Capital destruction, jobless recoveries and the discipline device role of unemployment*

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December 14, 2011

Abstract

I consider an economy growing along the balanced growth path, that is hit by an adverse shock to its capital accumulation process. The model integrates efficiency wages due to imperfect monitoring of the quality of labor in a search and matching framework with methods of dynamic general equilibrium analysis. I show that, depending on the firms' abilities to assess workers' performance, the incentive discipline device role of unemployment may account for sharp declines in employment and jobless recoveries driven by exceptional increases in the work effort of employees. The large movements in unemployment are associated with wage rigidity, which is generated endogenously by efficiency wages, supporting Solow's (1979) argument.

*Preliminary.

†Bank of Italy. The views expressed herein are those of the author and do not necessarily reflect those of the Bank of Italy.

Introduction

The recession ended officially in June 2009, but the U.S. still faces an unemployment crisis and the huge human costs of joblessness[1]. Prior to 1990, jobs recovered promptly after the GDP growth turned positive, but the economic downturn of 1990-91 heralded a new era of productivity-led recoveries: the most recent recoveries, ensuing from the 1990-91, 2001 and 2007-09 recessions, have featured failure to create jobs, accompanied by productivity growth (see Figures 1 and 2).

Particularly rapid productivity growth in the initial quarters after the NBER-dated cyclical trough has been a common feature of almost every postwar recovery[2]. Peculiar to the last three recoveries has been the unusual length of the phase of productivity growth complemented by continuing stalled growth in employment (Gordon, 2010). Labor productivity growth *per se* is good news but its connection with joblessness in the short run has been highlighted by many economists. Bernanke (2003) states that: *This surprising productivity performance probably reflects both some increase in the long-run rate of productivity growth as well as unmeasured increases in the work effort of employees...Strong productivity growth provides major benefits to the economy in the longer term [...]. But [...] it has also enabled firms to meet the demand for their output without hiring new workers. Thus, in the short run, productivity gains [...] have contributed to the slowness of the recovery of the labor market.* Yellen (2010) asserts that *[...] the recession has forced businesses to reexamine just about everything they do with an eye toward restraining costs and boosting efficiency. [...] My business contacts describe this as a paradigm shift and they believe it's permanent. This process of implementing new efficiency gains may have only begun and we may be in store for further efficiency improvements and high productivity growth for some time. If so, the rate of job creation will be frustratingly slow.*

This paper sheds light on the incentive discipline device role of unemployment as a channel that may drive exceptional increases in the work effort of employees in the face of a transitory adverse shock to the capital accumulation process[3], leading to large and

[1] Dao and Loungani (2010) evaluate the severe human toll of unemployment associated with the crisis, finding that the cost to those who become unemployed could be loss of earnings not just today but persisting 15-20 years into the future; reduced life expectancy of 1 to 1.5 years; and lower academic achievement and earnings for their children; all this in addition to lower social cohesion.

[2] In this respect, Gordon (1979, 1993 and 2003) identifies two tendencies: the "end-of-expansion effect" and the "early recovery productivity bubble". The former refers to the firms' tendency to overhire in the late stages of the business expansion, i.e. a tendency for labor input to grow faster than can be explained by output variations. The latter refers to the firms' tendency to underhire in the early stages of the recovery, which is associated with a complementary temporary spike in productivity growth.

[3] Reasons for looking at the effects of a shock to the capital accumulation process, as in Shimer (2010),

persistent unemployment movements, as the increased efficiency of insiders reduces firms' needs for workers during recoveries.

I consider an economy along the balanced growth path which is hit by a one-time shock rendering some of its capital stock unproductive. The model incorporates efficiency wages due to imperfect monitoring of workers' performance in a search and matching framework with methods of dynamic general equilibrium analysis. The threat of unemployment induces workers to provide effort. A key difference with respect to the Shapiro and Stiglitz's (1984) milestone, where effort is either provided or not provided, is that workers' performance is allowed to vary continuously. Also, while Shapiro and Stiglitz (1984) do not allow for any effect of household wealth on equilibrium wage determination, I assume that the marginal utility of income falls as income rises, thereby allowing for wealth effects and for a balanced growth path along which unemployment is trendless. I show that, in this framework, a transitory shock which causes some fraction of the capital stock to evaporate may lead to large and proportional declines in employment and in output, consumption and investment relative to trend, where high and involuntary unemployment persists over time and jobless recovery may emerge as anemic growth in employment accompanies trend growth in consumption, investment and output. Shimer (2010) points to wage rigidities as an explanation for jobless recoveries ensuing from adverse shocks to the capital accumulation process. Consistent with Shimer's (2010) hypothesis, the large movements in unemployment in the model economy I propose are synonymous with wage sluggishness, which, however, is generated endogenously by efficiency wages - supporting Solow's (1979) argument - rather than assumed. Thus, the model is able to capture the relative rigidity of real wages observed over the business cycle combined with large movements in employment.

The story goes as follows. Efficiency wages imply that workers' performance is strongly countercyclical relative to employment because movements in the quality of work are essentially due to the cyclically varying threat of unemployment[4]. Suppose that the economy is on its balanced growth path, there is a one-time capital depreciation shock and firms cut

are clarified in the next section.

[4]As Uhlig and Xu (1996) stress, the two main theoretical views with respect to cyclical movements in effort have opposite implications for employment fluctuations. Models of labor hoarding imply that effort co-moves positively with employment. Because labor costs cannot be adjusted costlessly in the short run, firms react to shocks by varying the intensity of labor utilization. Thus, effort increases in booms and decreases in recessions. In this context, effort movements allow firms to smooth the labor force over the cycle. By contrast, efficiency wage models that allow for adjustable effort predict a negative correlation between effort and employment, because increases in workers' performance are driven by increases in the threat of unemployment. In this context, effort movements amplify employment fluctuations.

back employment. The increased threat of unemployment makes insiders more efficient, inducing them to work harder. This increased efficiency lowers firms' employment needs, resulting in even higher unemployment. This again strengthens the threat and boosts the effort, ultimately leading to amplified unemployment and performance dynamics.

The strength of the discipline device role of unemployment depends on the firm's ability to monitor workers' performance and detect shirkers. If the detection probability is close to zero, the threat of firing as a method of discipline is weak; the mechanism described above is reduced, and effort and employment movements are smoothed. If the detection probability is close to one, the threat of a spell of unemployment is weak, because the surplus accruing to the household from an existing employment relation (which workers would lose were they to be detected shirking and not re-employed) is close to zero and the model tends to become a search and matching economy with zero workers wage bargaining power, where unemployment plays no role as a method of discipline[5]. The incentive discipline device role of unemployment is strong if the firm's ability to assess workers' performance is such that the probability to be detected and fall into the pool of unemployed is considerable and, at the same time, the loss that shirking workers would incur were they to be detected is still extensive. In this case, the mechanism described above is fully at work and the model outcomes in the face of a capital destruction shock resemble a jobless recovery associated with a burst of insiders' performance.

The explosion of a thriving industry devoted to the development of performance appraisal systems was at the root of the extraordinary increase in reliance on pay-for-performance mechanisms in the U.S. after the mid-1980s[6]. The literature provides much proof of this evolution[7] and explores its macro and micro implications[8]. This paper sheds

[5] The ability to monitor workers affects the wage markup: as long as the detection probability is less than one, in equilibrium the wage rate will be above the walrasian market clearing level and the surplus accruing to households from an employment relation will be positive.

[6] As shown by Lemieux, MacLeod and Parent (2009), the enhancement in the quality of performance measures can explain the widespread evidence of higher firms' reliance on performance related compensation schemes as well as higher performance-pay sensitivity, because the availability of good measurement systems is a necessary condition to the effectiveness of a pay-for-performance system (Baker 1992).

[7] Among them, Lemieux, MacLeod and Parent (2007) document that consulting companies specializing in job evaluation, reward services and pay strategy, such as Hay Associates, Hewitt and Towers Perrin, have experienced extraordinary growth since the 1980s, and report, as examplars of this trend, the extraordinary surge in the sales of SAP, a major supplier of software used to monitor employee performance, from DM150 m in 1985 to $8.8 bn today.

[8] The increased incidence of performance-pay has had a number of relevant implications at both the macro and micro levels: it accounts for shifts in the structure of correlations among U.S. macro variables (Nucci and Riggi, 2011), leads to higher firm productivity (Lazear, 2000), causes substantial increase in the volatility of wages relative to output (Champagne and Kurman, 2011), explains a large part of the rise in wage inequality in the United States and why changes in U.S. inequality has been concentrated

light on one possible reason why the recent recoveries have been jobless, which is related to this trend. In the 1970s firms' monitoring of workers' performance was poor. This reduced the risk of firing as a method of discipline and did not boost the countercyclical movements in effort: no performance-unemployment spiral was at work. In more recent years, firms' assessment of workers' performance has improved and possibly has driven the economy in regions where the incentive discipline device role of unemployment has been particularly strong. In this region, the high responsiveness of insiders' performance to unemployment allows firms to catch up with the recovery through underhiring and helps to explain large and persistent employment movements. I show that further improvements in the ability to assess workers' performance, towards overcoming the asymmetric information and the ensuing moral hazard problem can smooth the cyclical movements in labor input.

