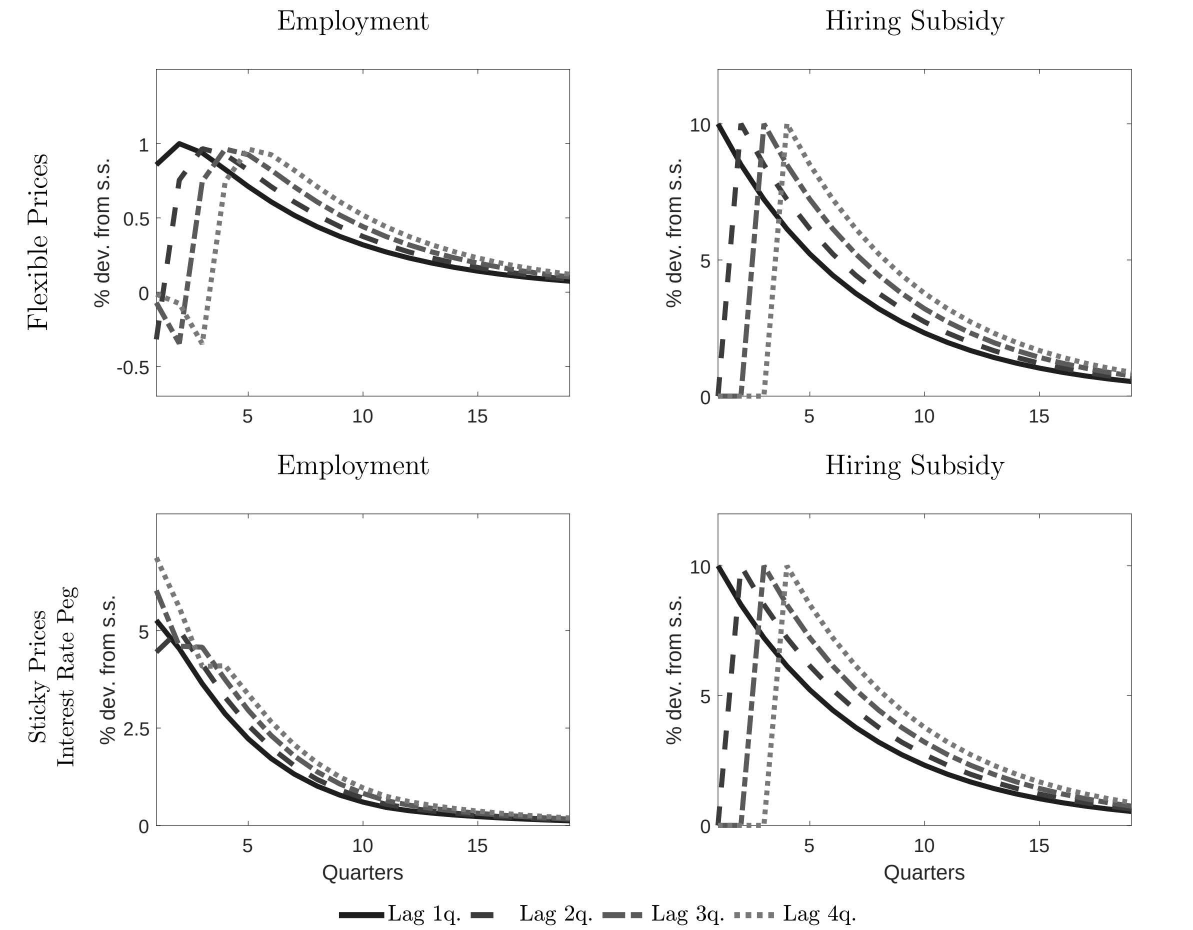

Figure 7: Implementation Lags

Notes: Effects of an increase in hiring subsidies, as shown in Figures 1 and 2, with different implementation lags in the imperfect insurance economy. The government announces at period 1 that it will increase hiring subsidies. Implementation takes place in period 1, 2, 3 or 4 as shown in the right column. The top row shows the effects in the case of flexible prices. The bottom row shows the effects with sticky prices and a nominal interest rate that is assumed to remain at its steady state level for 10 periods.

households expect higher future income and lower unemployment risk. Consequently, they reduce precautionary savings and increase demand for goods. With sticky prices, higher consumption demand induces firms to increase hiring and employment rises. Under an interest rate peg, the inflationary pressures reduce the real interest reate, further stimulating demand.

