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Natural Unemployment, the Role of Monetary Policy and Wage Bargaining: A Theoretical Perspective

by
Stefan Collignon[*]
Harvard University
London School of Economics
s.collignon@lse.ac.uk
www.stefancollignon.de

ABSTRACT

This paper models unemployment as a general equilibrium solution in labor and capital markets, while the natural rate hypothesis explains unemployment simply as a partial equilibrium in the labor market. It is shown that monetary policy can have long-run effects by affecting required returns on capital and investment. If monetary policy is primarily concerned with maintaining price stability, the interaction between wage bargaining and the central bank's credibility as an inflation fighter becomes a crucial factor in determining employment. Different labor market institutions condition different monetary policy reactions. With centralized wage bargaining, a central bank mandate focusing primarily on price stability is sufficient. With an atomistic labor market, the central bank must also consider output as a policy objective.

JEL Keywords: E22, E24, E31, E43, E44, E58.

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[*]I dedicate this article to the memory of Franco Modigliani, who encouraged me to think about these issues and died while I was working on this paper. I also would like to acknowledge SONAE Industria for financial support.

With the establishment of the European Central Bank (ECB) and the reform of the Bank of England in the late 1990s, two different regimes of monetary policy are operating in Europe: one focusing "primarily" on price stability, the other on a twin objective of inflation and output. The ECB has been criticized for not responding sufficiently to output shocks, while the U.S. and UK central banks react to possible deviations of unemployment from a fairly stable natural rate. In this paper, I argue that the different central bank mandates correspond to structural differences in the economy. This argument will become clear, when we drop the partial equilibrium of the natural rate hypothesis (NRH) and its correlate the Philips curve and adopt a general equilibrium approach for the labor, and capital market.

According to the NRH, unemployment consists of the sum of a structural component called the natural rate and a cyclical component reflecting short-run business cycle fluctuations. While unemployment in the U.S. seems to have oscillated around a stable long-term rate, the secular rise in European unemployment is explained by shifts in the natural rate. Social benefits and strong trade unions are supposed to be the cause of this rising unemployment. Policy proposals combating euro-unemployment focus on "structural reforms" in goods and labor markets, although the results are rarely convincing (Blanchard and Wolfes, 2000). The gap between theory and practice indicates faults in the theory. The distinction between structural and cyclical unemployment dependents on modeling the labor market as a partial equilibrium. By introducing capital markets into the model, the labor market has multiple equilibria. Monetary policy then selects one out of many equilibria and has long-term real effects. Which equilibrium is chosen depends largely on the time horizon of credit and wage contracts.

1. The natural rate hypothesis

Friedman (1968) derived the "natural rate hypothesis" from Wicksell's (1936/1965: 102) concept of a "natural" rate of interest:

> [a] rate of interest on loans which is neutral in respect to commodity prices, and tends neither to raise nor to lower them. This is necessarily the same as the rate of interest, which would be determined by supply and demand if no use were made of money and all lending where effected in the form of real capital goods.

In equilibrium, the rate of interest in the capital market is equal to the return on physical capital. For Friedman (1968:8) this rate corresponded to the labor market equilibrium, where real wages are neither under downward nor upward pressure and the equilibrium was "ground out by the Walrasian system of general equilibrium equations." This view implies complementarity between capital and labor markets, where the natural rate of unemployment is an equilibrium concept that links the labor market to interest rates. Money is neutral and can only be a disturbance, causing temporary deviations from the natural level, although political authorities may be tempted by "time inconsistent behaviour" (Cukierman, 1992) to increase employment. They do so by lowering interest rates below the natural rate, causing an inflation surprise that reduces real wages. Confused producers respond by increasing output (Lucas, 1972) and employing more labor. In the long run, workers realize their real wages have fallen and demand compensation, thereby pushing wages and prices permanently up and employment back to its natural level. Thus, the strategic interactions between wage

and price setters and monetary authorities create excessive inflation without any effect on the long-run level of employment (Barro and Gordon, 1983). By delegating authority to an independent central bank, which cares *primarily* about price stability, the inflation bias can be reduced without having an effect on average employment. Such arrangement would therefore be welfare improving (Rogdoff, 1985). A different formulation of this idea is the concept of NAIRU (non-accelerating inflation rate of unemployment).

A correlate to the NRH is the expectations-augmented Phillips curve where *real* wages or, taking into account productivity, the *wage share* respond negatively to unemployment. At first, a stable trade-off between nominal wages, prices and unemployment was assumed. But Friedman (1968) argued that wage earners were interested in real wages, so that money was neutral in the long run. This neutrality was a consequence of the "axiomatic construction" of the natural rate (Phelps, 1995) or as Friedman (1975:25) put it:

> The purpose of the concept [of natural rate] separates the monetary from the non-monetary aspects of the employment situation – precisely the same purpose that Wicksell had in using the word 'natural' in connection with the interest rate.

Yet, while for Wicksell there was no guarantee that the credit market would always reflect the "natural" interest rate, the NRH assumed that real wages would always return to the level corresponding to natural unemployment. Despite Friedman's (1968) vague reference to the Walrasian "general equilibrium," this reduction was made possible by decomposing the system of general equilibrium equations and treating the labor market as a partial equilibrium, which can be solved in isolation, and to which the capital market adjusts. But if causation runs in the opposite direction and the *equilibria in the labor and capital market are simultaneously determined,* the dynamics of adjustment become richer and multiple "natural" equilibria are possible (Dixon, 1995).

Usually, the natural rate (or its correlate the NAIRU) serves as a benchmark for monetary policy. If the capital market adjusts to the labor market, equilibrium unemployment will determine the natural rate of interest at which price stability is maintained. But if labor and capital market equilibria are determined simultaneously, the anchor for monetary policy disappears. The natural rate is no longer fixed, as empirical evidence reveals.[1] Shifting natural or time-varying NAIRU models pose two difficulties for monetary policy: First, if there is a rate of unemployment, below which inflation accelerates, and if the exact position of this natural rate is uncertain and moving, what interest level should be targeted by the central bank? Second, if it could be shown that the average rate of unemployment is affected by monetary

[1]See Gordon, 1996; Galbraith, 1997. While a stable NAIRU may still work for the U.S. (Smyth and Easaw, 2000), the large fluctuations in Europe are incompatible with the stable NRH, (Blanchard and Summers, 1988; Solow and Taylor; 1998; Collignon, 2002; Karanassou and Snower, 1997). Karanassou et al (2003) show that the rise in EU unemployment in the 1970s and early 1980s was largely due to permanent shocks such as the decline in capital formation, while the increases of the early 1990s resulted from temporary shocks such as rising interest rates. Henry et al. (2000) observe a reasonably stable natural rate for the UK over the long run, but medium-run swings in unemployment due to transitory but long-lasting shocks. Haldane and Quah (1999) observe a similar pattern for the Phillips curve.

policy, the natural rate cannot be exogenous and the neutrality hypothesis would not even apply in the long run.