Investment in the development of better performance appraisal systems can be thought of as an important part of the paradigm shift towards efficiency gains, blamed by Yellen (2010) for the frustratingly slow rate of job creation. This does not rule out the potential relevance of other mechanisms. I leave empirical assessment of the relevance of the channel highlighted by this model to future research.

This paper is organized as follows. Section 1 reviews the related literature. Section 2 presents the model. Section 3 provides the impulse response functions and gives the economic intuition. It also provides a comparison of the effects when workers' effort is perfectly observable. Section 4 concludes.

1 Related literature

A number of conjectures try to explain the delayed recovery of employment following the last three recessions. Shimer (2010) points to wage rigidities, and studies the transitional dynamics in an economy that has lost some of its capital stock, when wages hold steady along a balanced growth path. Wage rigidities drive proportional declines in employment and in capital, output, consumption and investment relative to trend. As in Shimer (2010), I consider the effects of a capital depreciation shock. Also, and consistent with Shimer's (2005) hypothesis, the large movements in unemployment in the model I propose are synonymous with wage sluggishness, which, however, is generated endogenously by efficiency wages - supporting Solow's (1979) argument - rather than assumed.

Another explanation relies on sectoral adjustments and has its roots in a large body

increasingly at the top levels in the wage distribution (Lemieux, MacLeod and Parent, 2007) .

of research, stemming from Lilien's (1982) influential contribution, aimed at exploring whether sectorial, rather than aggregate, shocks are responsible for fluctuations in the unemployment rate. Along this line of research, Andolfatto and MacDonald (2004) ascribe jobless recoveries to the uneven impact of technology innovations on different sectors along with slow sectoral adjustments in the labor market. The empirical evidence is not conclusive about whether the pace of sectoral reallocations has been remarkably higher over the last three recoveries and whether sectoral adjustments played a crucial role in driving the stalled growth in jobs[9].

The contraction of credit may have played crucial role in driving unemployment movements, especially during the last global crisis, by inducing employers to cut hiring because of financial difficulties. However, Monacelli, Quadrini and Trigari (2011) argue that this standard credit channel cannot account for the sluggishness of the labor market recovery once the liquidity has rebounded and shed light on another channel through which de-leveraging can drive persistent increases in unemployment. Their model builds on empirical studies showing that firms may use financial leverage strategically in order to contrast the bargaining power of workers: wage bargaining induces preference for debt on firms' part, because higher debt reduces the net bargaining surplus, which in turn reduces the wages paid to workers. When an adverse shock contracts the availability of credit for employers, de-leveraging raises workers' bargaining power and this leads firms to create fewer jobs. As long as the credit contraction is persistent the negative effect on unemployment is long-lasting.

Van Rens (2005) shows that jobless recoveries can be accounted for by substitution between organizational capital and labor. His model features two types of labor inputs: regular productive tasks and organizational capital accumulated by workers performing organizational tasks. When the recovery starts, hiring costs make it profitable to move workers from organizational tasks to productive activities, allowing firms temporarily to increase production without hiring extra workers.

Gordon (2010) interprets the recent jobless recoveries as the result of two complemen-

[9] The historical decomposition provided by Loungani and Trehan (1997), using a VAR estimation and data up to 1995, reveals that sectoral shocks were most important during the 1974–75 recession, but explain only a modest part of the rise in unemployment in the 1990 recession. Groshen and Potter (2003) report data suggesting that most of the jobs added during the recovery following the 2001 recession were new positions in other industries rather than rehires, thus suggesting that the sluggishness observed in the job market may be attributed to the relocation of workers. Chen, Kannan, Loungani and Trehan (2011) document that sectoral shocks account for about half of the increase in the long duration unemployment rate that has taken place over the last recession (2007-2009), concluding that, in this, the recent global recession is similar to the recession of 1973-75, as sectoral shocks appear to have played a large role at that time as well.

tary phenomena: the "disposable worker" and the lagged benefits from the late 1990s' boom of heavy investment in information and communication technology (ICT). First, the exceptionally slow recovery of the labor market would reflect many of the same causal factors that increased inequality and boosted the top decile income share over the last 25 years in the U.S. (Piketty and Saez, 2006; Atkinson and Piketty, 2006): declining minimum wage, weakening unions, increase in imported goods, increased immigration of unskilled labor and, above all, the shift in executive compensation toward stock options, which has exacerbated firms' emphasis on maximizing shareholder value. According to Gordon (2010), during the latest recession/recovery periods, the interplay between increased reliance of executive compensation on stock options and the collapse of profits and of the stock market created unusual pressure on corporate managers to cut costs and reduce employment, in a context in which such "savage corporate cost cutting" was no longer constrained by the countervailing power of labor[10]. Second, the aggressive cost cutting and the associated stellar productivity growth was made possible by the delayed effects of the ICT revolution that occurred in the latter part of the 1990s, a hypothesis that is upheld by Bernanke (2003).

All these factors have likely contributed to the slowness of the labor market revival after the last three downturns. My explanation is one of a complementary rather than a substitute mechanism.

My paper is related also to studies on shocks to the capital accumulation process. Many works show that these shocks, which take different forms in the literature[11], are important drivers of aggregate fluctuations (Barro 2006, Fischer 2006, Justiniano and Primiceri 2008, Justiniano et. al 2010, Liu et al 2010, Furlanetto and Seneca 2011). These shocks have been used to model the global crisis in the late 2000s (Gertler and Karadi, 2011; Gertler and Kiyotaki, 2011) and the subsequent slow recovery of the labor market (Shimer 2011). The reason: shocks to the capital accumulation process can be seen as a reduced-form way of capturing financial frictions which impact on supply of new capital. As Shimer (2011) stresses, while in reality no capital was destroyed during the recession, some investments made prior to the global downturn turned out to be worth

[10]The evidence provided by Oliner, Sichel and Stiroh (2007) confirms that productivity growth after 2000 has been boosted by industry restructuring and cost cutting in response to profit pressures. They document that those firms that had experienced the largest declines in profits between 1997 and 2002 also exhibited the largest declines in employment and the largest increases in productivity.

[11]Given a capital accumulation equation $K_{t+1} = \xi_{q,t}\left[\left(1-\varrho_t\right)K_t + \xi_{I,t}\varphi\left(\frac{I_t}{K_t}\right)K_t\right]$, the shock to the capital accumulation process may take the form of a depreciation shock ϱ_t as in Shimer (2010), an investment specific technology shock $\xi_{I,t}$ as in Justiniano and Primiceri (2008) and Justiniano et al. (2010), or a shock to the quality of capital $\xi_{q,t}$ as in Gertler and Kiyotaki (2011)

much less than originally forecast and the global crisis accelerated the contraction of some industries whose capital was ill-suited to the current economic environment and not easily adaptable to other purposes. Shimer (2011) stresses that this is analogous to a shock to the size of the capital stock. The 1990-91, 2001, and 2007-09 recessions were likely driven by different economic turmoils. An adverse shock to the capital accumulation process reflects a disturbance that renders a part of the capital stock economically obsolete and thus appears well suited to stylizing the three recent crises, without taking a stand on the specific nature of the downturn.

Finally, my paper relates to the prominent literature on efficiency wages, which treats unemployment as a real phenomenon resulting from incentive problems in the labor market. Much of this literature employs a static partial equilibrium approach in order to investigate the determinants of the steady-state level of unemployment. Relevant contributions towards understanding labor market dynamics outside of the steady state are those of Kimball (1994), Woodford (1994), Danthine and Donaldson (1995), Gomme (1999) and Alexopoulos (2004). My work takes another step in this direction.

2 The model

I consider an economy which grows along a balanced growth path. The model integrates search and matching frictions in the labor market - captured through hiring costs increasing with labor market tightness - and efficiency wages, using methods of dynamic general equilibrium analysis. Because workers' performance is imperfectly observable, firms pay above-market wages in order to induce workers to exert the desired amount of effort. The latter is adjustable on a continuous scale. In this context, I look at the effects of an adverse and transitory shock to the capital accumulation process.

2.1 Households

The decision unit is the infinitely-lived representative household with a continuum of members represented by the unit interval. State-contingent securities offer workers full insurance against differences in their specific labor income. The household's objective function is consistent with a balanced growth path[12] and is given by:

[12] I abandon Shapiro and Stiglitz's (1984) assumption of a constant marginal utility of income, in order to have wealth effects on equilibrium wage determination. This allows a balanced growth path along which unemployment is trendless.

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\log C_t - \int_0^{N_t^\varepsilon} \mathcal{E}_{i,t} di \right] \quad (1)$$

where $\beta \in (0,1)$ is the discount factor, C_t denotes consumption, $\mathcal{E}_{i,t}$ is the amount of effort exerted by the employed household member i and N_t^ε denotes the fraction of household members that is employed and does not shirk on the job. Workers' performance is imperfectly observable and shirkers are detected with probability d. Detected shirkers forgo payment of the wage and are dismissed. Denoting with $N_t \in [0,1]$ the fraction of household members who are employed and with N_t^s the fraction of shirkers, we have $N_t = N_t^s + N_t^\varepsilon$.