5 Conclusion

This paper has examined the ability of hiring subsidies to reduce unemployment in a liquidity trap. Towards this end, I have built a New Keynesian model with equilibrium unemployment, sticky real wages, and incomplete markets. A central finding of this paper is that precautionary savings crucially shape the aggregate effects of hiring subsidies at the zero lower bound. An increase in hiring subsidies induces firms to post more vacancies. This has two effects on aggregate demand. First, a tighter labor market bids up real wages, inducing households to increase savings to smooth consumption. Second, higher future job-finding rates reduce the need to self-insure, inducing households to cut precautionary savings and increase demand for goods. Quantitatively, I have found that the second channel dominates. As a consequence, hiring subsidies spur demand for goods and hence inflation, in spite of lower hiring costs. In a liquidity trap, higher inflation expectations reduce the real interest rate, further stimulating goods' demand and therefore amplifying the hiring stimulus.

I have found that, absent the precautionary savings channel, lower hiring costs and the desire to smooth consumption renders hiring subsidies deflationary in a representative agent economy. In a liquidity trap, this fall in inflation raises the real interest rate inducing consumption and employment to contract. The tractability of the model has allowed me to trace back the large disagreement between models to a second feature of incomplete markets: the consumption smoothing motive triggered by the hiring stimulus is substantially stronger with a representative agent. The reason is that the representative family, as a result of full risk-sharing, internalizes in its budget constraint that more family members are working after the hiring stimulus. A single worker in the incomplete markets economy does not, as she is constrained by her *own* current income – the real wage. Consequently, the hiring stimulus increases substantially more the current income of the representative household, triggering a stronger desire to increase savings and a consequent sharp fall in inflation.

In this paper, I have focused on hiring subsidies, a labor market policy tool that has been widely used during the economic downturns. However, a more general message from my paper is that stabilization policies that target the supply side of the economy are crucially shaped by household heterogeneity. To the extent that these policies can reduce idiosyncratic risk, while leaving the income of savers largely unaffected, they may stimulate aggregate demand for goods too. Most of the recent literature on heterogeneous agents and nominal rigidities has focused on the amplification and propagation of demand disturbances, and hence I consider this a fruitful avenue for future research.

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A Appendix

A.1 Sensitivity Analysis

Throughout the paper I have shown how the decline in unemployment risk brought about by the hiring stimulus prompts aggregate demand and inflation, rendering hiring subsidies a powerful tool in a liquidity trap. This is not the result of a particular combination of parameters, but rather a result of incomplete markets.

The strength of the mechanism, however, may vary as a result of particular assumptions. In particular, I have stressed that the main result of the paper, the increase in aggregate demand after hiring stimulus, is a consequence of two factors. Fist and foremost, households face unemployment risk against which they would like to self-insure. Second, the income of a worker, conditional on employment status, does not move much in response to the hiring stimulus, which weakens the consumption growth channel. I next evaluate the robustness of the main results of this paper to alternative assumptions and parameters affecting these channels.

A.1.1 Persistence of the Stimulus

The channel presented in this paper depends on the fall in unemployment risk that follows the increase in hiring subsidies. As a consequence, it is influenced by how long households expect a tighter labor market, which, in turn, is affected by the persistence ρ_τ of the stimulus. In order to show and quantify the relevance of the persistence of the hiring subsidy I first assume that the economy is in steady state. The government increases hiring subsidies by 10% in the imperfect insurance economy, as in previous experiments. I consider different duration of the policy, as shown in the third panel of Figure 8, with lighter lines representing less persistent stimulus.

The first panel of Figure 8 shows the effects on employment when prices are flexible. Employment follows a similar path to hiring subsidies for each persistence level. It increases on impact by always the same amount, as the hiring subsidy does, but then declines more sharply as a consequence of the shorter duration of the stimulus. The

