Fluctuations, labor markets and financial shocks

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Abstract

An apparent puzzle from the recent financial crisis is that economies with less competitive labor markets seem to have suffered less in terms of unemployment. The present paper investigates this puzzle by focusing on the interactions between financial and labor market imperfections. In particular, we augment a simplified version of Gertler and Kiyotaki (2010) by introducing imperfect competition in the labor market. We find that a higher labour wedge reduces real variables volatility in the presence of financial frictions. By using simple simulations, we also broadly explore the impact of the main factors driving the labor wedge to provide an intuition on the effects of different institutions.

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1 Introduction

A somewhat surprising effect of the recent financial crisis is that economies characterized by more competitive labor markets seem to have suffered more in terms of unemployment. Bentolila *et al.* (2009), e.g., point out that the unemployment rate dramatically rose from 8% in 2007 to 20% in 2009 in Spain, whereas it rose only slightly in France. They claim that the main root of this different performance can be found in the different labor market structures in the two countries.[1] The argument is simple: quantitative rigidities (e.g., hiring and firing costs) reduce unemployment volatility, as they prevent adjustments by varying employment; comparing Spain to France, in the former there is a larger gap between the dismissal costs of workers with permanent and temporary contracts. Thus the rapid growth of the unemployment rate in Spain

[1] They also stress the role of other factors, e.g. the different housing markets.

would represent a failure of the celebrated dual labor system.[2] OECD data on the unemployment rate support the idea that economies with imperfect labor markets have been hit less by the crisis. Spain, Ireland and United States are experiencing high increases in the rates, whereas Germany, France and Italy are suffering less. The same evidence is discussed in policy debates.[3] The objective of our paper is to build a simple macroeconomic model that sheds light on this puzzle.

Search models can easily explain the above evidence; however, it is not clear why countries characterized by low hiring and firing costs, such as the Anglo Saxon ones, have recovered quickly after adverse shocks in the past experiences. Probably, there is something more to be highlighted from labor market institutions and the specificity of financial shock has to be taken into account more explicitly. To quote Woodford (2010: 21), e.g., understanding phenomena such as the recent financial crisis and policy responses "requires the use of a macroeconomic framework in which financial intermediation matters for the allocation of resources." An appropriate framework has been developed by Gertler and Karadi (2009) and Gertler and Kiyotaki (2010), which extend the original mechanism for the financial accelerator based on the cyclical variations of the value of collateral (Bernanke *et al.*, 1999). Gertler and Karadi (2009) and Gertler and Kiyotaki (2010) show that if, due to an agency problem between bankers and depositors, bankers are constrained in the amount of credit they can provide; disturbances to the quality of capital induce a credit drop and a significant downturn by creating capital losses in the financial sector.

We follow this approach to model financial disturbances and consider the interactions between real imperfections in the labor and credit markets. We assume monopolistic competition in the labor market and potentially strategic non-atomistic wage-setters, who may coordinate wage-setting decisions. Our idea is twofold. On the one hand, financial shocks affect capital price, investment decisions and, in turn, the choice between capital and labour. On the other hand, these choices are also crucially influenced by the labor wedge, i.e. the difference between the marginal rate of substitution and the marginal rate of transformation between consumption and leisure, which may be different in economies with different labour market institutions and fiscal systems. In our model, the labor wedge crucially affects economic volatility.[4]

Two papers related to ours are Wasmer and Weil (2004) and Hristov (2008), who also consider the interactions between real imperfections in credit and labor markets.[5] Wasmer and Weil (2004) focuses on the credit and labor rationing

[2] However, we must consider that the labor market reforms of the Nineties were associated with a higher decrease of unemployment up to 2007.

[3] Costain *et al.* (2010), Darius *et al.* (2010) and Schulze-Cleven and Farrell (2010).

[4] The importance of the labor wedge from either a long run or a business cycle perspective has been highlighted by many authors. See, among others, Hall (1997), Cole *et al.* (2002), Mulligan (1998, 2002), Prescott (2004), Galì *et al.* (2007), Chari *et al.* (2007) and Shimer (2009). Full discussion is beyond the scope of the present paper.

[5] We focus on real distortions. In the recent literature more attention has been placed on the interaction between financial frictions and nominal price/wage rigidities. See e.g. Gilchrist and Leahy (2002), Faia and Monacelli (2006), Christiano *et al.* (2008), Monacelli (2008),

that arises from the stochastic matching between creditors and borrowers and show that the combination of moderate credit frictions and moderate labor frictions can give rise to high unemployment. Hristov (2008) shows that a New Keynesian model with labor market search, credit market frictions and price rigidity is able to generate the volatility of unemployment empirically observed. Thus, both conclude that labor and credit imperfections interact in a such a way as to cause a higher volatility.

By using the setup developed by Gertler and Karadi (2009) and Gertler and Kiyotaki (2010), we find a different result. The interaction between labor wedge and financial frictions in fact reduces the volatility of real variables with respect to financial disturbances. An intuitive explanation for our surprising results is as follows. A negative financial shock destroys capital and increases the cost of its replacement, because of the agency problem in the credit market. Firms will tend to postpone investment to reconstruct the capital stock by substituting capital with labor for current production. A high labor wedge dampens this mechanism by increasing the cost of the substitution.

As the labor wedge plays a crucial role in lowering the volatility of the economy, we also explore the impact of the main factors determining it, e.g. the taxation system and features of labor markets. In the spirit of Bentolila *et al.* (2009), we look at the problem from a positive perspective. A normative evaluation of the labor market institutions should, in fact, imply a more complex analysis taking account of the effects of distortions on long-run macroeconomic outcomes, the interplay between them and the business cycle, wage compression and so on. Therefore, a welfare analysis is beyond the scope of the present paper.

The rest of the paper is organized as follows. Section 2 describes our model. Section 3 provides some numerical simulations to describe our main results and provides their intuition. Section 4 briefly discuss the impact of different labor market institutions on volatilities. A final section concludes.

2 The model

Our core framework is a real business cycle model with distorted labor and financial markets, based on Gertler and Kiyotaki (2010). We consider a simple setup assuming no idiosyncratic uncertainty for producing firms and homogeneous financial intermediaries.[6] Households consist of both workers and bankers and perfect consumption insurance among them is guaranteed. Workers supply hours in a non-competitive labor market to non-financial firms and return wages to the household. Similarly, bankers transfer profits earned from the financial activity back to their family. Homogeneous banks intermediate funds between

Iacoviello and Minetti (2008), Gertler and Karadi (2009), Iacoviello and Neri (2010). See also Woodford (2010) for a partial survey.