Budget constraint is given by:

$$C_t + I_t = \int_0^{N_t^\varepsilon + (1-d) N_t^s} W_{i,t} di + R_t^k K_t + \Pi_t \quad (2)$$

where I_t denotes investment expenditures, $W_{i,t}$ is the real wage accruing to household member i and Π_t are firms' profits. I denote with K_t the household capital holdings rent to firms at the (real) rental cost R_t^k.

The capital accumulation equation is:

$$K_{t+1} = (1 - \varrho_t) K_t + \varphi \left(\frac{I_t}{K_t} \right) K_t \quad (3)$$

ϱ_t is a stochastic parameter which denotes the time-varying depreciation rate of capital. A positive shock to ϱ_t renders some of the capital stock unproductive. Capital adjustment costs are introduced through the term $\varphi \left(\frac{I_t}{K_t} \right) K_t$ which determines the change in the capital stock induced by investment spending. As in Gali et al. (2007), I assume:

$$\varphi' > 0, \text{ and } \varphi'' \leq 0, \text{ with } \varphi'(\frac{\widetilde{I}}{\widetilde{K}}) = 1 \text{ and } \varphi(\frac{\widetilde{I}}{\widetilde{K}}) = \frac{\widetilde{I}}{\widetilde{K}} \quad (4)$$

where $\frac{\widetilde{I}}{\widetilde{K}}$ is the steady state investment to capital ratio. From the first order conditions one gets that:

$$Q_t^{Tobin} = \mathbb{E}_t \left\{ \beta \frac{C_t}{C_{t+1}} \left[R_{t+1}^k + Q_{t+1}^{Tobin} \left((1 - \varrho_t) + \varphi_{t+1} - \left(\frac{I_{t+1}}{K_{t+1}} \right) \varphi'_{t+1} \right) \right] \right\} \quad (5)$$

$$Q_t^{Tobin} = \frac{1}{\varphi'\left(\frac{I_t}{K_t}\right)} \tag{6}$$

where Q_t^{Tobin} is the (real) shadow value of capital in place, i.e., Tobin's Q, and $\varphi_{t+1} = \varphi\left(\frac{I_{t+1}}{K_{t+1}}\right)$ and $\varphi'_{t+1} = \varphi'\left(\frac{I_{t+1}}{K_{t+1}}\right)$.

2.2 Labor market

In equilibrium profit maximizing firms will offer a wage that ensures workers will not shirk on the job. Employment evolves according to:

$$N_t = (1 - \delta)\, N_{t-1} + X_t U_t \tag{7}$$

where $\delta \in (0, 1)$ is an exogenous separation rate[13], U_t denotes the size of the pool of jobless individuals available for hire at the beginning of period t, and X_t is the job finding rate, defined by

$$X_t \equiv \frac{H_t}{U_t}, \tag{8}$$

where H_t denotes aggregate hiring. As in Blanchard and Gali (2010), workers are immediately productive in the period when they are hired. Firms incur a cost to hire new workers. The cost per hire (G_t) is taken as given by each firm and is increasing with labor market tightness X_t:

$$G_t = \gamma^t B X_t^{\eta} \tag{9}$$

where γ is the deterministic growth rate[14], B is a positive constant and $\eta \geq 0$ measures the elasticity of hiring costs to labor market conditions.

[13] The assumption of an acyclical separation rate is based on recent works proposing a dominant role of the job finding rate in explaining workers' flows. The standard view that recessions are periods characterized primarily by high job loss rates (see Blanchard and Diamond, 1990) has been contradicted by the last three downturns, which have not seen a wave of job losses: during the last two decades the sharp surges in unemployment have been due not to spikes of layoffs but rather to the fact that, once unemployed, workers' chances of finding jobs have fallen sharply. Hall (2005) concludes that in the modern U.S. economy unemployment rises because it is hard to find a job and not because an unusually large number of people are thrown into unemployment. Shimer (2005, 2007) observes that over the last two decades the separation probability is acyclical, whereas the job finding probability is strongly procyclical. See Barnichon (2011) for cautions about assumption of an acyclical separation rate.

[14] As in Blanchard and Gali (2010), the hiring cost is assumed to grow with productivity in order to rule out that productivity improvements can affect the cost of hiring relative to the cost of producing.

2.3 Firms

I assume a continuum of identical firms $j \in [0,1]$, which operate in a competitive market and produce a homogeneous consumption good with the following technology:

$$Y_{jt} = \left(\gamma^t \int_0^{N_{jt}^{\varepsilon}} \mathcal{E}_{jit}^{\varkappa} di\right)^{\alpha} K_{jt}^{1-\alpha} \tag{10}$$

where γ is the growth rate, capturing trend productivity growth, $\alpha \in (0,1)$ and $\varkappa \in [0,1]$.

Firms do not perfectly observe workers' performance. As a consequence, in order to induce workers to exert the desired amount of effort, they must offer them a wage that satisfies the incentive compatibility constraint.

Incentive compatibility constraint

The incentive compatibility constraint guarantees that the agent always takes the recommended action and exerts the desired amount of effort. Here the incentive compatibility constraint can be expressed as follows: the marginal value expressed in terms of the consumption goods accruing to the household generated by an employed non-shirker member ($\mathcal{V}_t^{N,\varepsilon}$) is at least as great as that generated by an employed shirker member ($\mathcal{V}_t^{N,S}$): $\mathcal{V}_t^{N,\varepsilon} \geq \mathcal{V}_t^{N,S}$. In equilibrium, the incentive compatibility constraint holds with equality and defines the *no shirking condition*, which is the equilibrium relationship between performance supply and wages. One has:

$$\begin{gathered} \mathcal{V}_t^{N,\varepsilon} = W_t - C_t \mathcal{E}_t + \\ + \mathbb{E}_t \beta \tfrac{C_t}{C_{t+1}} \left\{ \left[1 - \delta\left(1 - X_{t+1}\right)\right] \mathcal{V}_{t+1}^{N} + \delta\left(1 - X_{t+1}\right) \mathcal{V}_{t+1}^{U} \right\} \end{gathered} \tag{11}$$

$$\begin{gathered} \mathcal{V}_t^{N,S} = (1-d) W_t + \\ + \mathbb{E}_t \beta \tfrac{C_t}{C_{t+1}} \left\{ \left[1 - (\delta + d)\left(1 - X_{t+1}\right)\right] \mathcal{V}_{t+1}^{N} + (d + \delta)\left(1 - X_{t+1}\right) \mathcal{V}_{t+1}^{U} \right\} \end{gathered} \tag{12}$$

where V_t^U denotes the marginal value expressed in terms of the consumption goods accruing to the household, generated by an unemployed member. As in Shapiro and Stiglitz (1984) job histories do not matter: unemployed workers who were fired for shirking are indistinguishable from other unemployed workers, thus they all face the same probability of being hired in a given period. The *no shirking condition* can be written as:

$$\mathcal{E}_t = dU_{c,t} \left[W_t + \mathbb{E}_t \beta \frac{C_t}{C_{t+1}} \left(1 - X_{t+1}\right) \mathcal{S}_{t+1}^{H} \right] \tag{13}$$

where $U_{c,t} = \frac{1}{C_t}$ denotes the marginal utility of consumption and $\mathcal{S}_t^H \equiv \mathcal{V}_t^N - \mathcal{V}_t^U$ defines the surplus accruing to the household from an established employment relation. Equation (13) states that in equilibrium the level of effort that workers exert depends on the loss they would incur were they detected as shirkers, weighted by the probability of being detected (d). This loss is given by the sum of two components: the real wage they would forgo, were they detected, plus the expected present discounted value of the future surplus from an employment relation that they would forgo were they detected and not re-employed, which happens with probability $d(1 - x_{t+1})$.

Unemployment is a method of discipline because, as in Shapiro and Stiglitz (1984) framework, if a worker is fired, he will not immediately find another job. This is captured by the term $(1 - x_{t+1}) = \left(1 - \frac{H_{t+1}}{U_{t+1}}\right)$, which measures the expected probability of not finding another job: the higher the prevailing level of unemployment, the longer the expected spell of unemployment and the higher the level of effort that workers are willing to exert. Thus the threat of firing, implying a spell of unemployment, deters shirking. The strength of the discipline device role of unemployment can be quantified as follows:

$$\mathcal{I}_t \equiv \frac{\partial \mathcal{E}_t}{\partial (1 - X_{t+1})} = U_{c,t} d \mathbb{E}_t \beta \frac{C_t}{C_{t+1}} \mathcal{S}_{t+1}^H \tag{14}$$

In order to eliminate $\mathcal{S}_{t+1}^H$ in equation (13), $\mathcal{V}_t^U$ can be written as:

$$V_t^U = \beta \mathbb{E}_t \left\{ \frac{C_t}{C_{t+1}} \left[(1 - X_{t+1}) \mathcal{V}_{t+1}^U + X_{t+1} \mathcal{V}_{t+1}^N \right] \right\} \tag{15}$$

Subtracting (15) from (11) and using (13) yields:

$$S_t^H = \delta W_t + \left(\frac{1 - \delta - d}{d} \right) C_t \mathcal{E}_t \tag{16}$$