Below, I will focus on the mechanism through which monetary policy is transmitted to the real economy over the long run. Starting from the orthodox approach, section 2 introduces capital into the natural rate model. Section 3 shows how the mark-up and therefore price level is determined by the capital market. Section 4 describes the interaction of monetary policy and wages. Section 5 concludes.

2. Labor market equilibrium and the natural rate of unemployment

The natural rate reflects equilibrium in the labor market where the real wages equalize demand and supply. Wage earners are only interested in what money can buy. Goods' prices and interest rates, i.e., prices in the other markets of the Walrasian system, cannot influence output and unemployment systematically. Hence, the long-run aggregate supply curve is vertical and money is neutral. However, this result depends on the way the labor market is modelled.

The labor market equilibrium

In a simple model of the labor market, firms operate with a homogenous production function depending on the input of labor (L) and capital (K) at given technology (τ):

(1) $$Y = \tau F(L,K) \qquad \text{with}$$

$$F_L > 0, F_K > 0, F_{LL} < 0, F_{KK} < 0, F_{LK} > 0$$

We define average labor productivity, i.e., the output per employee as:

(1a) $$\Lambda = \tau f(k) \qquad f'(k) > 0, \qquad f''(k) < 0$$

with $\Lambda = Y/L$ and the capital intensity $k = K/L$. $f'(k)$ is the marginal product of capital per unit of labor. τ reflects Hicks-neutral technology at constant capital intensity. Firms maximize short-term profits defined as revenues minus the wage bill:

(2) $$\max \Pi = PY - WL = P\tau F(\overline{K}, L) - WL$$

where *W* is the nominal wage, *P* the price level and $\overline{K}$ the given capital stock. The *capital share* is the part of aggregate income that goes to capital. It is the complement of the wage share.

(2a) $$\frac{\Pi}{PY} = \frac{PY - WL}{PY} = 1 - \sigma_w = \sigma_k \text{ (capital share)}$$

Short-term maximization yields:

(2b) $$\frac{d\Pi}{dL} = 0 \quad => \quad PF_L(L, \overline{K}) - W = 0$$

and [2]

(2c) $$F_L\left(L,\overline{K}\right)=\frac{W}{P}$$

Short-term profits are maximized by equalling the marginal product of labor *at a given capital stock* $\overline{K}$ to real wages.

The demand for labor is a function of the real wage and the capital stock.

(2d) $$L^D=\Phi\left(\frac{W}{P},K\right)$$

By totally differentiating we get:

(2e) $$dL^D=(1/F_{LL})d(W/P)-(F_{LK}/F_{LL})d\overline{K}$$

The economic definition of the short-run is that the capital stock remains constant. Demand for labor falls with rising real wages, because $F_{LL}<0$, but in the long run an increase in the capital stock will increase labor demand.

Next we look at labor supply. Because workers face a trade-off between leisure and consumption, labor supply is assumed to be an increasing function of the real wage and a vector of shift parameters *X*:

(2f) $$L^s=\varphi\left(\frac{W}{P},X\right) \qquad \text{with } \varphi_{w/p}>0$$

The literature has produced a long list of factors, which might shift the labor supply curve exogenously. Typically it includes population growth, the reservation wage, the replacement ratio, factors affecting the job match function, efficiency wages, trade union power, etc.

The equilibrium rate of employment is where supply and demand meet as in Figure 1. At that rate output is exclusively determined by technical factors and the aggregate supply curve is vertical in the price-output space. Because of search costs, efficiency wages, and other microeconomic distortions, equilibrium employment (L*) and output levels may be lower than full employment of the labor force (N), so that a given "natural" rate of unemployment (U*) is associated with a specific level of potential output.

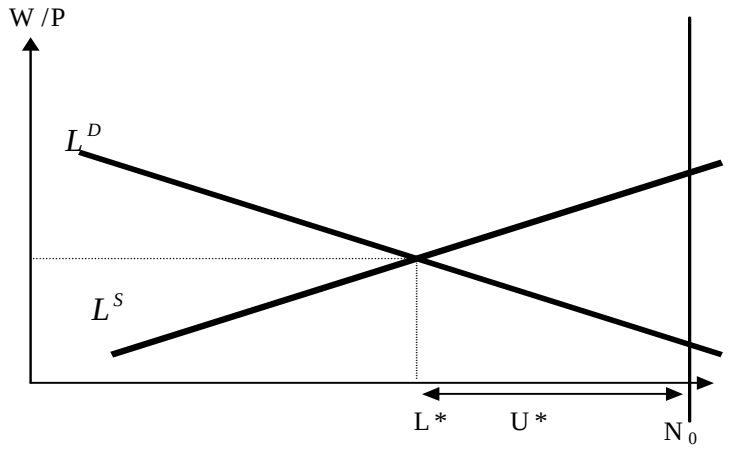
(3) $$U^*=N-L^*$$

Actual unemployment is:

(3a) $$U=N-L^D$$

[2]The second order condition describes a maximum, because $PF_{LL}<0$

Figure 1



Unemployment can result from temporary disequilibria or from "structural" shifts of the labor supply and demand curve. A deviation from equilibrium would bring about wage and price adjustments, pushing the real wage back in line with the marginal product of labor. The adjustment process may take a long time when the adjustment costs are high, creating unemployment persistence, although the natural rate remains fixed by the structure of the supply and demand curves.