[6] This setup developed by Gertler and Karadi (2009) mimics a frictionless interbank market with idiosyncratic shocks, as in the Lucas island model (see Gertler and Kiyotaki, 2010). Results can be easily extended to the case of interbank frictions. However, Gertler and Kiyotaki (2010) shows that this extension will only have quantitative effects with respect to the frictionless case (or homogeneous case).

households and non-financial firms in the financial market,[7] facing endogenously determined balance sheet constraints due to an agency problem. Banks provide funds against future profits of the firms which are able to offer perfect state contingent debt. Thus we can think of the banks' claims as equities.[8] Competitive non-financial firms produce output by means of capital and labour. Finally, competitive capital producing firms owned by the households are also introduced.

2.1 Households

In the economy there is a continuum of infinitely lived households indexed by i on the unit interval $(0,1)$; each of them supplies a differentiated labor type. Preferences of households are defined over consumption $(C_{t,i})$ and hours worked $(L_{t,i})$:

$$E_0 \sum_{t=0}^{\infty} \beta^t U\left(C_{t,i}, L_{t,i}\right) = E_0 \sum_{t=0}^{\infty} \beta^t [\ln(C_{t,i} - hC_{t-1,i}) - \frac{\chi}{1+\varepsilon} L_{t,i}^{1+\varepsilon}] \qquad (1)$$

with $\beta \in (0,1)$. h is the habits in consumption parameter, χ measures the relative weight of the labor argument and ε is the inverse Frisch elasticity of labor supply.

The household budget constraint at time t is:

$$C_{t,i} = \left(1 - \tau_L\right) W_{t,i} L_{t,i} + \Pi_t + R_t D_t - D_{t+1} - T_t \qquad (2)$$

where D_t is the total quantity of short term debt the household acquires from banks or government in the form of real bonds that pay the gross real return R_t from $t-1$ to t; $W_{t,i}$ is the real wage, Π_t net payouts to the household from ownership of both non-financial and financial firms;[9] T_t is a lump sum tax; τ_L indicates the labor income tax.

Households first order conditions imply a standard Euler condition:

$$1 = \beta E_t \frac{U_{Ct+1}}{U_{Ct}} R_{t+1} \qquad (3)$$

where U_C is the marginal utility of consumption which is defined as follows:

$$U_{Ct} \equiv \frac{1}{C_{t,i} - hC_{t-1,i}} - \frac{\beta h}{C_{t+1,i} - hC_{t,i}}$$

Thus, $\Lambda_{t,t+1} = \beta \frac{U_{Ct+1}}{U_{Ct}}$ is the household's discount factor. The condition about the optimal labor supply will be introduced at a later stage, when we consider the labor market.

[7] Households can lend money to the banks or fund the government debt. Both deposits and government debts are one period riskless financial activities, i.e. perfect substitutes. This implies that credit rationing only affects banks in collecting deposits, as household can lend to them or the government.

[8] In other words bank loans have the same value as firms' equities.

[9] Note that Π_t is net of the transfer the household gives to its members that enter banking at time t.

2.2 The non financial sector

2.2.1 Goods producing firms

The economy is populated by a continuum of symmetric competitive good producing firms indexed by f on the unit interval $(0,1)$; they employ both capital (K_{t-1}) and labour (L_t) as inputs. Each firm produces perfectly substitutable goods given a Cobb-Douglas production function:

$$Y_{t,f} = A_t K_{t-1,f}^{\alpha} {L_{t,f}}^{1-\alpha} \tag{4}$$

where $A_t = exp\,(a_t)$ is an aggregate productivity shock, with $a_t = \rho_a\, a_{t-1} + u_t$, and u_t a *i.i.d.* normal variable and $L_{t,f}$ denotes a labor bundle of imperfect substitutable labour types distributed over a unit interval, represented by:

$$L_{t,f} = \left[\int_0^1 L\,(i)_{t,f}^{\frac{\eta-1}{\eta}}\,di\right]^{\frac{\eta}{\eta-1}} \tag{5}$$

where η is a measure of the wage setters' monopoly power (i.e., the intratemporal elasticity of substitution across different labor inputs).

For any given level of its labour demand, $L_{t,f}$, each firm must decide the optimal allocation across labour inputs, subject to the aggregation technology (5). From the minimization cost problem solution, demand for labour type i by firm f is then:

$$L(i)_{t,f} = \left(\frac{(1+\tau_S)\,W_t\,(i)}{W_t}\right)^{-\eta} L_{t,f} \tag{6}$$

where τ_S is the payroll tax and

$$W_t = \left[\int_0^1 W_t\,(i)^{1-\eta}\,di\right]^{\frac{1}{1-\eta}} \tag{7}$$

is the average real wage index.

Firms equate the marginal productivity of labour to the wage. As firms are symmetric we can just drop the index f and obtain aggregate labour demand:

$$L_t = \left(\frac{(1+\tau_S)\,W_t}{A_t K_{t-1}^{\alpha}\,(1-\alpha)}\right)^{-\frac{1}{\alpha}} \tag{8}$$

or

$$W_t = \frac{1-\alpha}{1+\tau_S}\,\frac{Y_t}{L_t} \tag{9}$$

As far as capital services demand is concerned, we observe that the gross profit per unit of capital Z_t is given by:

$$Z_t = \frac{Y_t - W_t L_t}{K_t} = \alpha A_t \left(\frac{L_t}{K_t}\right)^{1-\alpha}. \tag{10}$$

Firms are financed by banks, who collect the savings of households. Firms buy new capital goods from capital producers by issuing state-contingent equities at price Q_t and committing to pay the flow of future gross capital profits to the banks.

2.2.2 Capital producing firms

There is a continuum of length one of competitive capital producing firms.[10] They transform one unit of final good into one unit of capital good (priced Q_t) subject to a flow adjustment cost. Thus, the representative capital producing firm maximizes the following expected present discounted value of future profits:[11]

$$E_t \sum_{t=0}^{\infty} \Lambda_{t,t+1} \left(\left(Q_t - 1\right) I_t - f\left(\frac{I_t}{I_{t-1}}\right) I_t \right)$$

where I_t is the production (i.e., investment) and $f\left(\frac{I_t}{I_{t-1}}\right) = \frac{\gamma}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2$ is the adjustment cost.