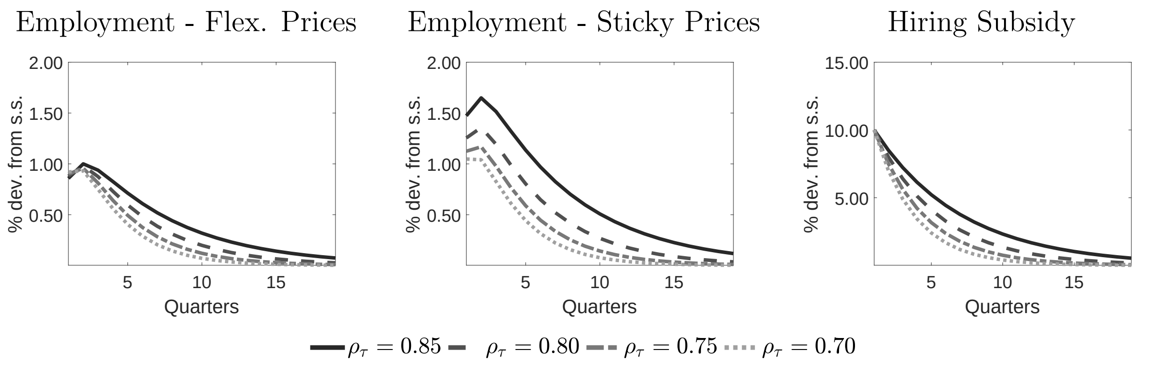

Figure 8: Persistence of the Stimulus

Notes: Effects of an increase in hiring subsidies, shown in the third panel, for different persistence of the shock in the imperfect insurance economy. The first panel shows the effects on employment with flexible prices. The second panel shows the effects on employment with sticky prices. The last panel shows the path for the hiring subsidy. In every case the hiring subsidy increases by 10 % on impact, lighter lines representing less persistent shocks, as captured in the legend.

second panel of Figure 8 shows the evolution of employment with sticky prices. As before, employment declines faster when the hiring subsidy is transitory. In contrast to what we have seen with flexible prices, this has a relevant effect on the impact response of employment. As employment returns back to steady state more rapidly, the decline in unemployment risk is muted. As such, the increase in demand for goods is dampened on impact, limiting the expansion on labor demand and hence employment.

A.1.2 Amount of Insurance

A crucial quantity of the model is the income drop upon unemployment. This is controlled by the replacement rate, b, that I have set to 0.9 implying a consumption drop of 10%. Figure 9, top row, shows the path for the natural interest rate and inflation after the increase in hiring subsidies for different values of b. Lighter lines represent higher replacement rates. In all cases, I recalibrate the model to match the same steady state and wage cyclicality as in the baseline.

As the income drop upon unemployment falls, the need to self-insure declines. Consequently the precautionary savings channel becomes weaker, and the rise in the natural rate and inflation triggered by hiring subsidies becomes smaller. Yet, hiring subsidies