The *no shirking condition* can be rewritten as follows:

$$\begin{gathered} C_t \mathcal{E}_t = d W_t + \\ + \mathbb{E}_t \beta \tfrac{C_t}{C_{t+1}} (1 - X_{t+1}) \begin{bmatrix} d \delta W_{t+1} + \\ + (1 - \delta - d) C_{t+1} \mathcal{E}_{t+1} \end{bmatrix} \end{gathered} \tag{17}$$

or, denoting $MRS_{(C,N)_t} \equiv C_t \mathcal{E}_t$, in the following way:

$$W_t = \frac{MRS_{(C,N)_t}}{d} - \mathbb{E}_t \beta \frac{C_t}{C_{t+1}} (1 - X_{t+1}) \left[\delta W_{t+1} + \frac{(1 - \delta - d)}{d} MRS_{(C,N)_{t+1}} \right] \tag{18}$$

Note that in the *stationary* steady state[15] the *no shirking condition* implies that

$$\widetilde{W} = \widetilde{C}\mathcal{E}\underbrace{\frac{[1-(1-\delta-d)\,\beta\,(1-x)]}{d\,[1+\delta\beta\,(1-x)]}}_{\text{Steady State Wage Markup}} \tag{19}$$

where $\sim$ indicates that the variable has been detrended by the level of technology γ^t. Consistently with the efficiency wage literature, the critical wage must be higher when:

- the desired level of effort is higher
- the probability of being caught shirking (d) is lower
- the exogenous separation rate (δ) is higher (that the worker is going to lose the job soon anyway increases the incentive to shirk)
- the job finding rate (x) is higher (that the workers will be re-employed soon - if they lose the job - increases the incentive to shirk)
- the discount factor (β) is lower (if future benefits - that workers would forgo if they were detected and not re-employed- matter less, the incentive to shirk is higher).

Note also that in steady state the participation constraint is always satisfied as $(1-\delta-d)\,\beta\,(1-x) < 1$.

Firm's problem

The representative firm's period t problem is:

$$\max \mathbb{E}_t \sum_{k=0}^{\infty} Q_{t,t+k}\Pi_{jt+k}\ , \tag{20}$$

subject to (10), (7) and the incentive compatibility constraint (17), where $Q_{t,t+k} = \beta^k \frac{C_t}{C_{t+k}}$ is the stochastic discount factor and $\Pi_{j,t+k} = Y_{j,t+k} - W_{t+k}N_{j,t+k} - \gamma^{t+k}BX^{\eta}_{t+k}H_{j,t+k} - R^k_{t+k}K_{j,t+k}$. Assuming that firms take private sector expectations as given for solving the optimization problem would require wages and effort at time $(t+1)$ to be a function only of exogenous state variables. Because this is not the case, since employment is an endogenous

[15] The economy grows along a balanced growth path: trend productivity growth determines trend increases in output, consumption, wages, capital and investment, without affecting employment and workers' effort. The stationary representation of the model can be obtained by detrending the former group of variables.

state variable, the equilibrium I consider is a timeless-perspective commitment in which firms internalize the effects of their choices on workers' expectations. Denoting with $MPE_t \equiv \frac{\alpha\varkappa Y_t}{\mathcal{E}_t}$ the marginal product of effort and with $MRS_{(C,\mathcal{E})t} \equiv C_t N_t$ its marginal disutility in terms of consumption, the first order conditions for the firm's problem imply:

$$W_t = \alpha Y_t/N_t - B\gamma^t X_t^\eta + (1-\delta)\,\mathbb{E}_t Q_{t,t+1} B\gamma^{t+1} X_{t+1}^\eta \tag{21}$$

$$MRS_{(C,\mathcal{E})t} = dMPE_t + \frac{C_t}{C_{t-1}}(1-X_t)\left[MRS_{(C,\mathcal{E})t-1}(1-\delta-d) + d\delta MPE_{t-1}\right] \tag{22}$$

$$R_t^k = (1-\alpha)\frac{Y_t}{K_t} \tag{23}$$

Equation (21) is the *pseudo*-labor demand, that gives the optimal hiring policy. According to (21) each period the firm hires workers up to the point where the marginal product of labor ($\alpha Y_t/N_t$) equals the cost of a marginal worker, which is given by the real wage, the hiring cost and the discounted savings in future hiring costs resulting from having to hire $(1-\delta)$ fewer workers in the following period.

Equation (22) is a sluggish relation between the marginal product of effort and its marginal disutility expressed in terms of consumption, that gives the optimal relationship between effort and employment. It can be read as giving the performance standard as a function of employment. Note that (22) is a backward looking equation: because the incentive compatibility constraint faced by firms is a forward looking constraint, in a commitment equilibrium the implied policy does not change much over time. As long as worker's performance is imperfectly observable ($d < 1$), the level of effort will not be determined efficiently, and, in steady state, its marginal product will be greater than its marginal disutility expressed in terms of consumption[16]:$\frac{\widetilde{MPE}}{\widetilde{MRS}_{(C,\mathcal{E})}} = \frac{[1-(1-\delta-d)(1-x)]}{[1+\delta(1-x)]d} > 1$. Besides $\frac{[1-(1-\delta-d)(1-x)]}{[1+\delta(1-x)]d}$ is monotonically strictly decreasing with d, meaning that increases in the ability to assess workers' performance are associated with increases in the steady state level of effort (see Appendix B).

Equation (23) gives the demand of capital.

[16]When d=1, then $\widetilde{MPE} = \widetilde{MRS}_{(c,\varepsilon)}$.

2.4 Aggregate resource constraint

Market clearing requires:

$$Y_t = C_t + G_t H_t + I_t \tag{24}$$

Appendix A provides the complete log-linear model and the steady state relations.

3 Capital destruction and unemployment

3.1 Unobservable effort

Suppose that the economy is at a steady state and an unanticipated, transitory, one percentage point increase in the depreciation rate of capital destroys some of the capital stock. In this section, I show that the effects on unemployment depend crucially on the extent to which workers' performance is observable.

I assume that the depreciation rate of capital is independently and identically distributed over time: $\varrho_t = \overline{\varrho} e^{v_t^{\varrho}}$, where v_t^{ϱ} is an i.i.d. shock with mean 0 and standard deviation 1. The time period is a quarter. I use conventional values for the discount factor ($\beta = 0.998$), the mean depreciation rate ($\overline{\varrho} = 0.025$) and the share parameter on capital ($1 - \alpha = 1/3$)[17]. The elasticity of investment with respect to Tobin's Q, μ, is assumed to be equal to 1 (as in King and Watson 1996 and Gali et al. 2007). I set $\varkappa = 0.9$, in order to have additional diminishing returns to effort. I fix $\delta = 0.105$, based on the observation that jobs last about two and a half years (Shimer 2005 and Gertler et al. 2008). Based on Shimer (2005) finding that the average exit probability from unemployment to employment in the U.S. is 0.34 per month, I set $x = 0.7$ (as in Blanchard and Gali 2010)[18]. I follow Blanchard and Gali (2010) and set $\eta = 1$[19]. I fix $\gamma = 1.004$, consistent with a steady state value for productivity growth of 0.4% on a quarterly basis. Finally, I assume that the ratio of the cost per hire to the quarterly real wage ($h_w \equiv \frac{Bx^{\eta}}{\widetilde{W}}$) is 0.15, meaning that the cost per hire is 5% of the annual wage. As shown in Appendix A,

[17] Note that, because of labor market frictions, α does not measure labor share, which is given in the model by: $\frac{\alpha}{1+h_w[1-(1-\delta)\beta]}$. Because this share is just below α, I simply follow convention by setting $\alpha = 1 - (1/3)$. Under this calibration the labor share is 0.66, which is in line with U.S. macro data.

[18] As in Blanchard and Gali (2010), the equivalent quarterly rate is computed as $x = x_m + (1-x_m)x_m + (1-x_m)^2 x_m$, where x_m is the monthly job finding rate.

[19] As stressed by Blanchard and Gali (2010), assuming a matching function of the form $H = ZU^{\varsigma}V^{1-\varsigma}$, we have $\frac{V}{H} = Z^{\frac{1}{\varsigma-1}} \left(\frac{H}{U}\right)^{\frac{\varsigma}{1-\varsigma}}$. Thus, the parameter η corresponds to $\frac{\varsigma}{1-\varsigma}$ in the standard Diamond, Mortensen, Pissarides model and $\eta = 1$ is consistent with estimates of ς, which typically are close to 0.5.

hiring costs represent a fraction $h_y \equiv \frac{Bx^\eta H}{\widetilde{Y}^r} = h_w \frac{\alpha\delta}{1+h_w[1-(1-\delta)\beta]}$ of GDP. According to my calibration, that fraction equals one percent of GDP, which is a plausible upper bound, in line with what is assumed in Blanchard and Gali (2010).