Workers are interested in the purchasing power of their money wages. When bargaining for wage increases, they therefore take into account inflation expectations, secular productivity increases and actual unemployment relative to equilibrium (as a measure for labor market tightness). If there is excess demand for labor, not only nominal but also real wages will rise and, given productivity, the labor share as well:[3]

$$(4) \qquad \Delta w = \alpha_1 \Delta p^e + \Delta\lambda + \alpha_2 (u^* - u),$$

Δw stands for the proportional rate of wage increases and Δp^e for the expected rate of inflation; $\Delta\lambda$ is the secular growth in labor productivity and *u*-u* is excess demand for labor. The coefficient α_1 is a parameter for wage indexation or *nominal wage rigidity*. The value of α_1 is controversial. Sargent (1971) showed that under the rational expectations hypothesis $\alpha_1 = 1$ must always hold. Nominal wages are then flexible and wage bargaining is about the real wage.[4] Subsequently, Fischer (1977) and Taylor (1979) showed that in the presence of long-term nominal contracts staggered negotiations lead to slow adjustment, even if expectations are rational. Thus, $\alpha_1 < 1$ is possible and nominal wages may be sticky. One explanation for such wage contracts is imperfect knowledge (Ball and Cechetti, 1988). I will argue below that they may also depend on conditions in the capital market.

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[3]Small letters denote logs, unless otherwise specified.

[4](4a) $\Delta w - \Delta p^e = \Delta\lambda + \alpha_2 (u^* - u)$ (bargained real wage)

(4a') $\Delta w - \Delta p^e - \Delta\lambda = \alpha_2 (u^* - u)$ (expected wage share)

α_2 measures the elasticity by which wages respond to excess demand in the labor market. It is an indicator for real wage rigidity and the slope of a log-linear short-term Phillips curve. There are good theoretical reasons, supported by empirical evidence, to think that both α_1 and α_2 are regime dependent (Coricelli et al., 2003; Collignon, 2002). They are low in a low inflation regime with infrequent nominal contract changes and high if price stability is uncertain. However, for our argument it is sufficient to assume that α_2 is constant. Empirical estimates usually show α_2 to be significantly below α_1.

Equation (4) reveals two implications of the NRH: real wages follow the secular trend of productivity growth, and with respect to nominal wages (and prices) the short-run Phillips curve shifts upward with rising inflation. At this point it is useful to remember that the real wage is identically equal to the rate of average labor productivity times the wage share in income: $\frac{W}{P} = \Lambda\sigma_w$ or in logs

(5) $\quad w - p = \lambda + s_w$

where $s_w = \ln\sigma_w = \ln(1-\sigma_k)$. A correlate of the NRH is therefore that the wage share is stable over time. This would not be the case if $\alpha_1 < 1$, as nominal wages then increase less than prices and the wage share falls. We re-define the inverse of the wage share as the mark-up

(5a) $\quad c = -s_w$

and obtain the price equation

(5b) $\quad p = w - \lambda + c$ (price equation)

We also derive the *targeted* mark-up from the price level firms seek to achieve

(5c) $\quad c^T = -s_w^T = p^T - (w - \lambda)$ (targeted mark-up)

Inserting (4) into (5c) yields is a function of labor market disequilibria. I call the relation between the targeted mark-up and the labor market the modified Phillips curve.[5]

(5d) $\quad (u - u^*) = \frac{1}{\alpha_2}\Delta c^T$ (modified Phillips curve)

If price setters target the expected rate of inflation, which is reasonable under rational expectations, a change in the targeted mark-up would require a change in labor market conditions. When the targeted mark-up is constant, the labor market is in equilibrium and unemployment is at its "natural" level. A higher mark-up target would raise actual unemployment above the natural rate.

[5]If we kept productivity constant, (5d) would express the usual relation between the labor market and the (targeted) real wage.

Note the direction of causality. Under Friedman's NRH, the *natural rate is exogenous* and fixed and the mark-up is constant. Surprise inflation increases *realized* mark-ups above the level *targeted* by wage bargainers. Real wages fall, labor demand increases and unemployment falls below equilibrium. At that point real wages will increase again, as workers seek to restore the purchasing power of their wages (adaptive expectations) or try to recuperate the wage share - the "justice motive" (Hahn and Solow, 1995). Because price setters target a constant mark-up, prices will increase with rising wage costs, but the labor market returns to its "natural" equilibrium. Thus, surprise inflation will reduce unemployment only temporarily, while changes in nominal variables are permanent and the Phillips curve shifts vertically up.

The story is different if we take the *targeted mark-up as the exogenous* variable and labor market adjustment as endogenous. Assume for a moment that firms will increase their targeted mark-ups permanently. According to (5d), an initial increase in c^T requires unemployment to rise above the natural rate. There is no other way to lower real wages. But once mark-ups have met their targeted new *level*, the higher *actual* rate of unemployment will become the new *natural* rate. This is the hysteresis effect of the unemployment which can be written as

$$\text{(5d')}\quad U_t - U^*_{t-1} = \frac{1}{\alpha_2}(C^T_t - C^T_{t-1})$$

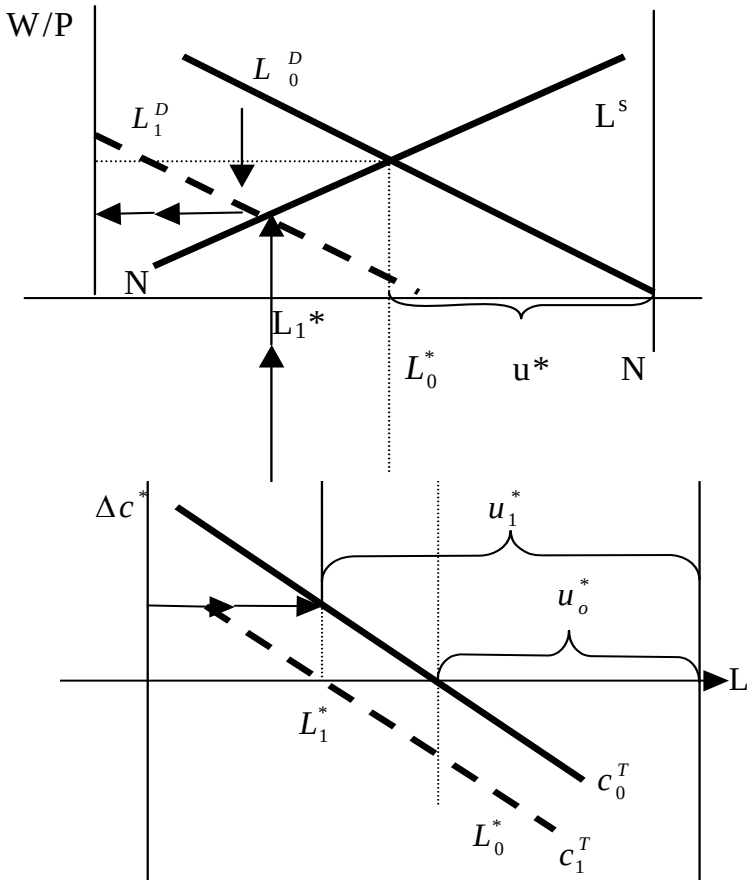
where U^*_{t-1} is no longer a constant natural rate, but simply the previous equilibrium position.