Profit maximization implies:

$$Q_t = 1 + f\left(\frac{I_t}{I_{t-1}}\right) + \frac{I_t}{I_{t-1}} f'\left(\frac{I_t}{I_{t-1}}\right) - E_t \Lambda_{t,t+1} f'\left(\frac{I_{t+1}}{I_t}\right)\left(\frac{I_{t+1}}{I_t}\right)^2 \tag{11}$$

The law of motion for capital is given by:

$$K_t = \Psi_t \left(I_t + K_{t-1}\left(1-\delta\right)\right) \tag{12}$$

where δ is the capital depreciation rate and $\Psi_t = exp\left(\psi_t\right)$ is a capital quality shock, i.e. an exogenous source of variation in the value of capital; $\psi_t = \rho_\psi \, \psi_{t-1} + \varepsilon_t$ and ε_t is a *i.i.d.* normal variable with zero mean and finite variance, σ^2.[12]

2.3 Labor markets

Differently from Gertler and Kiyotaki (2010), the labor market is not competitive as each worker sells a different kind of labor. Each wage-setter bargains over the real wage, taking other workers' decisions as given. However, wage setting might be coordinated to various degrees.[13] The coordination degree is captured by the parameter n^{-1} in the following way. Each wage-setter (indexed by j, with $j = 1, ...n$) acts on behalf of a length n^{-1} of workers. More specifically, each union j set the wage $W_{t,j}$ of the agent $i \in j$, (i.e., $W_{t,i} = W_{t,j}$ if $i \in j$) so

[10] Firms' indices are dropped for simplicity.

[11] Capital producing firms earn no profits in steady state; when fluctuations occur they redistribute profits directly to the households who own capital producing firms.

[12] See Gertler and Karadi (2009), Brunnermeier and Sannikov (2009) and Gourio (2009) for this kind of shock.

[13] See e.g. Gnocchi (2009) for a similar framework.

as to maximize his utility in (1), subject to the budget constraint (2), (6) and (8).

In fact, by (7), in the decentralized equilibrium each union j anticipates that

$$\frac{\partial W_t}{\partial W_{t,j}} = \frac{\partial}{\partial W_{t,j}} \left[\int_{i \in j} W_t(i)^{1-\eta} di + \int_{i \notin j} W_t(i)^{1-\eta} di \right]^{\frac{1}{1-\eta}} = \frac{1}{n} \left(\frac{W_{t,j}}{W_t} \right)^{-\eta} \tag{13}$$

At the symmetric equilibrium, the wage-setters' first order conditions yield:

$$0 = E_t \left[\frac{1}{C_{t,i} - hC_{t-1,i}} - \frac{\beta h}{C_{t+1,i} - hC_{t,i}} \right] \left[(\eta - 1)(n-1) + \frac{1-\alpha}{\alpha} \right] + - \chi \frac{(1-\tau_L) L_t^{\varepsilon}}{W_t} \left[\eta (n-1) + \frac{1}{\alpha} \right] \tag{14}$$

This implies that labor supply is

$$W_t = -\upsilon E_t \frac{U_{Lt}}{U_{Ct}} \frac{1}{1-\tau_L} \tag{15}$$

where $\upsilon = \frac{1+\alpha\eta(n-1)}{1-\alpha[1-\alpha(\eta-1)(n-1)]}$ denotes the gross wage markup.

Observe that our formulation nests alternative labor market regimes, ranging from perfect competition (n, $\eta \to \infty$, $\upsilon = 1$) to monopolistic competition ($n \to \infty$, $1 < \eta < \infty$, $\upsilon = \eta(\eta-1)^{-1}$), to strategic wage setting ($1 \leq n < \infty, 1 < \eta < \infty$).

If we rearrange (9) and (15) in order to focus on the ratio between the marginal rate of substitution $\frac{U_{Lt}}{U_{Ct}}$ and the marginal product of labour, i.e. the "labor wedge" ϑ we have:

$$(1-\alpha) \frac{Y_t}{L_t} = -\vartheta E_t \frac{U_{Lt}}{U_{Ct}} \tag{16}$$

where $\vartheta \equiv \upsilon \frac{1+\tau_S}{1-\tau_L}$. This wedge is an increasing function of η and n[14] (i.e. the elasticity of substitution of wage-setters' coordination) and of the tax rates (τ_S and τ_L). In other words, the labor wedge reflects, on the one hand, technology, labor market institutions and the productive structure of a country and, on the other hand, the taxation and social security system.

In our setup, an increase in the gross wage markup or in the tax wedge raises the cost of labor (and real wages) and, *coeteris paribus*, lowers employment.[15]

[14] For reasonable values of α and η.

[15] Of course, our simplified model does not capture all relevant channels. For instance, the ultimate effects of tax wedges on employment cannot be unambiguously inferred without considering that the labor taxes might be used to finance policies that foster labor supply.

2.4 The financial sector

As explained, the representation of the financial sector is borrowed from Gertler and Karadi (2009) and Gertler and Kiyotaki (2010). Banks are owned by households. Each period a fraction σ of bankers survives while a fraction $1-\sigma$ exits and is replaced.[16] Each banker's objective is then to maximize the expected discounted present value of its future flows of net worth n_t, that is:

$$V_t = E_t \sum_{i=1}^{\infty} (1-\sigma)\sigma^{i-1} \Lambda_{t,t+i} n_{t+i} \tag{17}$$

Bankers can loan the sum of the bank net worth n_t and deposits d_t to firms or can divert a fraction θ of this sum to their family. Diverting assets can be profitable for the banker who, afterwards, would default on his debt and shut down, and correspondingly represents a loss for creditors who, at most, could reclaim the fraction $1-\theta$ of assets. As a consequence, depositors would restrict their credit to the banks as they realize that the following incentive constraint must hold for the banks in order to prevent them from diverting funds:

$$V_t(s_t, d_t) \geqslant \theta\,(n_t + d_t) \tag{18}$$

i.e., the value of the bank must always be greater than the amount the banks can divert.