Bargaining set

As long as the real wage is consistent with a non-negative surplus for both firms and workers, workers and firms will not voluntary put an end to their relationship, over the life of their relationship. The bargaining set is defined by the range of wage levels above the workers' reservation wage W_t^L and below the firm's reservation wage W_t^U: $W_t \in [W_t^L, W_t^U]$. Subtracting (15) from (11) yields:

$$S_t^H = W_t - C_t\mathcal{E}_t + (1-\delta)\,\beta\mathbb{E}_t\frac{C_t}{C_{t+1}}\,(1-X_{t+1})\,S_{t+1}^H \tag{25}$$

Thus the worker's reservation wage can be expressed as follows:

$$W_t^L = C_t\mathcal{E}_t - (1-\delta)\,\beta\mathbb{E}_t\frac{C_t}{C_{t+1}}\,(1-X_{t+1})\,S_{t+1}^H \tag{26}$$

The surplus from an existing employment relation accruing to firm is given by:

$$S_{j,t}^F = \alpha Y_{j,t}/N_{j,t} - W_{j,t} + (1-\delta)\,\mathbb{E}_t Q_{t,t+1} S_{j,t+1}^F \tag{27}$$

Thus the corresponding reservation wage for the firm is:

$$W_t^U = \alpha Y_{j,t}/N_{j,t} + (1-\delta)\,\mathbb{E}_t Q_{t,t+1} S_{j,t+1}^F \tag{28}$$

Under the continuing assumption that the firm is maximizing profits, it follows from (27) and (21) that $S_{j,t}^F = G_t \ \forall\ j$ and t.

In order to show that, under the calibration discussed above, wages have a negligible probability of falling outside the bargaining set, I first generate artificial time series of 12000 observations from the model[20] and then compute a time series for the reservation wage of workers, the reservation wage of firms and the equilibrium wage, under different calibrated values of the probability of being caught shirking. The first panel in Figure 3 plots the three time series when $d = 0.25$, a value which implies a steady state wage markup of 213%; the second panel in Figure 3 reports the three time series when $d = 0.95$, a value which implies a steady state wage markup of 3.74%. In both cases, the real wage

[20] In order to preserve the clarity of the figure I plot only 1000 observations.

stays in the bargaining set, moving close to the upper bound when $d = 0.25$, while lying close to the lower bound when $d = 0.95$.

Impulse response functions

Figure 4 reports the impulse response functions (IRFs) of employment, effort, output, investment, real wage, capital, consumption and capital rental cost for different values of d. All the IRFs, except employment and effort, are expressed relative to trend. The following emerges:

- An adverse shock to the size of the capital stock leads to recession, regardless of the firms' ability to evaluate workers' performance. Capital destruction causes proportional declines in output, investment and consumption relative to trend. These three variables display roughly the same volatility.

- There is a negative correlation between employment and workers' performance, i.e. workers' effort and employment move in opposite directions as the shock hits the economy: when employment falls, workers' effort rises and vice-versa. In addition, the model delivers two sets of outcomes, depending on the firms' ability to evaluate workers' performance. As long as d is less than a certain threshold value (d_*), employment rises and effort declines in the face of the capital depreciation shock; and vice-versa, when d is larger than a certain threshold value (d_*) the shock leads to a drop in employment and an increase in effort. When $d = d_*$ the model falls in the region of indeterminacy. Given the calibration discussed above, $d^* \cong 0.8$. To give a sense of magnitude, $d = 0.8$ implies a steady state wage markup over the reservation wage of 18%.

- The firm's ability to assess workers' performance affects not only the sign but also the size of the employment and effort movements. As long as $d < d_*$ (as long as the steady state wage markup is larger than 18%), the larger is d, the larger the variations in employment and effort. By contrast when $d > d_*$ (as long as the steady state wage markup is smaller than 18%), the larger is d, the smaller the variations in employment and effort.

- The response of the real wage is negative and its size depends on d: the negative responses of the real wage associated with values of d lower than d_* (i.e. values of d that imply a positive response of employment) are larger (in absolute value) than the IRFs associated with values of d greater than d_* (i.e. values of d that imply a negative response of employment).

Accordingly, the model generates large declines in employment when $d \to d_*^+$. As an example, Figure 5a collects the IRFs of output, investment, consumption and real wage relative to trend, and of employment and effort when $d = 0.85$, a value which is slightly larger than d_* (and which implies a steady state wage markup over the reservation wage of 12.52%). Employment and output, consumption and investment relative to trend fall with the impact of the shock and have nearly the same volatility. Workers' performance booms. Thereafter consumption, investment and output grow at around their usual balanced growth rate γ, with employment persistently at the depressed level and effort persistently at the high level: the adverse shock rendering some of the capital stock unproductive generates a jobless recovery driven by a boom in workers' performance. Figure 5b shows the dynamic simulation of employment and undetrended GDP in levels. Importantly, the same scenario for employment and output investment and consumption is obtained in Shimer's (2010) search model, in which firms can adjust labor input only along the extensive margin, by imposing that the real wage stays fixed. Similarly here, despite sizeable movements in unemployment, the real wage remains roughly constant but as a result of the forces at stake in the economy.

Let me stress that, as in Shimer (2010), I use the term jobless recovery in order to refer to a business cycle phase during which GDP growth turns positive while employment stays depressed. However, note that, as in Shimer (2010), following the adverse capital depreciation shock, the level of GDP remains persistently below its potential.

Economic intuition

I cannot solve for the equilibrium analytically, but the economic intuitions for the results presented above are clear-cut.

Unemployment acts as a threat that motivates workers to devote effort to their works. This is the reason behind the negative correlation between effort and employment, shown in Figure (4). Let's consider again the incentive compatibility constraint:

$$W_t = \frac{\mathcal{E}_t}{dU_{c,t}} - \mathbb{E}_t \beta \frac{C_t}{C_{t+1}} \mathcal{S}_{t+1}^H \left(1 - X_{t+1}\right) \tag{29}$$

which represents the supply-wage as a positive function of employment[21]. The positive

[21] As shown in section 2.3 $(1 - X_{t+1}) = \left(1 - \frac{H_{t+1}}{U_{t+1}}\right)$ represents the probability of not finding a job and

slope reflects the incentive discipline device role of unemployment: for any given level of effort, the higher the job finding rate, the higher will be the incentive compatible wage. The intersection of the *pseudo labor demand (*21) and the no-shirking condition (29) is a downward sloping locus, mapping the quantity of labor into the effort level such that the demand wage equates with the incentive compatible wage.

Two effects ensue from the capital depreciation shock. First, workers are poorer. Because preferences are such that the marginal utility of income ($U_{c,t}$) increases as income falls, the reservation wage decreases and with it the wage required to deter shirking. Hence, this wealth effect implies that, for any given level of effort, the level of employment satisfying the incentive compatibility constraint increases. Second, labor productivity falls, making the pseudo labor demand shift to the left. Hence, this effect implies that, for any given level of effort, the level of employment satisfying the incentive compatibility constraint decreases. Both movements lead to a drop in the equilibrium wage level, while the sign of the response of employment is ambiguous.

The incentive compatibility constraint (29) shows that the former effect will be stronger with a smaller d. Intuitively d affects the sensitivity of the incentive compatible wage to the reservation wage: the smaller the detection probability, the higher will be the desired wage markup, thus the larger will be the change in the incentive compatible wage driven by a change in the reservation wage. As for the second effect, low values of d make the incentive compatibility constraint steeper, because workers' surplus $\mathcal{S}_{t+1}^{H}$ decreases with d. When the shift in labor demand traces out a steeper incentive compatibility constraint, the negative effect on employment is smaller than in the case of a fairly flat wage-supply schedule. Both considerations suggest that, as shown in Figure (4), given the other parameters, low values of d are more likely to be associated with positive responses of employment, whereas high values of d are more likely to be associated with negative responses of employment.

Similarly, the volatility of wages when employment rises (i.e. associated with low values of d) is larger than the volatility of wages when employment falls (i.e. associated with high values of d), because increases in the firms' ability to evaluate workers' performance flatten the wage schedule (29).[22]

Figure (4) puts forward a relevant effect of d on the magnitude of employment and effort responses. In particular, as stressed above, when d is such that employment falls

remaining unemployed.

[22] Gomme (1999) stresses that the shape of the incentive compatibility constraint is an important determinant of wage volatility.

in the face of the capital depreciation shock (i.e. d is relatively high), the larger is d the smaller the magnitude of employment and effort responses. Accordingly, large declines in employment and jobless recoveries emerge for values of d slightly larger than d^*. By contrast, when d is such that employment rises (i.e. d is relatively low), the larger is d the larger the magnitude of employment and effort responses. The intuition hinges again on the threat of unemployment as a method of discipline.

Suppose that the economy is on its balanced growth path, there is a one-time capital depreciation shock and the firms' ability to monitor workers d is relatively high, so that firms cut back on their employment. The increased threat of unemployment makes insiders more efficient, inducing them to work harder. The increased efficiency reduces firms' needs for workers, resulting in even greater unemployment. This further strengthens the threat and further boosts the effort, leading ultimately to amplified unemployment and performance dynamics. The opposite happens when d is relatively low. In this case the increased employment reduces the threat of firing, and makes insiders less efficient, inducing them to work easier. The depressed efficiency increases firms' need for workers, resulting in lower unemployment, leading ultimately to amplified employment and performance dynamics. It follows that, both when employment rises and when it falls, the stronger the incentive discipline device role of unemployment - i.e. the responsiveness of the level of effort that workers are willing to exert to changes in the expected probability of not finding a job - the larger will be the cyclical employment and effort movements. The effect that increases in d play on the effort responsiveness to unemployment is thus crucial to the economic intuition.