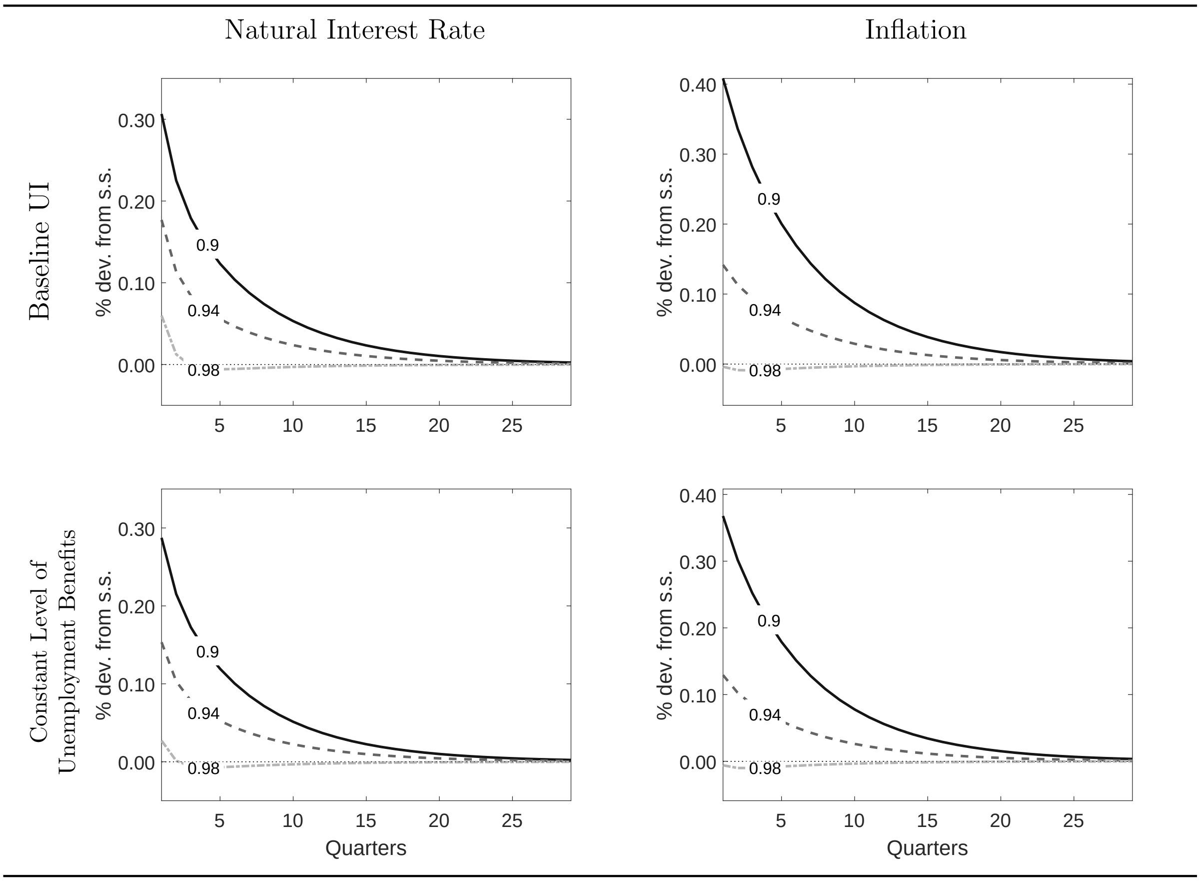

Figure 9: The Role of Insurance

Notes: Impulse responses of the natural interest rate (left column) and inflation (right column) to an increase in hiring subsidies, as shown in Figures 1 and 2, in the imperfect insurance economy. The top row shows the impulse responses for different values of b, the replacement rate, under the baseline unemployment insurance scheme $B_t = bW_t$. The bottom row shows the same but when the level of unemployment benefits is assumed to remain at its steady state value $B_t = B = bW$.

only become deflationary once the income drop upon unemployment is lower than 3%, substantially below the empirical estimates (e.g. Chodorow-Reich and Karabarbounis (2016)).

A second form of idiosyncratic risk that I have abstracted from is a cyclical income drop upon unemployment. One may be concerned by the fact that if the increase in employment triggered by hiring subsidies raises real wages, the income fall upon a separation could become larger. Households, therefore, would like to self-insure against this procyclical source of risk, working against the decline in precautionary savings generated by higher future job-finding rates.

To investigate this issue, I drop the assumption of a constant replacement rate and I assume that the government provides a constant unemployment benefits *level* $B_t = B = bW$. The second row of Figure 9 shows the results for different levels of b. As before, in every simulation I recalibrate the model to maintain the same steady state and wage cyclicality as in the baseline.

The differences with respect to the baseline imperfect insurance economy are small; compare the two panels of the left column in Figure 9. The reason is that even with a constant unemployment benefits level, since the real wage is sticky, the consumption drop upon unemployment remains roughly constant in response to higher hiring subsidies.

A.1.3 Income Volatility

A second crucial part of the mechanism presented in this paper is that, conditional on employment status, the income of workers does not move much following an increase in hiring subsidies. This is the result of two features. First, the only income source of employed workers is the real wage. Second, the real wage is sticky.

Flexible Real Wages

I drop the latter assumption and assume that the prevailing real wage is the outcome of the Nash bargaining protocol (18), commonly viewed as a flexible wage benchmark. Figure 10, bottom row, shows the results under the Nash bargained wage, for different levels of the replacement rate b. For the baseline value of $b = 0.9$, the precautionary savings channel still dominates and hiring subsidies stimulate demand for goods, raising the natural rate and inflation. Yet, the increase is quantitatively muted and inflation raises on impact by about one fourth of what it does in the baseline, with a sticky wage.