Each period, the value of loans funded, $Q_t\, s_t$, must equal the sum of the bank net worth n_t and deposits d_t:

$$Q_t\, s_t = n_t + d_t \tag{19}$$

where s_t is the volume of loans funded. Recall that the bank's loans can be interpreted as firms' equities owned by the bank.

The net worth for the single bank evolves according to:

$$n_t = \Psi_t[Z_t + (1-\delta)\ Q_t]s_{t-1} - R_t d_{t-1} \tag{20}$$

where Z_t is the dividend payment at t on the loans the bank funded at time $t-1$. It is worth noticing that Ψ_t affects the value of the capital of the non financial firms and, in turn, the value of the equities held by the bank.

The solution of the above dynamic optimization problem implies[17]

$$Q_t\, s_t = \phi_t n_t \tag{21}$$

as and

$$\mu_t \equiv \frac{v_{st}}{Q_t} - v_t > 0 \tag{22}$$

$$\phi_t = \frac{v_t}{\theta - \mu_t} \tag{23}$$

[16] New bankers are endowed with a fraction $\zeta/(1-\sigma)$ of the value of the assets intermediated by the existing bankers. Indeed, there are different ways to model bankers turnover. See Gertler and Kiyotaki (2010: 10) for a discussion.

[17] See Appendix A for details on the derivation.

where ϕ_t is the leverage ratio of the bank; υ_{st} is the marginal value of assets for the banks; and υ_t is the marginal value of deposits to the bank at time t.

As banks are constrained on the retail deposit market, there will be a positive difference between the marginal value and cost of loans for the banks. Moreover, the marginal value of net worth Ω_t and the gross rate of return on bank assets R_{kt} must obey the following conditions:

$$\begin{aligned} \upsilon_t &= E_t \, \Lambda_{t,t+1}\Omega_{t+1}R_{t+1} &(24) \\ \mu_t &= E_t \, \Lambda_{t,t+1}\Omega_{t+1}(R_{kt+1} - R_{t+1}) &(25) \end{aligned}$$

with[18]

$$\begin{aligned} \Omega_{t+1} &= 1 - \sigma + \sigma(\upsilon_{t+1} + \phi_{t+1}\mu_{t+1}) &(26) \\ R_{kt+1} &= \Psi_{t+1}\frac{Z_{t+1} + (1-\delta)Q_{t+1}}{Q_t} &(27) \end{aligned}$$

It follows that there will always be an excess return of assets over deposits:

$$E_t \, \Lambda_{t,t+1}\Omega_{t+1}R_{kt+1} > E_t \, \Lambda_{t,t+1}\Omega_{t+1}R_{t+1} \tag{28}$$

Aggregating (21) over all banks,[19] we obtain the sector balance sheet and the demand for assets from the banks:

$$\begin{aligned} Q_t \, S_t &= N_t + D_t &(29) \\ Q_t \, S_t &= \phi_t N_t &(30) \end{aligned}$$

The overall bank lending capacity depends on the aggregate bank capital which, in turn, may be affected by the changing value of the funded assets.

2.5 Market clearing

In order to close the model, market clearing conditions are required for both the labour and the securities markets. The labor market clearing condition comes from (9) and from (15):

$$(1-\alpha)\; A_t K_{t-1}^{\alpha} L_t{}^{-\alpha} = \frac{1+\tau_S}{1-\tau_L}\upsilon\chi L_t^{\varepsilon} E_t \left[\frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t}\right] \tag{31}$$

The securities markets clear when ($S_t = K_{t+1}$):

$$S_t = I_t + (1-\delta)K_t \tag{32}$$

[18] The term $\Lambda_{t,t+1}\Omega_{t+1}$ can be thought of as the "augmented stochastic" discount factor since it accounts for the stochastic marginal value of the net worth (Ω_{t+1}).

[19] Aggregate values for s, n and d are described by capital letters.

The economy-wide resource constraint must also be considered:

$$C_t = Y_t - I_t \left[1 + \frac{\gamma}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right] - Y_t \, \bar{g} \tag{33}$$

where $\bar{g}$ is a fixed fraction the government expenditure financed by lump-sum taxation without any recourse to debt.

The aggregate net worth (N_t) evolves according to

$$N_t = (\sigma + \zeta) \, \Psi_t [Z_t + (1 - \delta) \; Q_t] S_{t-1} - \sigma R_t D_{t-1} \tag{34}$$

The above expression is determined by a double aggregation. We compute the aggregate net worth of new and old bankers and then we sum them up. In detail, we aggregate the new individual bankers by knowing that they are endowed with a fraction $\zeta/(1-\sigma)$ of the value of the asset intermediated by the exiting bankers (i.e., $(1 - \sigma) \, [Z_t + (1 - \delta) \; Q_t] S_{t-1}$) and the old ones by using (20).

3 Financial shocks and labor rigidities

We consider 17 equations to determine the dynamics of 17 endogenous variables (C, L, Y, I, K, Q, Z, R_k, R, N, D, S, v, v_s, Ω, ϕ, μ). In detail, numerical simulations involve the following equations: (3), (4),[20] (10)-(12), (22)-(31), (29)-(34).

Regarding our calibration, as benchmark we set the intra-temporal elasticity of substitution across labor inputs to 6, corresponding to a wage markup of 20% when the workers do not coordinate their actions (i.e., they behave as atomistic wage-setters) and there is no a tax wedge. The rest of calibration follows Gertler and Kiyotaki (2010) to whom we refer for a full discussion.[21] Parameters are summarized in the following table.

β	0.960	Discount rate
χ	5.584	Relative utility weight of labor
ε	0.333	Inverse Frisch labor supply elasticity
h	0.500	Habits parameter
θ	0.383	Fraction of divertable assets
σ	0.972	Survival rate of bankers
$\frac{\zeta}{1-\sigma}$	0.107	Transfer to new entering bankers
α	0.330	Effective Capital share
γ	2.790	Capital adjustment cost
δ	0.025	Depreciation rate
η	6.000	Wage-setters' monopoly power (intra-temporal elasticity of substitution across labor inputs)
$\frac{1+\tau_S}{1-\tau_L}$	1.000	Tax wedge

Table 1 – Baseline parameter values

[20] After aggregating.

[21] Investment adjustment is calibrated as in Altig *et al.* (2004).