How will the labor market adjust to this new equilibrium? The endogeneity of the labor market requires the labor demand curve to shift downward. According to equation (2e), this is only possible if the capital stock falls. Here we simply note that the new (higher) natural rate of unemployment is a long-term consequence of a permanently higher targeted mark-up by firms.

We can picture this relationship in Figure 2. The upper part reproduces Figure 1, the lower part shows the modified Phillips curve.

If the targeted mark-up changes only in the short run and then returns to the initial position, we move along the c^T_o - curve, which cuts through the zero-line at the natural rate u^*_o. The slope of the c^T curve is the slope α_2 of the Phillips curve. If the targeted mark-up increases permanently, a permanently lower real wage is required (given productivity), which can only be obtained by shifting the labor demand curve to the left, i.e., by lowering the capital stock. At the new equilibrium (L^*_1) the c^T curve has also shifted to the left. In this new position the increase in the initial mark-up is stabilized because the lower capital stock has reduced unemployment. *The natural rate of unemployment has permanently increased and the Phillips curve has shifted horizontally.*

Figure 2



The difference between the two explanations for monetary policy is fundamental. If the natural rate is exogenously given, surprise inflation can temporarily stimulate employment[6] by reducing the real wage (increasing the mark-up). But if the mark-up is exogenous, the labor market has a continuum of equilibria and the natural rate (or the NAIRU) does not provide much guidance for monetary policy. We therefore need a theory for explaining the exogeneity of the mark-up.

3. Capital market equilibrium and the mark-up

The capital market is defined as the market where financial claims for real assets are traded. The net wealth of an economy consists of all real assets. Because ownership and possession of real assets do not necessarily coincide, the financial assets of one are the liabilities of another. To make things simple, we assume that the private non-banking sector (PNB) has a choice of holding its wealth in the form of financial claims, i.e., currency and deposits and as possession of real assets, called private capital.[7] Hence, money (i.e., a claim) is not net wealth in the economy (Dullien, 2004). Deposits are created by banks lending to firms at the

[6]Note that this is a consequence of the axiomatic definition of the short-term. Because the capital stock does not change, employment can only change temporarily.

[7]I borrow the concept from Tobin and Golub (1998:135)

prevailing interest rate. Assuming that all private sector liabilities are close substitutes, we may talk about *the* interest rate. However, interest rates may be fixed over the entire period of the loan (like for bonds), or variable as for overdraft facilities. This has consequences for the conduct of monetary policy as shown below. Firms pay their workers and suppliers with deposits or with currency , i.e., with the reserve asset, which extinguishes debt contracts. Currency is created by the central bank lending to commercial banks. It therefore has utility as a liquid store of wealth and this is the motive to hold currency. The price for liquidity is the interest rate controlled by the central bank.[8] Financial claims held by the central bank earn interest that is serviced by PNB-payments. This fact creates the structural shortage for liquidity in the money market that allows the central bank to set its interest rate as the marginal price for currency. To simplify even further, we abstract from default risk, and let banks operate without profit, so that they lend to firms at the same rate at which they borrow from the central bank.

Firms borrow from banks if they expect to earn a profit at least sufficient to service their liabilities. With the borrowed funds they buy capital equipment (real assets), which they use together with labor for the production of goods and services. The excess of profits over the cost of capital is *entrepreneurial profit*. Hence, the capital share must be sufficient to service at least the interest and repayment cost of the aggregate capital stock.

An important implication of this model of the monetary economy is that increases in wealth and the creation of income depend on capital, i.e. monetized real assets, rather than resource endowment. Money is endogenously generated by firms' demand for loans or financial institutions' demand for liquidity. As the marginal supplier of liquidity, the central bank is the price setter for money and not a quantity setter. How is the aggregate price level determined in such a model?

Determining the price level

For Keynes (1936:41), the wage unit anchored nominal values in the real economy. In early Keynesian models, prices were linked to wages by fixed mark-ups and this is rationalized by the NRH. Recent models of monopolistic competition have provided microfoundations for more or less fixed mark-ups (Blanchard and Fischer, 1989; Carlin and Soskice, 1990; Coricelli, et al., 2003). However, Keynes's (1930) theory of the mark-up focused on the capital market.[9] The link between the wage unit, prices and profitability was formulated in the fundamental equation. Keynes split the price level into two terms: the first covered standard production costs, the second reflected "entrepreneurial profits" Q, which are "positive, zero or negative, according as the cost of new investment exceeds, equals or falls short of the volume of current savings" (Keynes, 1930, p.122).[10] These Q-profits can also be translated into Tobin's q so that $q = 1$ when entrepreneurial profits are zero.[11] Tobin's q is

[8]By implication the real interest rate has to be positive, for otherwise currency is not a store of wealth and has no utility.

[9]In the General Theory Keynes hid his mark-up theory behind the concept of user cost. For a modern reformulation see Riese, 1986, and Collignon, 1997. For a synthesis with the monopolistic model, see Dullien, 2004.

[10]Keynes, 1930, p. 53. For his explanation of the link between the *Treatise's* entrepreneurial profits and the *General Theory's* aggregate income, see Keynes 1973: 424-437

[11]The Q-concept is also found in Myrdal, 1933. Tobin was apparently not aware of this link between q and Q. See Tobin and Golub, 1998, p. 150; Schmidt, 1995; Collignon 1997.

usually defined as the ratio of the market value of the enterprise to capital replacement cost (Tobin and Brainard 1977), but it can also be expressed as the ratio of the internal rate of return of an investment project to the cost of capital.

$$(6) \qquad q(i) = \frac{1+i_K}{1+i} = \frac{1+i_K - E(\Delta p)}{(1+i-\Delta p)} \approx \frac{R}{r}$$

where i_K is the internal rate of return, R the expected real return on investment and $r = i - \Delta p$ the real short-term interest rate. Δp is the current rate of inflation and $E(\Delta p)$ is the expected average inflation rate over the life of the capital equipment. Thus, q is the shadow price of capital that expresses windfall profits. It is a function of the interest rate *i,* which is controlled by the central bank.[12] The effect of monetary policy on q is:[13]

$$(6a) \qquad q_i = \frac{\partial q}{\partial i} = \frac{R_i r - R}{r^2} < 0$$

R_i measures the degree by which expectations on the return on capital are affected by variations in interest rates. In a strictly neoclassical world, where R reflects the marginal product of capital $R_i = 0$ and R = r, so that $q_i = -\frac{1}{r}$. If demand effects are taken into consideration, the *expected* rate of return would be negatively influenced by higher interest rates $(R_i < 0)$[14], and q_i should be smaller than the factor $-\frac{1}{r}$. Thus, in general, q_i is negative and its absolute value rather large.