In section (2.3) I quantified the discipline device role of unemployment as follows:

$$\mathcal{I}_t \equiv \frac{\partial \mathcal{E}_t}{\partial(1-X_{t+1})} = U_{c,t} d \mathbb{E}_t \beta \frac{C_t}{C_{t+1}} \mathcal{S}^H_{t+1} \tag{30}$$

Looking at (30), it can be seen that unemployment plays a weak role as a method of discipline not only when the detection probability d is close to zero - meaning that the threat of firing is weak - but also when it is close to one, because in this case the expected surplus accruing to the household from an existing employment relation (that workers would lose if they were detected shirking and not re-employed) is close to zero. Indeed, if the detection probability tended to one the model would become a search and matching economy with zero workers bargaining power, the wage rate would be equal to the workers' reservation wage - since firms would have no reasons to pay above the market wage - involuntary unemployment would be determined only by the presence of search and matching frictions. In other words, unemployment would play no role as a method of discipline. The discipline device role of unemployment is strong when the firms' ability to assess workers' performance is such that the probability to be detected shirking and to join the pool of unemployed is considerable and, at the same time, the loss workers would incur were they detected shirking is still extensive.

Thus increased ability of firms to monitor labor quality strengthens the role of unemployment as a discipline device as long as the decreased surplus does not counterbalance the increased fear of losing the job. I cannot proceed analytically outside of the steady state but, given the other parameters, this is clearly more likely when d is relatively small. Appendix B and Figure 6 clarify this point by illustrating the dependence of the incentive discipline device role of unemployment (as quantified in 30) - evaluated in steady state - on d.

Summing up, when d is relatively high, so that firms cut back on their employment, the strength of the discipline device role of unemployment decreases with d. This explains why the model delivers sharp declines in employment, proportional to declines in GDP relative to trend, when d is large enough to induce firms to cut back on employment and raise performance standard, but not large enough to dim the discipline device role of unemployment. In this case the large movements in unemployment are driven by the increased efficiency of insiders that reduces firms' needs for workers. Conversely, when d is relatively low, so that firms increase their employment, the strength of the discipline device role of unemployment increases with d. This explains why when $d < d_*$ the larger is d the larger are the cyclical movements in employment and effort.

3.2 Observable effort

Shimer (2010) looks at the effects of an adverse shock to the capital accumulation process in a search model where firms can adjust labor input only along the extensive margin. The major conclusion is that a model with flexible wages never generates a large decline in employment. The latter is indeed much less volatile than output. In order to get a quantitative large decline in employment, one has to assume rigid real wages, that do not fall after the shock. In this case the adverse shock leads to a proportional decline in employment and in output, consumption and investment relative to trend. Thereafter jobless recovery emerges because output, consumption and investment grow at around their usual growth rate γ while employment stays persistently at the depressed level. In order to allow a comparison with Shimer's (2010) results, Figure 7 shows the impulse responses to a capital depreciation shock of employment and effort and of output, consumption, investment and real wages relative to trend implied by the model developed in Section 2, when workers' performance is perfectly observable.

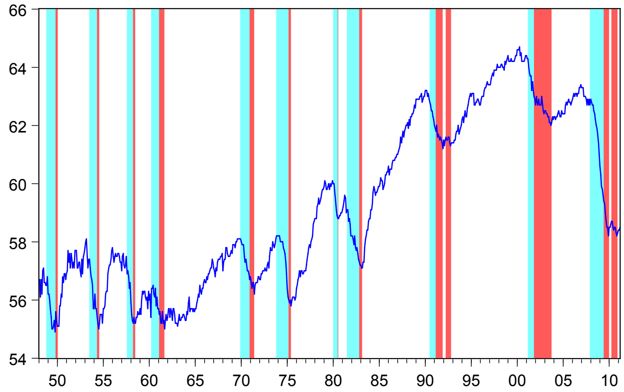
Figure 7 illustrates that Shimer's (2010) results are replicated in the model I put forward in this paper, which features the possibility to adjust labor input along both the extensive (employment) and the intensive (effort) margin. The model is still calibrated to U.S. data, as indicated in Section 3.1. When wages are flexible employment declines by much less than output, consumption, wages and investment relative to trend. The positive movements in effort are muted as well as those in employment. When wages are assumed to be rigid, the model produces an equal decline in employment and in output, consumption and investment relative to trend on the impact of the adverse shock. Thereafter, output, consumption and investment growth turns positive (at around γ) with employment persistently at the depressed level. Note also that the behavior of the economy in this case (Figure 7, panel b) resembles the jobless recovery obtained under the assumption of efficiency wages (Figure 5a) when the incentive discipline device role of unemployment is particularly strong. In the latter case however the response of effort is somewhat larger than in the case of observable effort.

4 Conclusions

Historically, as the economy emerged from a downturn, revival of GDP growth was accompanied by a prompt increase in employment. The 1990-91 recession broke this pattern and opened an era of jobless recovery, where revival of GDP growth is associated with prolonged anemic growth in employment. Using an efficiency wage model with search and matching frictions, this paper has highlighted a channel that may have played a role in establishing this tendency.

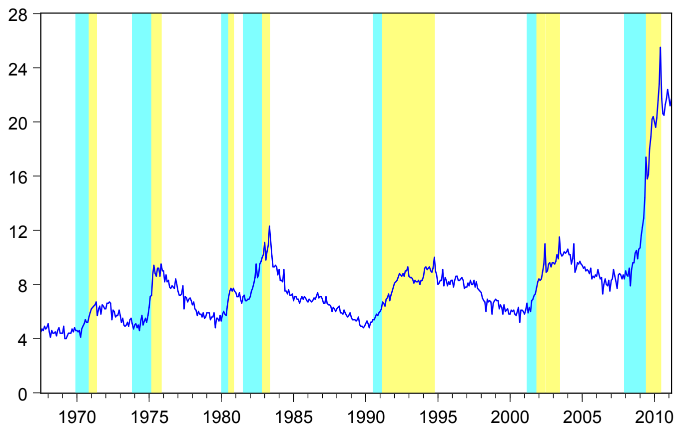
The mechanism at stake hinges on incentive problems in the labor market. When an adverse shock to the capital accumulation process hits the economy and firms cut back on their employment, the increased threat of being fired and of enduring long spells of unemployment can amplify the cyclical movements in workers' performance. Large declines in employment and jobless recovery emerge because the increased insiders' efficiency reduces firms' needs for workers. Also, the model explains the relative rigidity of real wages observed over the business cycle combined with large variations in employment. I have shown that the clearing of asymmetric information and moral hazard can smooth cyclical movements in effort and unemployment. A general conclusion of this paper is therefore that incentive problems in the labor market help account for business cycle comovement.

Figure 1. Jobless recoveries



NOTES. Civilian-Employment Population Ratio (%). Light Blu shaded areas indicate NBER-dated U.S. recessions. Red shaded areas indicate jobless recoveries. Sources: Bureau of Labor Statistics.

Figure 2. Unemployment duration



NOTES. Light Blu shaded areas indicate NBER-dated U.S. recessions. Yellow shaded areas indicate periods between the end of the recession and the begin of a downward trend in unemployment duration. The duration of unemployment has dramatically increased during the latest economic crisis, reaching a spike of 25.5 weeks. Sources: Bureau of Labor Statistics.