As shown in Gertler and Kiyotaki (2010) the effect of a negative capital quality shock implies a decrease in the value of the non financial firms which entails a rise in the external finance premium.[22] Investment falls instead of increasing, as would occur in a standard frictionless business cycle model, and the value of the capital stock is thus later restored. Disruption of financial intermediation causes a real crises in the economic activity.

The following figure describes the above mechanism by comparing three different scenarios. We display the impulse response functions to a negative capital quality shock by comparing our baseline scenario (where the labor markup is 1.20)[23] to competitive wages (as in Gertler and Kiyotaki, 2010) and to an economy with larger imperfections (i.e., a markup equal to 1.30).

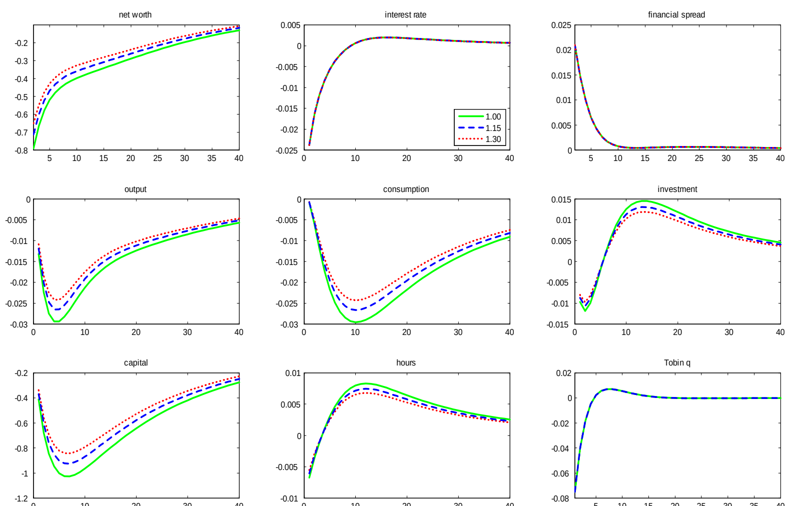

Figure 1 – Financial shock and labor rigidities (IRF)

In all scenarios, differently from the frictionless case, which is not reported,[24] the financial shock triggers a financial accelerator that implies a fall in the investment activity as well as in the other real variables because of the reduction in the value of the net worth of banks and their capacity of collecting deposits. The fall of investment leads to a fall in the labor demand and a consequent

[22] Banks are also affected by the financial shock as they are leveraged and the effect of a drop in the value of assets is amplified proportionally to the leverage ratio. Besides, as their budget constraint is tightened, banks are induced to sell owned assets which leads to a further asset devaluation.

[23] As well as the labor wedge as in our baseline calibration we consider a case with atomistic wage-setters and no taxes.

[24] See Gertler and Kiyotaki (2010).

fall in output and consumption. The increase in the cost of investment also implies *coeteris paribus* a rise in labor demand as firms attempt to substitute capital with labor. The net effect of these two forces on hours worked is however negative.

By comparing the competitive market to the other two scenarios, it is clear that the effects of the financial accelerator are dampened by the labor wedges. In the alternative scenarios, the different labor wedges support a different real wages. The higher real wages reduce the incentive to substitute capital with labor. By smoothing the reduction in the quantity of capital, the real wage rigidities limit the credit disruption (see the net worth). As a result, the effect of the financial shock are dampened by the presence of real rigidities in the labor market. It is worth noticing that there is no complementarity between financial and labor market rigidities as in the two scenarios the behavior of financial factors is the same (see the interest rate, the external finance premium and the Q-dynamics).

Table 2 describes the effect of financial instability on the volatilities. The table is built by considering 200.000 simulations for each different labor wedge (column 1) and reports the volatilities of output, consumption, investment and hours (columns 2-5).

labor wedge	σ_Y^2	σ_C^2	σ_I^2	σ_L^2
1.00	0.0106	0.0040	0.0168	0.0013
1.05	0.0099	0.0037	0.0158	0.0012
1.10	0.0092	0.0035	0.0147	0.0011
1.15	0.0087	0.0033	0.0138	0.0011
1.20	0.0081	0.0031	0.0129	0.0010
1.25	0.0076	0.0029	0.0121	0.0009
1.30	0.0071	0.0027	0.0113	0.0009
1.35	0.0067	0.0025	0.0106	0.0008
1.40	0.0064	0.0024	0.0102	0.0008
1.45	0.0062	0.0023	0.0098	0.0008

Table 2 – Volatility and real wage rigidities.

Table 2 shows that the economies characterized by more rigid labor markets experience lower volatilities associated to financial instability. For instance, the output volatility in a competitive labor market is about double with respect to economies with markups higher than 30%.

4 Labor market institutions and volatilities

The degree of volatility in the economy after financial shocks crucially depends on the size of the labor wedge. When a financial shock destroys capital and the cost of raising funds becomes higher because of financial frictions, firms are induced to substitute labor to capital and postpone investment. By contrast, higher labor wedges reduce substitutability and thus firms do not postpone investment. We find it useful to disentangle the relative relevance of the factors driving the labor wedge to provide an intuition of the effects of different institutions and discuss their relevance. We thus use simple simulations to explore the impact of the main factors driving the labor wedge. Of course, we consider an extremely simplified picture and our results must be interpreted as a broadly suggestive representation of the mechanisms at work in our model.[25]

In our setup the labor wedge is determined by the degree of elasticity of substitution among labor inputs (sη), wage-setters coordination (n), payroll tax (τ_S) and labor income tax (τ_L). These depends on different institutions. Even if a neat distinction is impossible as institutions are interrelated, we can explain η and n in terms of labor market legislation and wage bargaining system, whereas τ_S and τ_L can be explained considering the social security and the redistributive systems.

The literature has investigated the impact of different labor market institutions on the labor wedge and employment in quantitative terms.[26] Among the labor market institutions, EPL, the degree of centralization of wage bargaining, unemployment benefits, minimum wages seem to be the most relevant. When comparing these institutions across countries strong differences emerge. Continental Europe and the Anglo-Saxon economies still seem to be anchored to two different systems in spite of the numerous "pro-competitive" labor market reforms implemented by many European countries in the past two decades. Moreover, union density, wage bargaining levels and coverage present large degrees of heterogeneity even in Continental Europe. The coverage rate, e.g., is high in the euro area and Scandinavian countries (typically higher than 60 percent) and lower in Central and Eastern European countries (typically 30-40 percent).[27]

A simplified picture of the labor market institutions is given in the following table.