Building on Tobin's formulation for entrepreneurial profits and splitting the costs of production into wage costs (i.e., unit labor cost W/Λ) and the (rental) cost of capital per unit of output (i^*b),[15] Keynes' fundamental equation can be reformulated as:

$$(7) \qquad P = \frac{W}{\Lambda} + i^* b q(i) = \frac{W}{\Lambda}\left(1 + \frac{i^* b}{W/\Lambda} q\right)$$

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[12]In more complex models, q is also related to the real exchange rate and fiscal policy (Collignon, 1997). Because we have taken *i* as exogenously given by monetary policy, our model implies that the marginal product of capital ($F_K \equiv R$) will adjust to *r* - and not the other way round. In a Keynesian environment, *R* must itself be a function of *r*, because an increase in real interest rates would have negative consequences for effective demand, which in turn would affect the future cash-flow of the firm as well as the internal rate of return.

[13]Starting in equilibrium and taking the total differential of (6) yields (6b): $dq = \frac{1}{r}\, dR - \frac{R}{r^2}\, dr$. In the very short run, the inflation rate is fixed so that $dr = di$. In equilibrium $q = 1$ and therefore $R = r$, for $r \neq 0$ Inserting these values into (6b) and dividing by *di* yields: $q_i = \frac{dq}{di} = \frac{1}{r}[R_i - 1] < 0$, which is a reduced version of (6a).

[14]This might be the case when the central bank follows an aggressive interest rate policy to combat inflation, as in Goodfriend (1998)

[15]At the firm level the cost of capital consists the interest paid for the loan and of the depreciation δ of and the capital stock $(i^* + \delta)b$. However, if we look at net value added in the economy it is net investment that matters and we can ignore depreciation.

Or in logs:

(7') $$p = w - \lambda + \ln\left(1 + \frac{i^* b}{W/\Lambda} q\right)$$

Because of (5b): $c = \ln\left(1 + \frac{i^* b}{W/\Lambda} q\right)$. Prices are determined by unit labor costs and the mark-up, which covers the cost of capital and entrepreneurial income. The value of capital equipment purchased is equal to the value of loans ($P_0K=B$) and b is the ratio of outstanding loans (B) to output (Y) or the historic value of capital per unit of output.

Furthermore, we assume that B can be divided into two kinds of credit contracts: fixed rate contracts (bonds) freeze the interest rate over the entire life of the loan; the cost of borrowing vary for flexible rate contracts (overdrafts) with the interest rate set by the central bank. Aggregate capital equipment is purchased by a combination of fixed and flexible rate finance agreements, where ϕ is the share of loans financed by fixed rates. The cost of net capital per unit of output is:

(7a) $$i^* b = [(\phi i^{fix} + (1-\phi) i^{flex}] \frac{B}{Y}$$ (cost of capital)

We assume all capital equipment is purchased at the beginning of the period.[16] The cost of capital represents the *required rate of return* and is also dependent on the capital-output ratio and the financial structure of the economy. The larger the share of flexible rate contracts (1 - ϕ), i.e., the more the financial system operates as a *spot economy* (typically the UK), the higher will be the volatility of the required rate of return. By contrast, economies that operate like *coordinated market economies* (typically Germany), are dominated by long-term contracts (Hall and Soskice, 2001), and volatility should be lower. The structure of the financial market has also consequences for the nature of wage contracts, which determine nominal wage rigidity as discussed above. If risk-averse firms have contracted fixed-rate loans, they would prefer long-term wage contracts in order to stabilize the cash flow needed to service their debt. In contract economies, employers would resist greater flexibility in wage contracts.[17]

The mark-up in equation (7) is determined by the cost of capital and the margin of entrepreneurial profits, given unit labor costs. From (6) we know that when the actual return on capital is equal to the required return i^*, there are no entrepreneurial profits: $q(i\ ) = \bar{q}(i^*) = 1$. The market value of the investment project is then equal to its replacement costs and its net present value is zero. This reflects therefore the "normal" capacity utilization of the firm. Thus, i^* is Wicksell's natural rate of interest when $q(i\ ) = \bar{q}(i^*) = 1$ and unemployment is at its natural rate. We then also have the equilibrium price level (P^*) determined by unit labor costs (W/Λ) and the "normal" cost of capital per output.

[16]Equation (7a) could also be reformulated as a model of overlapping credit contracts, where i^{fix} and i^{flex} represent different interest rates at different points in time and the cost of capital is a moving average. However, sticking here with the fixed/flexible model allows a simpler modelization of the effects of monetary policy.
[17]For an empirical study, see Thelen, 2000.

(7') $$P^* = \frac{W}{\Lambda} + i^* b \qquad \text{or in logs} \quad p^* = w - \lambda + c^{T}\,*$$

where $c^{T}* = \ln(1 + \frac{i^* b}{W/\Lambda})$

Because i^* is the required rate of return, $c^{T}*$ is the minimum mark-up firms need to target in order to service their debt liabilities. Hence, the mark-up is exogenous and not real wages. *Firms must set prices so that they cover their cost of capital, and real wages will adjust.* This has consequences for employment (see equation 5d): the system clears by adjustment in the labor market, as Franco Modigliani (1997) never ceased to remind us.