Other Income Sources

A second concern is that, even if the real wage is sticky, other income sources could fluctuate. This is relevant, as I have illustrated by comparing the representative agent and perfect insurance economies. The income response of the representative family differs from that of a worker in two dimensions. First, it receives the dividends from the firms. Second, it internalizes the income gains from all workers in the economy. I have bypassed

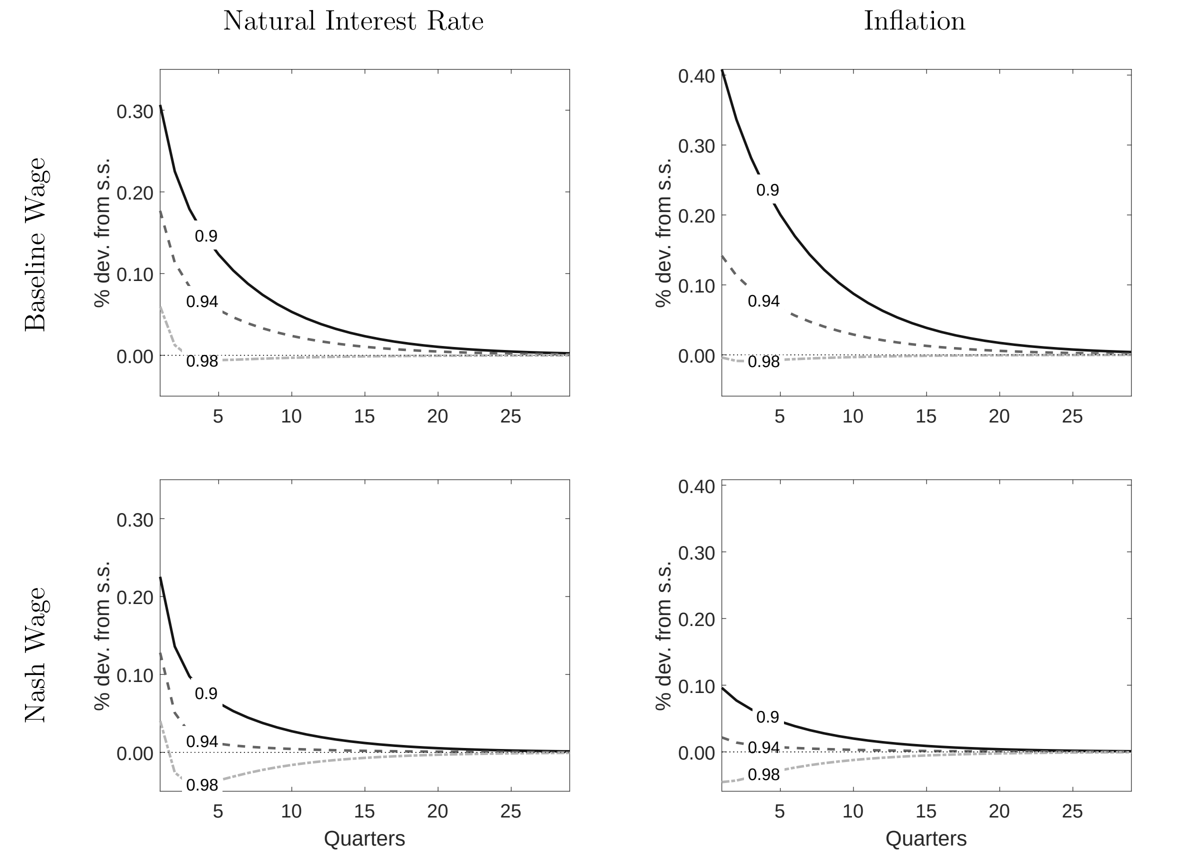

Figure 10: The Role of Wage Stickiness

Notes: Impulse responses of the natural interest rate (left column) and inflation (right column) to an increase in hiring subsidies, as shown in Figures 1 and 2, in the imperfect insurance economy. The top row shows the impulse responses for different values of b, the replacement rate, under the baseline unemployment insurance scheme $B_t = bW_t$ and the baseline elasticity of the real wage $\zeta = 0.54$. The bottom row shows the same variables as the top row when the prevailing real wage is given by the Nash bargained real wage, that is $\zeta = 0$.

the former by assuming the existence of perfectly-insured entrepreneurs. The second one, however, is a result of income pooling with complete markets and, hence, goes hand in hand with the precautionary savings channel in the baseline imperfect insurance economy.

In order to tell these two dimensions apart I implement redistributive fiscal policies. First, I assume that the government entirely taxes before vacancy posting costs dividends away from entrepreneurs, and rebates the revenue uniformly to workers in a lump-sum manner. That is, the equilibrium consumption of a worker is $C_{e,t} = W_t + \tilde{T}_t$, where $\tilde{T}_t = \Delta_t^{-1} N_t - N_t W_t$.