[25] Mulligan (1998, 2002) and Shimer (2009) have attempted to measure such a wedge and discussed its dynamics and effects. However, a rigorous derivation of the determinants of the labor wedge is beyond the scope of the present paper.

[26] See Belot and Van Ours (2001) and Nickell *et al.* (2005), Acocella *et al.* (2008) for extensive treatment of the issues. See also Dobbelaere (2004) and Dobbelaere and Mairesse (2008) on the impact of the bargaining system on markups and elasticities.

[27] See ECB (2009).

	EPL	benefit rate	density	coordination
Germany	1.59	0.39	0.33	3.00
France	1.26	0.58	0.16	1.85
Italy	1.97	0.10	0.44	1.63
Sweden	1.47	0.61	0.80	2.37
Denmark	1.03	0.60	0.74	2.40
Finland	1.18	0.39	0.69	2.25
Spain	1.89	0.65	0.12	2.00
Netherlands	1.33	0.67	0.31	2.00
Norway	1.52	0.45	0.54	2.50
Portugal	1.79	0.46	0.49	1.88
United Kingdom	0.34	0.28	0.50	1.37
Canada	0.30	0.57	0.36	1.00
United States	0.10	0.28	0.21	1.00
Japan	1.40	0.31	0.27	3.00
Ireland	0.47	0.42	0.54	2.31
Australia	0.50	0.23	0.47	2.15
New Zealand	0.80	0.29	0.36	1.30

Table 3 – Labor market institutions. Nickell and Nunziata (2001).

The table gives the average values of EPL, benefit replacement rate,[28] union density, and bargaining coordination index over the period 1970-1995 for some industrialized economies (Nickell and Nunziata, 2001). The table shows a huge cross-country variation in terms of the labor market characteristics among countries. For instance, the EPL index varies between 0.1 (United States) and 1.97 (Italy). The same pattern can also be observed for other labor market institutions.

The tax wedge is also a crucial variable to understand volatility in our framework. The relative distortionary effects of the tax wedge on the gross labor wedge (ϑ) have been stressed by Ohanian *et al.* (2008), which focuses on the trend changes in hours worked across 21 OECD economies between 1956 and 2004.[29] By comparing the actual change in hours worked with that predicted by a standard neoclassical growth model augmented with labor and consumption taxes, they show that changes of cross-country differences in the tax wedge are able to explain the observed fluctuations of hours. They also conduct a simple panel regression in order to prove the influence of institutional factors other than the tax wedge[30] on the gross labor wedge. Their results confirm the predominant influence of the tax rates on the labor wedge, and the relatively significant but smaller impact of the other institutional regressors. Tax wedges for different countries are reported in the following figure.

[28] Note that Belot and van Ours (2004) make the theoretical argument that an increase in the replacement rate will have an ambiguous effect on unemployment and markups, depending on the labour tax system.

[29] Cole and Ohanian (2002) conduct a similar analysis on the changes in hours worked during the US Great Depression. See also Daveri and Tabellini (2000) and Prescott (2004).

[30] The institutional variables considered are employment protection, union density, bargaining coordination, benefit replacement rate and benefit duration.

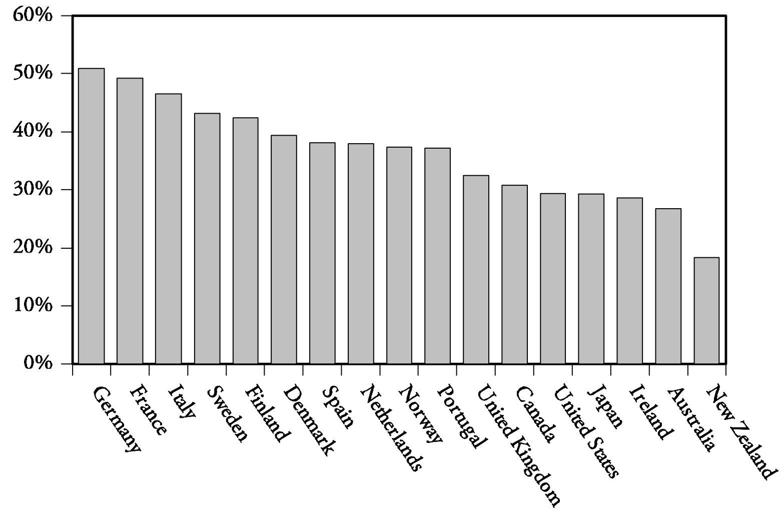

Figure 2 – Tax wedges in 2009 (Source OECD).

Wedges vary between 19% to 50%. The difference between France and Spain is about 10%, the difference between Germany and Anglo-Saxon economies is about 20%.

In our framework higher markups and tax wedges imply lower volatilities. In order to have an idea on the quantitative effects, we compute the difference in volatilities implied by different elasticities of substitution, degrees of coordination and tax wedges.

Everything else equal, the effects of different elasticities are described by table 2 above. For instance, a change in the degree of the elasticity of substitution from 6 to 5 implies a reduction in output volatility of 6%. The effects captured by this channel are thus relevant as a change in the elasticity from 6 to 5 increases the markup only by 5%. By contrast, we find that the effects related to wage-setters' coordination are less relevant as changes in the degree of wage setting coordination have a small impact on markups.[31] However, comparing extreme cases, e.g. a centralized economy (60% wage coordination) vs. a decentralized one (20%), relevant differences may emerge for low value of the elasticity of substitution across labor types.