Figure 3. Efficiency wages and the bargaining set

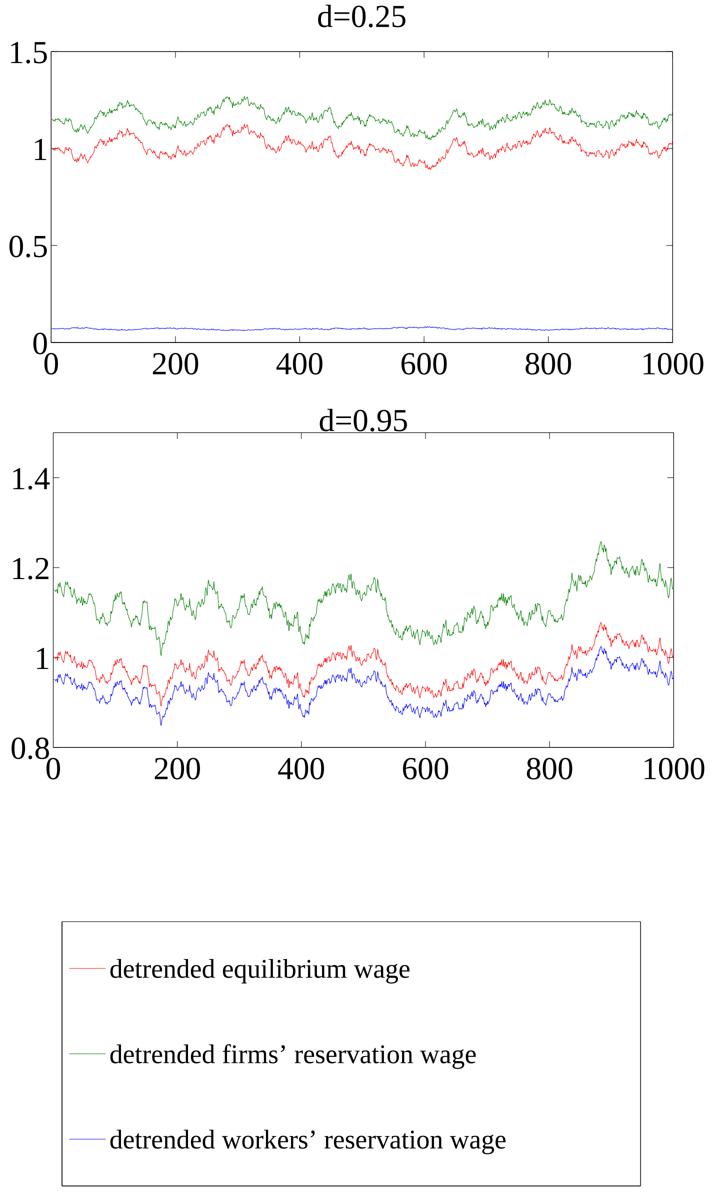
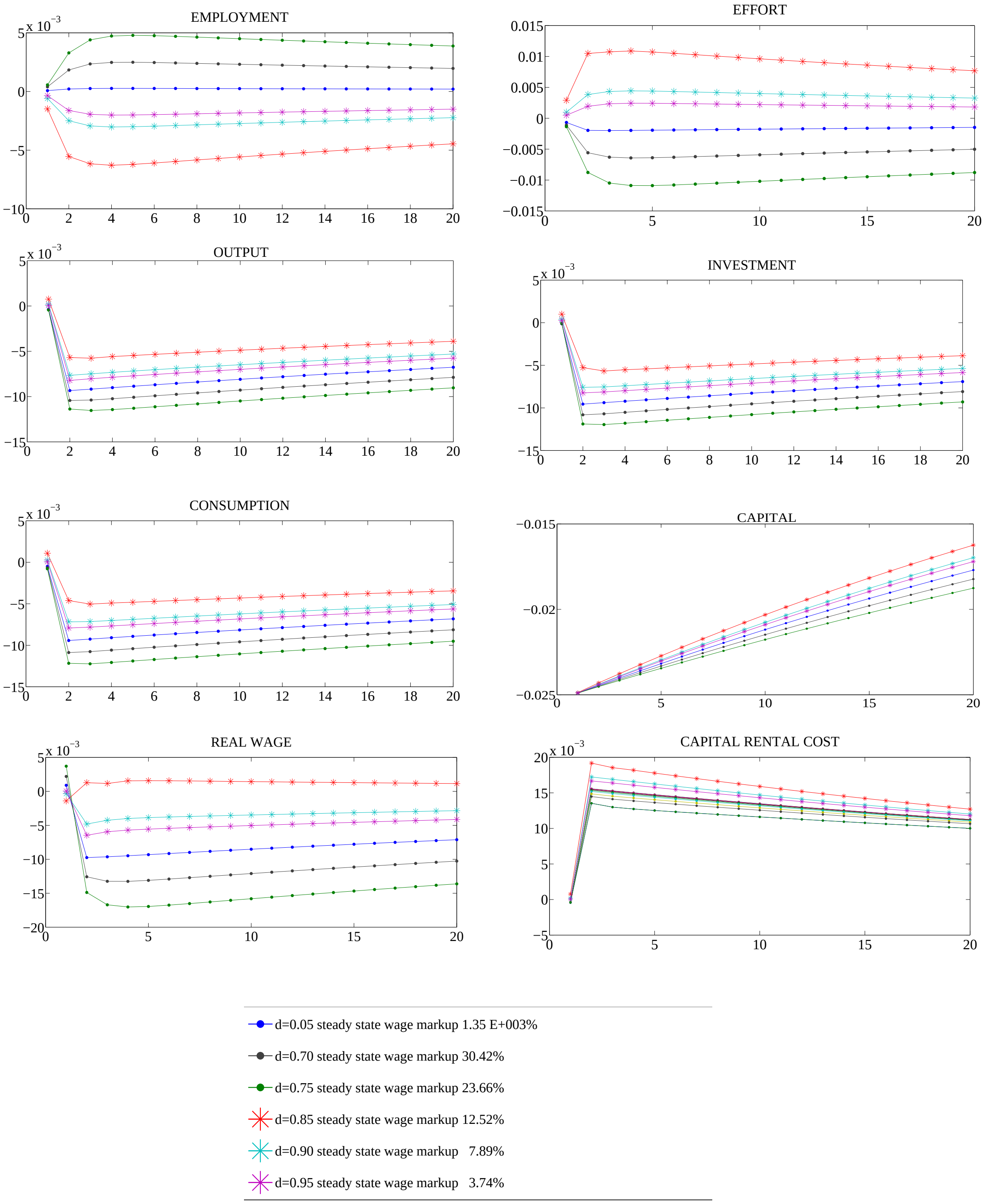
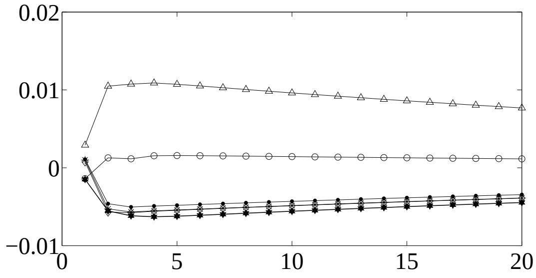


Figure 4. Impulse response functions to a capital depreciation shock



NOTES. All the IRFs, except employment and effort, are expressed relative to trend. Parameters are calibrated as reported in section 3.1.

Figure 5a. Jobless recovery. Impulse response functions

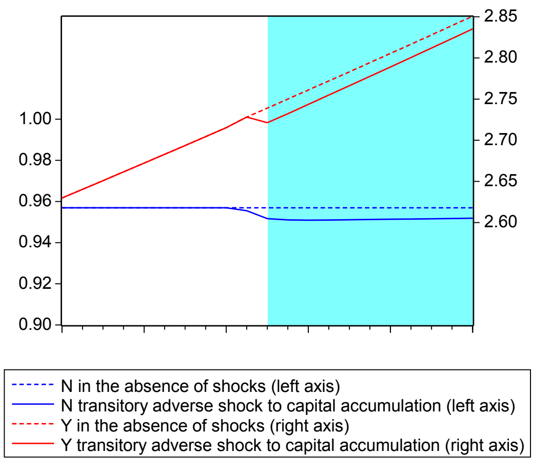


— △ — Effort — ◯ — Real Wage — ● — Consumption

—◇ — Output —★ — Employment — ∗ — Investment

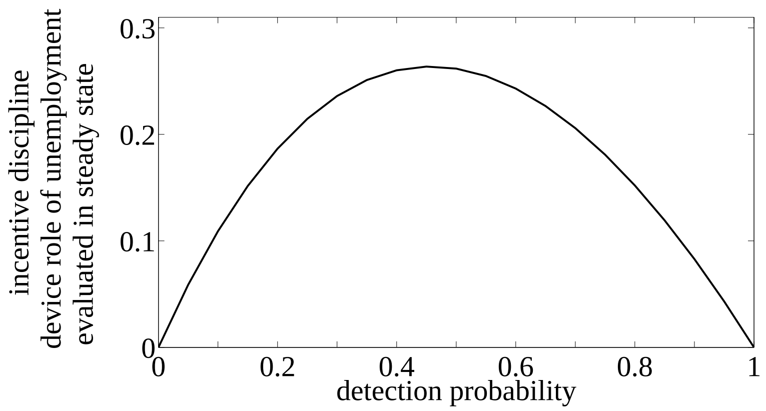
NOTES. Parameters are calibrated as reported in section 3.1, d is set=0.85 consistent with a steady state wage markup of 12%. All the IRFs, except employment and effort, are expressed relative to trend.

Figure 5b. Jobless recovery. Dynamic simulation of employment and undetrended GDP in levels.



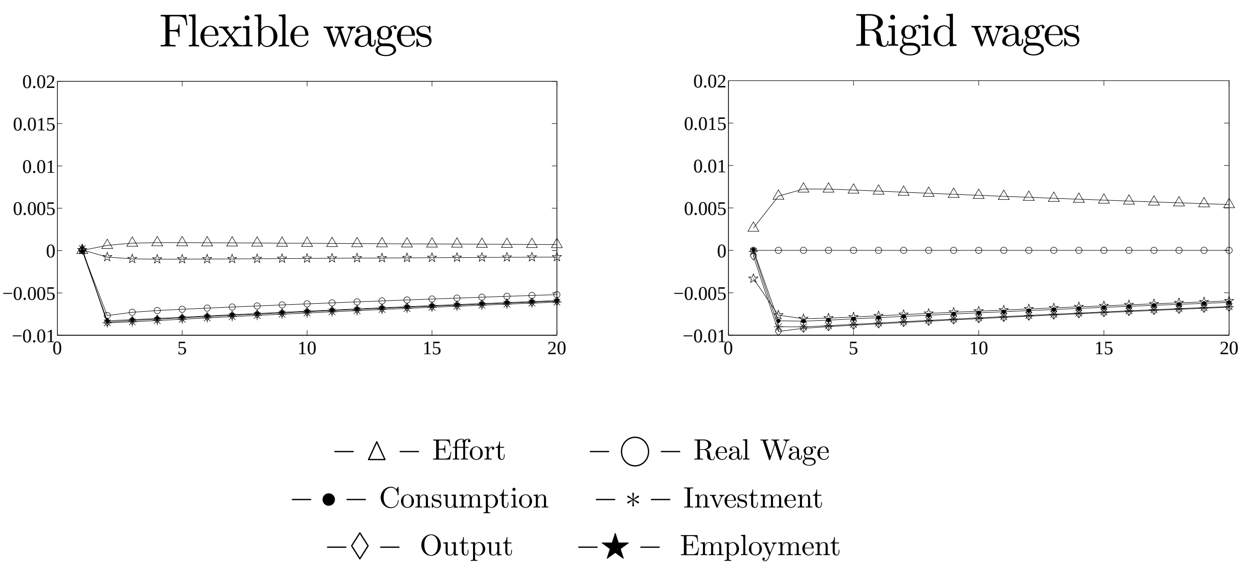
NOTES. The figure shows the dynamic simulation of N_t and undetrended Y_t, both in the absence of any shocks and in the case of the transitory adverse shock to the capital accumulation process. Parameters are calibrated as in section 3.1. and $d = 0.85$. Light blue shaded area indicates jobless recovery: Y_t grows at its balanced growth rate γ while N_t stays persistently at the depressed level.