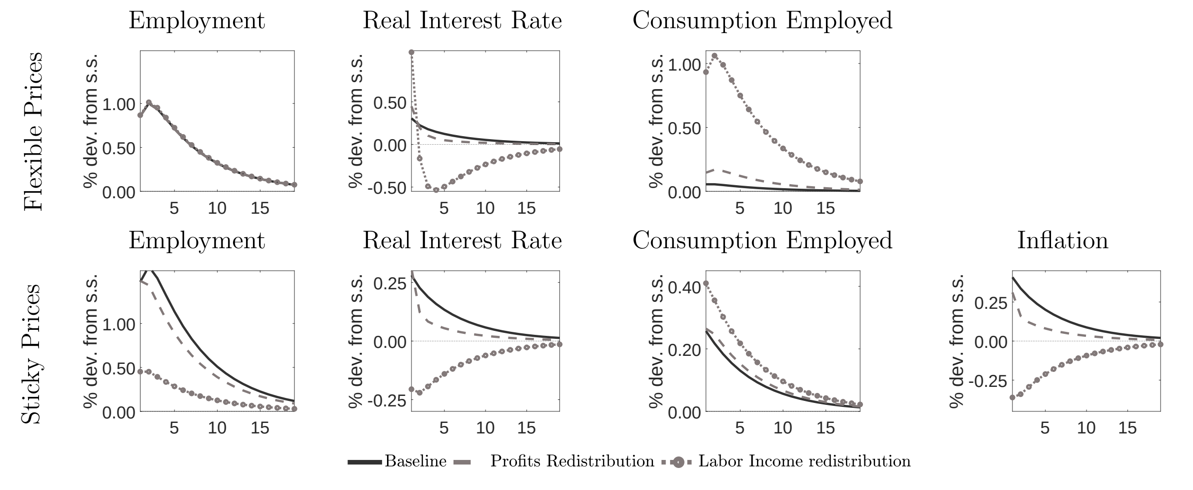

Figure 11: The Role of Other Income Sources

Notes: Effects of an increase in hiring subsidies, as shown in Figures 1 and 2, under different redistributive fiscal policies in the imperfect insurance economy. The top row shows the effects with flexible prices, and bottom row with sticky prices. See the main text for a descriptions of different cases considered.

This effectively still leaves the income pooling channel out, while accounting for the distribution of dividends. To account for the income pooling effect, in a second scenario, I assume that the government provides every worker with a transfer $\tilde{T}_t = N_t W_t - W_t$ that is financed with lump-sum taxes on firm-owners. This implies that the equilibrium consumption of a worker is now given by $C_{e,t} = N_t W_t$. This is, then, "as if" an employed worker internalized the income gains of all other workers in the economy as it does the representative family, by means of a transfer in this case.

Figure 11 displays the effects of increasing hiring subsidies in the baseline imperfect insurance economy, with black lines, and the two redistribution scenarios, with gray lines. Dotted gray lines show the effect of raising hiring subsidies when the redistribution of labor income is implemented, and dashed gray lines the responses in the dividends redistribution scenario.

The main conclusions drawn from the baseline are robust to the redistribution of profits. With flexible prices, the precautionary savings channel dominates and the natural rate rises. Yet, it does by less as the income an employed worker markedly increases relative to the baseline, as consequence of higher dividends. With sticky prices, hiring subsidies remain inflationary and employment closely tracks the response in the baseline. The policy is mildly less expansionary since, as result of a stronger consumption growth channel, demand for goods rises somewhat less.

Results, however, resemble those obtained under a representative family when the income pooling transfer is implemented, depicted with dashed lines. Since now an employed worker, as the representative agent, internalizes the income gain from all workers in the economy, her income rises substantially. This implies that the consumption growth channel is markedly stronger, and hence dominates the precautionary savings channel. Consequently, the natural rate and inflation decline, muting the hiring stimulus considerably. Yet, this channel, that I have illustrated here by means of fiscal redistribution, is a consequence of complete markets, that gives raise to the representative agent representation. [16]

[16] This is consistent with the available empirical evidence. Rogerson and Shimer (2011) show that the majority of cyclical fluctuations in aggregate hours comes from movements between employment and unemployment. Furthermore, Nakajima and Smirnyagin (2019) find that cyclical changes in household income risk are mainly explained by the amount of hours worked, possibly due to unemployment, and not wages. Moreover, Nakajima and Smirnyagin (2019) show that this result is robust to considering a second earner in the household.