The following table reports the impact of coordination on output volatility. The table compares the reduction of volatility with respect to the atomistic wage-setters' case associated to different degrees of wage coordination. The

[31] Centralisation is instead a relevant institution in solving coordination problems among unions arising from nominal rigidities. See, among others, Soskice and Iversen (1998, 2000), Lippi (2003), Holden (2005), Acocella *et al.* (2008). See Cukierman (2004) for a review.

different bars refers to different degrees of the elasticity of substitution across labor types. We consider a range of elasticities implying a markup varying from 1.20 to 1.35 in the atomistic case. The effect becomes relevant for mid-centralized economies. Increases in the elasticity magnify the difference. Wage coordination and elasticity are complement in reducing the output volatility.[32]

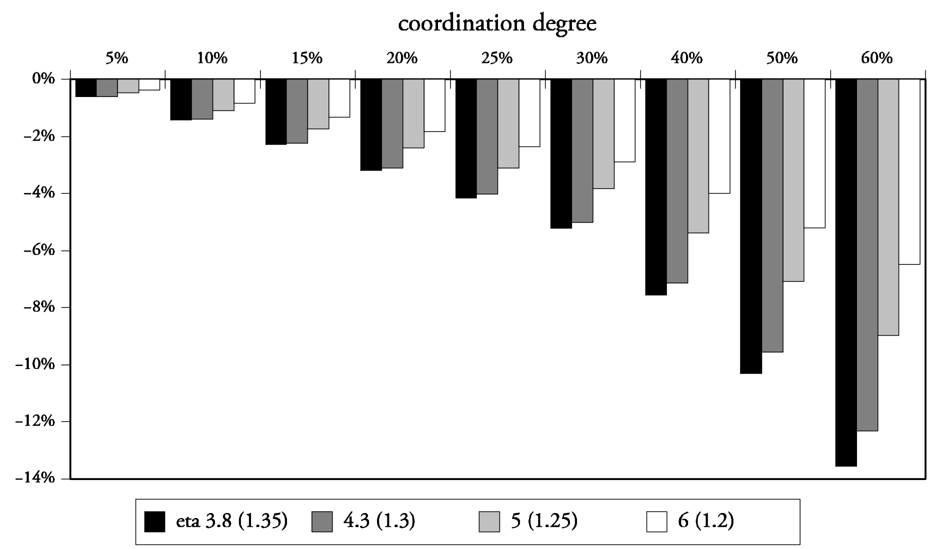

Figure 3 – Lower output volatility and wage coordination.

We also compute the difference in volatilities implied by a 10% differential in the tax wedge, as that between France and Spain. The effects on volatilities of such a difference also depends on the level of wage markup. If we consider for the sake of robustness a net markup ranging from zero to 35%, a higher tax wedge implies a reduction of output volatility ranging from 13.2% to 7.5% (11.4% on average);[33] i.e., a 10% higher tax wedge has a lower impact the higher the distortion of the economy. Considering a difference of 20% in tax wedges, as that between Germany and the Anglo-Saxon countries, leads to similar results; i.e., a reduction of output volatility ranging from 23.6% to 18.4% (22% on average).

[32] Similar effects can be drawn with respect to the other volatilities (see Appendix B).

[33] These values are computed from table 2 (column of output volatility). A lower volatility of 18% is obtained by comparing that case associated to 1.00 wedge to 1.10; 23% derives from 1.35 vs. 1.45. Finally, 22% is obtained as moving average between 1.00 and 1.45. See Appendix B, where we also report the impact on investment volatilities.

5 Conclusions

The recent experience of some European countries, after the financial crisis, shows that economies with higher degrees of imperfections in the labor markets seem to have experienced a limited rise in unemployment. Search models can explain this evidence; however, they do not explicitly consider financial shocks and their interaction with labor market institutions. We provide an alternative interpretation by considering a simplified version of the financial accelerator model by Gertler and Kiyotaki (2010) augmented with labor market imperfections. More in general, we consider the role played by the labor wedge, which depends on both labor market institutions and taxes.

Our main result is that, even if the labor wedge increases real wages, its interaction with financial frictions reduces the volatility of real variables when financial shocks entail credit destruction. The rationale is as follows. As a negative financial shock would destroy capital and increase the current cost of its replacement, if the labor wedge is low, firms would substitute capital with labor for current production, while postponing investment. A high labor wedge would instead dampen that mechanism, lowering the volatility of the economy.

By using simple simulations, we also explore the impact of the main factors driving the labor wedge to provide an intuition of the effects of different institutions. We find that a key role is played by differences in the elasticity of substitution across labor inputs, which could mainly reflect differences in labor market institutions. Disentangling the effects of the elasticity from those of wage coordination, we derive a sort of complementarity among the two: coordination has small effects on volatility for high values of the elasticity, but increases its impact in imperfect labor markets. By contrast, the dampening effects on volatility of tax wedges are stronger the less distorted is the economy.

Appendix A – Financial sector appendix

A1 – Banker's maximization problem

The banker's decision over whether to divert funds must be made before the realization of aggregate uncertainty in the following period. The net worth at t, n_t, i.e. the gross payoff from assets funded at $t-1$, net of borrowing costs, evolves according to

$$n_t = \psi_t[Z_t + (1-\delta)\ Q_t]s_{t-1} - R_t d_{t-1} \tag{35}$$

Given $V_{t-1}(s_{t-1}, d_{t-1}) = \underset{\{n_{t-1+i}\}}{Max} E_{t-1}\sum_{i=1}^{\infty}(1-\sigma)\sigma^{i-1}\Lambda_{t,t-1+i}n_{t-1+i}$, the rational banker has therefore to solve the following Bellman equation:

$$V_{t-1}(s_{t-1}, d_{t-1}) = E_{t-1}\Lambda_{t-1,t}\{(1-\sigma)n_t + \sigma[\underset{s_t}{Max} V_t(s_t, d_t)]\} \tag{36}$$

given the incentive constraint stemming from the agency problem:

$$V_{t-1}(s_{t-1}, d_{t-1}) \geqslant \theta Q_{t-1} s_{t-1} \tag{37}$$

and the balance sheets:

$$Q_{t-1} s_{t-1} - n_{t-1} = d_{t-1}. \tag{38}$$

Given the following guessed linear value function:

$$V_t(s_t, d_t) = v_{st} s_t - v_t d_t \tag{39}$$

We see that he can either choose separately d_t or s_t but not the two. Equation (36) can be written, using (35), as

$$\begin{aligned} V_{t-1}(s_{t-1}, d_{t-1}) = \max_{d_t} E_{t-1} \Lambda_{t-1,t} [((1-\sigma)\psi_t [Z_t + (1-\delta)\ Q_t] s_{t-1} - R_t d_{t-1}) \\ + \sigma\{V_t(s_t, d_t) + \lambda_t [V_t(s_t, d_t) - \theta Q_t s_t]\}] \end{aligned} \tag{40}$$