The mark-up and interest rates

How does monetary policy affect inflation and the mark-up? Taking first differences of (5b) yields the inflation rate. Using $\Delta c = \frac{d\mu}{\mu}$, where $\mu = \frac{i^* bq}{W/\Lambda}$ we get the elasticity by which the mark-up responds to an interest variation:

(7c) $$\beta = \frac{\partial c}{\partial i} = \frac{\partial \mu}{\partial i}\frac{1}{\mu} = \frac{i^* q_i}{q} + (1-\phi)\frac{q}{i^*} < 0$$

We can then write the inflation equation:

(8) $$\Delta p = (\Delta w - \Delta\lambda) + \beta \Delta i$$

Inflation is determined by unit labor cost increases and monetary policy. An interest rate hike Δi operates through two transmission channels: it reduces demand and actual prices (because $q_i < 0$). At the same time it increases capital costs, as shown by the second part of the RHS in (7c), hence raising cost prices. On balance, a rise in rates by the central bank will lower inflation, if the demand effect $\frac{i^* q_i}{q}$ dominates the cost effect $(1-\phi)\frac{q}{i^*}$. We assume that this is generally the case, so that $\beta < 0$. [18] However, the larger the share of flexible rates (1-ϕ) in the economy, the larger will be the cost effect and the lower will be the elasticity β, by which inflation responds to monetary policy. Thus, financial structure matters for the transmission of monetary policy. In order to have the same effect on inflation, central banks in spot economies need to shift interest rates more aggressively.

[18] Under simplified neo-classical assumptions $q_i = -\frac{1}{r}$, stability implies $\phi < 1 - r - 2\Delta p - \frac{\Delta p^2}{r}$.

As long as there are some flexible rate credit contracts, a rate hike also increases the minimum mark-up $c^T *$ needed for firms to service their debt.[19]Thus, the total change in targeted mark-up is:

$$\Delta c^T = \Delta c^{T*} - \beta \Delta i \qquad (5e)$$

If all loans were fixed rate contracts *(ϕ=1),* $\Delta c^{T*} = 0$ and monetary policy would only affect profits, but not capital cost. In any case, rising interest rates *(Δi)* will depress effective demand, because $q_i < 0$. The price level and actual mark-up fall below their expected equilibrium level ($p < p^*$). To service their debt, firms have to target higher mark-ups, causing higher unemployment.[20] The demand-induced fall of the actual mark-up below equilibrium leads to a reduction of the capital stock, and the labor demand curve will shift to the left until the mark-up has attained the level necessary to service capital. The equilibrium rate of unemployment will have risen as a consequence of a *persistent* one-off increase in interest rates. A symmetric movement occurs when the central bank cuts interest rates.[21]

Monetary policy therefore has long-run real effects. By setting the marginal interest rate i^{flex}, the central bank determines the required mark-up. The impact depends on the financial structure β. When credit contracts have a high share of flexible rates, the targeted mark-up and unemployement will be higher than in the fixed rate economy. A spot economy therefore requires more "flexible labor markets" (in terms of hiring and firing) than a contract economy.

Determining the capital stock

The capital market will adjust to monetary policy by changing the stock of capital. It is in equilibrium when investment neither increases nor decreases. This is Wicksell's natural rate, where planned savings are equal to planned investment (Wicksell, 1965: xiii). Hence, *it is the capital market that determines the equilibrium rate of unemployment and not the labor market that determines the equilibrium interest rate*. The adjustment can be modelled by using Tobin's investment function. While short-term profit-seeking entrepreneurs compare the return to the cost of capital, in the long-term they will expand their productive capacity if the rate of return from investment exceeds the cost of capital. If the return is less, firms go bankrupt and the capital stock is reduced.[22] In neo-classical models, *R* is equivalent to the marginal product of capital (F_K), a technical variable dependent on the size of the capital stock. Investment is determined by the growth of the capital stock to the point where the marginal product of capital ($F_K \equiv R$) is equal to *r*. Thus, entrepreneurial profits tend to disappear as the capital stock increases. When the capital stock is in equilibrium, all opportunities for entrepreneurial profits have been exhausted and the return on capital reflects the costs of borrowing, so that

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[19] $$\frac{\partial c^*}{\partial i} = \frac{\partial \mu^*}{\partial i}\frac{1}{\mu} = \frac{1-\phi}{i} \qquad (7c')$$

[20]See equation (5d). In fact, lower employment may simply be the consequence of the bankruptcies of marginal firms and that may accelerate productivity growth.

[21]A persistent change in interest rates is defined as a rate variation that lasts until the capital stock has adjusted.

[22]Investment may already stop at an earlier rate, say $\bar{q}$, if a minimum profit rate is required for investment.

Tobin's $q(i^*)=1$.[23] The speed of convergence to equilibrium after a shock to q depends on the cost of adjustment: if these costs were zero, the capital stock would instantaneously jump to equilibrium where $q(i^*)=1$. As long as adjustment costs are positive, q will only gradually return to 1.

The rate of investment is determined as a function of Tobin's q (Tobin and Brainard, 1997):

$$dK = a_0 + \varphi\left[q(i) - \bar{q}(i^*)\right] \tag{9}$$

Because our model deals with net capital and assumes a constant labor force (a_o=0), investment at the natural rate equals zero. In order to stimulate investment, expected entrepreneurial profits must be larger than capital costs and the interest rate needs to be cut. Excess demand will then push the price level above the equilibrium P*. *Q*-profits would last until additional output satisfies excess demand and the capital stock finds its new equilibrium $(q(i) = \bar{q} = 1)$. At that point the price level will also have returned to *P**. Keynes's price equation (7) implies that profit margins at first rise above equilibrium because $q > 1$, but fall subsequently when competition and additional supply push q back to equilibrium. Hence, the demand-induced acceleration of inflation is transitory – unless it spills over into wage bargaining.[24]

Thus, monetary policy affects prices (via demand q_i, and via the borrowing costs i^*) in the short run, and output (via investment) in the long-run. But while the impact ceases once q has returned to the level of $\bar{q}(i^*)$, the consequences are durable. Because the capital stock grows (or falls) during the entire adjustment period, the *effects of a persistent interest variation are transitory on demand but permanent on the capital stock, equilibrium output and employment*. Aggregate demand has hysteresis effects[25], but monetary policy does not. Nevertheless, monetary policy is not neutral, as it is the transitory cause of output and unemployment hysteresis.[26]

4. Monetary Policy and Inflation Dynamics

We can now describe the role of monetary policy for the inflation process. Starting in equilibrium, let us cut interest rates. q increases and additional investment opportunities become available. Market prices are expected to exceed production costs.[27] Firms borrow funds to buy capital equipment. As the capital stock grows and more labor is employed, the supply of goods and services increases and entrepreneurial profits are competed away. Prices return to their cost levels. However, labor cost may also rise in the process, as the labor mar-

[23]Hence, Wicksell's natural rate of interest implies q=1 and there is an infinite number of natural rates.