Figure 6. The detection probability and the incentive discipline device role of unemployment



NOTES. As shown in Appendix B, in steady state $\mathcal{I} = \beta \frac{(1-d)}{[1+\delta\beta(1-x)]} \frac{[1+\delta(1-x)]d}{[1-(1-\delta-d)(1-x)]} \frac{\alpha\varkappa}{\Theta} \frac{[\delta+x(1-\delta)]}{x}$. Parameters are calibrated as reported in section 3.1.

Figure 7. Impulse response functions to a capital depreciation shock when effort is observable



NOTES. Parameters are calibrated as reported in section 3.1. Effort is perfectly observable. All the IRFs, except employment and effort, are expressed relative to trend.

Appendix A

The model is consistent with balanced growth: trend productivity growth determines trend increases in output, consumption, wages, capital and investment, without affecting employment and workers' effort. Given the presence of a trend, before log-linearizing the model I derive its stationary representation. In what follows the "$\sim$" superscript indicates that level variables are expressed in terms of stationary ratios (i.e. given the generic variable Z_t, we have $\widetilde{Z}_t = \frac{Z_t}{\gamma^t}$). The model is then log-linearized around the steady state of the scaled (stationary) variables. Lower case letters with a "$\sim$" thus denote log-deviations of the corresponding detrended variables from the stationarized steady state.

Steady state relations

Using the *no-shirking condition* (19) I define:

$$\Psi \equiv \underbrace{\frac{\widetilde{C}}{\widetilde{W}^r}\frac{\mathcal{E}}{d}}_{MRS_{C,N}/d\widetilde{W}} = \frac{[1+\beta(1-x)\delta]}{[1-\beta(1-x)(1-\delta-d)]} \tag{31}$$

Equation (21) implies that:

$$\Omega \equiv \underbrace{\frac{\alpha Y}{NW}}_{\widetilde{MPN}/\widetilde{W}} = 1 + h_w[1-(1-\delta)\beta] \tag{32}$$

where I define $h_w \equiv \frac{Bx^\eta}{\widetilde{W}^r}$. The steady state investment to capital ratio is:

$$\frac{\widetilde{I}}{\widetilde{K}} = \gamma - 1 + \overline{\varrho} \tag{33}$$

where $\overline{\varrho}$ is the mean depreciation rate. Equation (5) implies $R^k = \frac{\gamma}{\beta} - 1 + \overline{\varrho}$, thus taking into account that $R^k = (1-\alpha)\frac{\widetilde{Y}}{\widetilde{K}}$, we have:

$$\Theta_I \equiv \frac{\widetilde{I}}{\widetilde{Y}} = \frac{(1-\alpha)(\gamma-1+\overline{\varrho})}{\frac{\gamma}{\beta}-1+\overline{\varrho}} \tag{34}$$

which implies:

$$\Theta_C \equiv \frac{\widetilde{C}}{\widetilde{Y}} = 1 - \Theta_I - \delta h_w \frac{\alpha}{\Omega} \tag{35}$$

Note that hiring costs represent a fraction $h_y \equiv \frac{Bx^\eta H}{\widetilde{Y}^r} = h_w \frac{\alpha\delta}{\Omega}$ of GDP.

The complete loglinear model

Technology

$$\widetilde{y}_t = \alpha n_t + \alpha\varkappa\varepsilon_t + (1-\alpha)\widetilde{k}_t$$

Job Finding Rate

$$\delta x_t = n_t - (1-\delta)(1-x)n_{t-1}$$

Aggregate Resource constraint

$$\widetilde{y}_t = \Theta_C \widetilde{c}_t + \frac{\alpha h_w}{\Omega}\left[n_t - (1-\delta)\, n_{t-1} + \delta\eta x_t\right] + \Theta_I \widetilde{i}_t$$

Rental Cost

$$r_t^k = \widetilde{y}_t - \widetilde{k}_t$$

Capital Accumulation

$$\widetilde{k}_{t+1} = \frac{(1-\overline{\varrho})}{\gamma}\widetilde{k}_t - \frac{\varrho}{\gamma}\varrho_t + \frac{(\gamma-1+\overline{\varrho})}{\gamma}\widetilde{i}_t$$

Investment and Capital

$$i_t - k_t = \mu q_t^{Tobin}$$

Tobin Q

$$q_t^{Tobin} = \beta\mathbb{E}_t q_{t+1}^{Tobin} + (c_t - \mathbb{E}_t c_{t+1}) + \left[1 - \frac{\beta}{\gamma}\left(1-\overline{\varrho}\right)\right]\mathbb{E}_t r_{t+1}^k - \frac{\beta}{\gamma}\overline{\varrho}\varrho_t$$

Labor Demand

$$\widetilde{w}_t^r = \Omega\left(\widetilde{y}_t - n_t\right) - \eta h_w x_t + (1-\delta)\,\beta h_w \mathbb{E}_t\left\{\eta x_{t+1} + \widetilde{c}_t - \widetilde{c}_{t+1}\right\}$$

Effort/Employment Relation

$$n_t = (1-\delta-d)\,(1-x)\,n_{t-1} - x\,(1-\delta-d)\,x_t + \frac{\varkappa\Omega}{\Psi}\left[\widetilde{y}_t - \widetilde{c}_t - \varepsilon_t\right] + \\ + \frac{\varkappa\Omega}{\Psi}\delta\,(1-x)\left[\widetilde{y}_{t-1} - \widetilde{c}_{t-1} - \varepsilon_{t-1}\right] - \delta x\frac{\varkappa\Omega}{\Psi}x_t$$

No-Shirking Condition

$$\widetilde{w}_t^r = \Psi\left[\widetilde{c}_t + \varepsilon_t\right] - \beta\,(1-x)\left[\delta + (1-\delta-d)\,\Psi\right]\mathbb{E}_t\left[\widetilde{c}_t - \widetilde{c}_{t+1}\right] + \\ + \beta x\left[\delta + (1-\delta-d)\,\Psi\right]\mathbb{E}_t x_{t+1} - \beta\,(1-x)\,\delta\mathbb{E}_t\widetilde{w}_{t+1}^r - \beta\,(1-x)\,(1-\delta-d)\,\Psi\mathbb{E}_t\left[\widetilde{c}_{t+1} + \varepsilon_{t+1}\right]$$

Appendix B

This appendix sheds light on the dependence of the incentive discipline device role of unemployment (as quantified in 30), evaluated in steady state, on the detection probability d.

Combining (19) with (16) one gets the steady state surplus accruing to the household from an existing employment relation:

$$S^H = \frac{1-d}{[1+\delta\beta(1-x)]}\frac{C\mathcal{E}}{d} \tag{36}$$

Accordingly, one has:

$$\mathcal{I} = \beta\frac{(1-d)}{[1+\delta\beta(1-x)]}\mathcal{E} \tag{37}$$

Equation (22) evaluated in steady state yields the steady state level of effort $\mathcal{E}$. The latter is zero when $d=0$ and is monotonically strictly increasing with d:

$$\mathcal{E} = \frac{d}{x}\frac{\alpha\varkappa[\delta+(1-\delta)x]}{\Theta_C}\frac{[1+\delta(1-x)]}{[1-(1-\delta-d)(1-x)]} \tag{38}$$

Finally, the previous equation (38) can be combined with (37) to get:

$$\mathcal{I} = d(1-d)\beta\frac{\alpha\varkappa[\delta+(1-\delta)x]}{\Theta_C[1-(1-\delta-d)(1-x)]}\frac{[1+\delta(1-x)]}{[1+\delta\beta(1-x)]x} \tag{39}$$

Note that in steady state unemployment plays no role as a method of discipline, i.e. $\mathcal{I}$ =0, both when the detection probability is zero and when it is equal to one. The dependence of the incentive discipline device role of unemployment evaluated in steady state on the detection probability d is illustrated in Figure 6, that shows that when the detection probability is relatively small, increases in d strengthen the role of unemployment as a method of discipline and, vice-versa, weaken it when d is relatively high.

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