The derivative with respect to d_t equals zero (using (38) to calculate the derivative of s_t with respect to d_t):

$$E_{t-1} \Lambda_{t-1,t} \left(-\lambda_t \theta - \frac{\partial V_t(s_t, d_t, b_t)}{\partial d_t} (1 + \lambda_t) \right) = 0$$

or, assuming (39), as:

$$-\theta \lambda_t + v_t (1 + \lambda_t) = 0$$

equation (37) can be written using (39) as $v_{st} s_t - v_t d_t \geq \theta Q_t s_t$ or $v_{st} s_t - v_t (Q_t s_t - n_t) \geq \theta Q_t s_t$, (by using (38)):

$$v_t n_t \geq Q_t s_t \left(\theta + v_t - \frac{v_{st}}{Q_t} \right) \tag{41}$$

so $V_t(s_t, d_t) = v_{st} s_t - v_t (Q_t s_t - n_t) = (v_{st} - v_t Q_t) s_t + v_t n_t = \frac{(v_{st} - v_t Q_t) v_t n_t}{Q_t \left(\theta + v_t - \frac{v_{st}}{Q_t} \right)} + v_t n_t$. Hence:

$$V_t(s_t, d_t) = v_t n_t \left(\frac{\mu_t}{\theta - \mu_t} + 1 \right) \tag{42}$$

where $\mu_t = \frac{v_{s_t}}{Q_t} - v_t > 0$.

If we define:

$$\phi_t \equiv \frac{v_t}{\theta - \mu_t} \tag{43}$$

it follows that

$$V_t(s_t, d_t) = n_t (\mu_t \phi_t + v_t) \tag{44}$$

By substituting the above expression (44) for $V_t(s_t, d_t)$ in (40), we have:

$$V_t(s_t, d_t) = E_t \Lambda_{t+1,t} \left[(1-\sigma) n_{t+1} + \sigma n_{t+1} \left(\mu_{t+1} \phi_{t+1} + v_{t+1} \right) \right]$$

or

$$V_t(s_t, d_t) = E_t \Lambda_{t,t+1} \Omega_{t+1} n_{t+1} \tag{45}$$

where

$$\Omega_{t+1} = (1-\sigma) + \sigma \left(\mu_{t+1} \phi_{t+1} + v_{t+1} \right) \tag{46}$$

and using (35):

$$V_t(s_t, d_t) = E_t \Lambda_{t,t+1} \Omega_{t+1} \left(\psi_{t+1} [Z_{t+1} + (1-\delta)\ Q_{t+1}] s_t - R_{t+1} d_t \right)$$

So by the method of undetermined coefficients it follows that

$$v_t = E_t \Lambda_{t,t+1} \Omega_{t+1} R_{t+1} \tag{47}$$

and

$$v_{st} = E_t \Lambda_{t,t+1} \Omega_{t+1} \left\{ \psi_{t+1} [Z_{t+1} + (1-\delta)\ Q_{t+1}] \right\} \tag{48}$$

A2 – Assets demand

We can rewrite (41), given (**??**), as:

$$(\theta - \mu_t)\, Q_t s_t = v_t n_t \tag{49}$$

The individual bank total demand for assets $Q_t\, s_t$ can then be written, using (22) as:

$$Q_t\, s_t = \phi_t n_t \tag{50}$$

which, at the aggregate level, turns out to be:

$$Q_t\, S_t = \phi_t N_t \tag{51}$$

Appendix B – Tax wedges and volatilities

Table B1 reports the impact of coordination on consumption and investment volatilities. The table compares the reduction of volatility with respect to the atomistic wage-setters' case associated to different degrees of wage coordination. The different columns refer to different degrees of elasticity of substitution across labor types. We consider a range of elasticity implying a markup ranging from 1.20 to 1.35 in the atomistic case.

	consumption					investment			
	1,2	1,25	1,3	1,35		1,2	1,25	1,3	1,35
5%	-0,64%	-0,70%	-0,54%	-0,33%	5%	-0,61%	-0,63%	-0,47%	-0,31%
10%	-1,48%	-1,62%	-1,23%	-0,75%	10%	-1,42%	-1,46%	-1,08%	-0,71%
15%	-2,38%	-2,59%	-1,96%	-1,19%	15%	-2,28%	-2,33%	-1,72%	-1,12%
20%	-3,33%	-3,60%	-2,72%	-1,63%	20%	-3,20%	-3,24%	-2,37%	-1,54%
25%	-4,35%	-4,68%	-3,50%	-2,10%	25%	-4,18%	-4,21%	-3,06%	-1,98%
30%	-5,46%	-5,82%	-4,33%	-2,58%	30%	-5,24%	-5,24%	-3,79%	-2,43%
40%	-7,90%	-8,30%	-6,09%	-3,57%	40%	-7,59%	-7,47%	-5,32%	-3,37%
50%	-10,76%	-11,11%	-8,02%	-4,64%	50%	-10,35%	-10,00%	-7,01%	-4,38%
60%	-14,16%	-14,32%	-10,16%	-5,78%	60%	-13,62%	-12,89%	-8,88%	-5,46%

Table B1 – Lower output volatility and wage coordination.

Table B2 describes the reduction in output and investment volatilities associated with different tax wedge differentials (10% and 20%) for different labor wedges.

labor wedges	$\Delta\sigma_Y^2$	$\Delta\sigma_I^2$	labor wedges	$\Delta\sigma_Y^2$	$\Delta\sigma_I^2$
1,10 vs. 1,00	-13,21%	-12,50%	1,20 vs. 1,00	-23,58%	-23,21%
1,15 vs. 1,05	-12,12%	-12,66%	1,25 vs. 1,15	-23,23%	-23,42%
1,20 vs. 1,10	-11,96%	-12,24%	1,30 vs. 1,20	-22,83%	-23,13%
1,25 vs. 1,15	-12,64%	-12,32%	1,35 vs. 1,25	-22,99%	-23,19%
1,30 vs. 1,20	-12,35%	-12,40%	1,40 vs. 1,30	-20,99%	-20,93%
1,35 vs. 1,25	-11,84%	-12,40%	1,45 vs. 1,35	-18,42%	-19,01%
1,40 vs. 1,30	-9,86%	-9,73%			
1,45 vs. 1,35	-7,46%	-7,55%			
average	-11,43%	-11,48%	average	-22,01%	-22,15%

Table B2 – Tax wedge differentials and volatilities.

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