[24]To the degree that the rate cut lowers the cost of capital, the equilibrium price level P* also falls.

[25]Hysteresis is defined as the response of a system when there is permanent effect on output after the value of input has been modified and brought back to its initial position. Amable et alt. 1995 :155.

[26]Empirical findings by Karanassou et al. (2003), Henry et al. (2000), Haldane and Quah (1999) found an apparent stability of the natural rate and the Phillips curve in the very long run, and the very prolonged aftereffects of persistent shocks and structural shifts in the medium term. My reading would be that in the very long run interest shocks are i.i.d. with zero mean, while in the medium term *persistency in interest rates causes shifts in the natural rate*. We therefore need to explain this persistency in interest rate variations.

[27]In a flexible rate (spot) economy the equilibrium price level falls after an interest rate cut.

ket tightens and workers try to recuperate their initially lost purchasing power. The interaction between profits and wages will create the inflation process.

Because the profit inflation is a transitory shift in the price level, sustained inflation must be driven by unit labor costs ($\Delta w - \Delta\lambda$). Yet, monetary policy can only affect the mark-up directly and not unit labor costs, as equation (8) shows. The central bank's success depends therefore on the indirect effects on wage bargainers' inflation expectations.

The central bank's reaction function

Assuming an exogenous inflationary shock, let us first look at the central bank's reaction function. Using (8), the extent of an inflation-stabilizing interest rate move is:

$$\Delta i = \frac{\gamma}{\beta}\left[\pi_m - (\Delta w - \Delta\lambda)\right] \tag{10}$$

Given the inflation target π_m and productivity growth, the extent by which monetary authorities should move interest rates will depend on the increase in nominal wages. Monetary policy should stay neutral, when unit labor costs are in line with the inflation target. If wage increases exceed the inflation target plus productivity, policy must be tightened.[28] The extent of the rate response depends on the financial structure parameter β and the policy parameter γ. According to equation (7c), the reaction is higher in spot economies than in contract economies. However, the full extent depends on the parameter γ, which indicates the degree of conservativeness by which monetary authorities respond to inflationary pressures. In principle, central banks could change interest rates aggressively to hold inflation to a desired path. With $\gamma = 1$, equation (10) simply indicates how large an interest rate hike would be required, in order *to counterbalance the inflationary cost-push effect of wage settlements by a corresponding reduction of demand in order to achieve the inflation target*. If wage pressure is high and/or β low, this could lead to excessively high interest rates, with the risk of destabilizing the financial system or society. The central bank will therefore also consider other factors than inflation and will smooth interest rates (Goodhart, 1997). Therefore a "normal" conservative central bank would have a reaction parameter between zero and one but at the higher end. For all $0 < \gamma < 1$ the time path of interest rates reflects inflation persistence and this persistence is higher, the lower γ. The consequence of a low γ will be a relatively slow process of disinflation and a drawn out rise of interest rates and natural unemployment. As a consequence interest rate rises are more persistent and cause a reduction in the capital stock, thereby increasing equilibrium unemployment. A more aggressive central bank would respond with higher interest rate increase, causing higher unemployment in the short run. But given that this will break inflation dynamics more quickly, it will also be able to lower rates more rapidly. The modified Phillips-curve would therefore shift less. Thus, interest rate smoothing contributes to higher equilibrium unemployment, a more aggressive monetary policy would stabilize the natural rate. The difference in unemployment behavior in Europe and the U.S. may be explained by the activism of monetary policy.

[28] Remember $\beta < 0$.

Equation (10) brings out another interesting feature: if central banks aim to maintain price stability: it is the development of nominal wages (unit labor costs) that determines the long-run level of interest rates. Because interest rates have consequences for firms' required mark-ups and capital market equilibrium, wage bargainers ultimately determine the equilibrium in the labor market. But contrary to the NRH, this leads to a general and not a partial equilibrium.

Labor markets and the central bank's reputation

What determines nominal wages? The literature has studied the interactions between wage bargainers and economic performance (for an overview see Flanagan, 1999). Institutional structures in labor markets, such as the power of trade unions, are often used to explain the time-path of wages. Calmfors and Driffill (1988) conjectured a "hump-shaped" curve between the degree of centralized wage bargaining and the real wage, although what matters is the *coordination* of wage contracts, rather than the institutional *level* of bargaining (Soskice, 1990; Hancke and Soskice, 2003). The degree of coordination depends on organizational structures, which vary from country to country (Hall and Franzese, 1998). Under uncoordinated wage bargaining, many units act separately, ignoring the externalities of their acts. They take the labor demand curve as given and maximize utility with respect to wages and employment, say by the trade union setting the wage and the firm employment (Oswald, 1985). Each individual unit considers its contribution to the aggregate labor cost development as negligible and is unlikely to care about monetary policy. Alternatively, coordinated wage bargains are important enough to influence the level of wage settlements in the economy as a whole and social partners internalize the externalities related to inflation and employment. Believing that the central bank will respond to excessive wage increases by raising interest rates,[29] and knowing that this will shift the labor demand curve down, coordinated wage bargainers would avoid settlements that are incompatible with the central bank's objectives. Coordinated wage bargaining has therefore a longer time horizon and will commit to longer-term contracts than uncoordinated wage bargaining, where individuals exploit the short-term opportunities of a spot economy. Thus, nominal wage rigidity is likely to be higher in contract than in spot economies.

However, an additional feature is the fact that in contract economies wage bargainers are more likely to respond to monetary policy. Hall and Franzese (1998) argue that the central bank's disinflationary policies send a signal to wage bargainers that will induce them to settle for lower wage increases, if they are credible. This effect may well dominate other structural effects of wage bargaining. Yet, Dullien (2003) points out that the optimal response by wage bargainers to the central bank's signal may fail due to signal uncertainty lack of coordination (insufficient information) or non-cooperation between monetary authorities and wage bargainers. Thus, we would expect that the institutional structures in the labor market as well as the reputation of the central bank will determine the optimal size of interest rate responses to inflationary pressures.

The credibility of monetary policy can be modelled as the weight social partners attach to the central bank's inflation target relative to past inflation when forming inflation expectations:

[29] In an open economy, the argument must include considerations of competitiveness and exchange rate policy.

(11) $$E(\Delta p_t) = (1-\vartheta)\pi_m + \vartheta \Delta p_{t-1} + \varepsilon_t$$

ϑ is the weight attached to past inflation and ε_t is a white noise disturbance. The steady state of the series is π_m, the central bank's inflation target. If ϑ is high, price and wage setters attach little weight to monetary authority's inflation target and are therefore backward looking in the formation of inflation expectations. Hence, deviations from the steady state inflation target may become long-lasting. A low ϑ implies high credibility of the central bank's commitment to achieve its target, so that the persistence of inflation shocks is lower.

We can now reformulate the wage equation. As discussed above, nominal wage rigidity is reflected by the parameter α_1, real rigidity by α_2. However, α_2 now indicates the responsiveness to short-term labor market disequilibria and not to the deviation from a constant natural rate. To take into account the externality argument of coordinated wage bargaining, we will add a term for monetary policy to the wage equation (4). α_3 indicates the responsiveness of nominal wages to changes in the interest rate. In a spot economy, we expect $\alpha_3 = 0$; in a coordinated market economy, where trade unions have power, $\alpha_3 < 0$. Using (11) and (14) we formulate the wage equation:

(11a) $$\Delta w = \alpha_1[(1-\vartheta)\pi_m + \vartheta \Delta p_{t-1}] + \Delta\lambda + \alpha_2(u^* - u) + \alpha_3 \Delta i + \varepsilon_t$$

Substituting (11a) into (10):

(10a) $$\Delta i = \frac{\gamma}{\beta + \alpha_3 \gamma}[(1-\alpha_1)\pi_m + \alpha_1 \vartheta(\pi_m - \Delta p_{t-1}) - \alpha_2(u^* - u) - \varepsilon_t]$$

Assuming that shocks are i.i.d with E(ε)=0, monetary policy could ignore short-term inflation shocks. We can then distinguish four idealized policy regimes: a contract economy, where wages are sticky but responsiveness to monetary policy; and a spot economy with perfect nominal flexibility and no response to interest rate externalities. Each regime is operating either with a perfectly credible or with an ill-reputed central bank, so that wage contracts are either forward or backward looking. Table 1 indicates the central bank's optimal interest response, given the reaction function (10a). Assuming the degree of conservativeness γ and the financial structure β as given, the time path of the interest rate is not the same under each regime.

1) In a contract economy with perfect nominal rigidity, it makes no difference how credible the central bank's future inflation target is, because cost prices are determined by existing contracts. Hence, the expression in brackets of case (1) and (3) are identical. Monetary policy will then have to rely on creating excess supply of labor to contain inflation pressures, shifting the natural rate of unemployment in the process. A relatively generous target and a flat Phillips curve would stabilize interest rates and equilibrium unemployment. However, inflation-conscious trade unions would also contribute to greater output and employment stability. Yet, such "responsible" behavior is more likely in regimes with credible central banks, so that α_3 is expected to be higher in regime (1) than in regime (3). As a consequence, interest rate variations and unemployment variability are lower in a contract economy with credible reputation for maintaining price stability.

Table 1: Interest variations under different regimes

Labor market

Central Bank reputation

ϑ \ α_1	(contract economy) $\alpha_1 = 0,\ \alpha_3 < 0$	(spot economy) $\alpha_1 = 1,\ \alpha_3 = 0$
Forward $\vartheta = 0$	*(1)* $\frac{\gamma}{\beta + \alpha_3\gamma}[\pi_m - \alpha_2(u^* - u)]$	*(2)* $\frac{\gamma}{\beta}[-\alpha_2(u^* - u)]$
Backward $\vartheta = 1$	*(3)* $\frac{\gamma}{\beta + \alpha_3\gamma}[\pi_m - \alpha_2(u^* - u)]$	*(4)* $\frac{\gamma}{\beta}[\pi_m - \Delta p_{-1} - \alpha_2(u^* - u)]$

In a spot economy, the central bank's reputation is crucial for the size of interest variations. If its credibility is high (regime 2), so that individual wage settlements are forward looking, monetary policy must be more active than in a contract economy: because wage bargainers anticipate the inflation target, any tightening in the labor market leads to inflation overshooting of the central bank's target and requires an immediate reaction. If restrictive monetary policy causes excess supply of labor and wages fall again, interest rates need to be cut again. Hence, in an economy with flexible and individualistic labor markets, rational expectations and forward looking wage bargaining, interest rate movements and unemployment variability are larger than in a contract economy. Finally, in a spot economy with flexible nominal wages but backward looking wage indexation (regime 4), monetary policy is most restrictive, as it will not only have to react to wage pressure from labor market tightness, but also to deviations of past inflation from the inflation target. As a consequence interest rate variations may become quite persistent, causing significant shifts in the rate of unemployment over both the short and the long term.

5. Conclusion

The natural rate hypothesis of stable equilibrium unemployment and the related claim of long-term neutrality of money are dependent on the axiomatic assumptions of a partial equilibrium in the labor market to which the capital market adjusts and the exogenous supply of money determines the price level. However, when central banks set interest rates as the marginal price for liquidity, money supply is endogenous to the demand for credit. This demand for credit depends on the rate of investment, which is a function of interest rates. Monetary policy therefore affects simultaneously prices and, via capital, also output and employment and has therefore enduring real effects.

The mechanism by which monetary policy is transmitted to these variables depends on the financial structure of the economy (the mix between fixed and flexible rate credit contracts) and the institutional structures of the labor market. Monetary policy will respond to inflationary shocks by raising interest rates, thereby increasing the required mark-ups for firms to service their financial liabilities. This leads to a reduction in the capital stock and a

rise in unemployment, which ultimately becomes permanent. Inversely, a cut in interest rates will lower required mark-ups, increase entrepreneurial profits and investment and therefore employment.

Whether a stimulating policy is feasible depends on the sensitivity of wage bargainers to central bank objectives. Low inflation supports low unemployment, because stability in unit labor costs allows low interest rates and high investment. If the central bank commitment to price stability is highly credible, a contract economy with wage coordination will produce better results in terms of inflation and employment. *In such an economy it is sufficient for the central bank to focus on price stability*, because coordinated wage bargains take into account employment externalities. In *flexible spot* economies this is not the case, so that *the central bank must include the employment externality into its objective function.* If the Euroland economy functions as a contract economy, the focus of the ECB's mandate on primarily maintaining price stability is appropriate. If the U.S. or the UK economy resembles more a spot economy, their central banks' objective function should include both inflation *and* output targets. Bringing down unemployment in Europe requires therefore not necessarily structural reforms of labor markets, but the establishment of a credible central bank and long-termism in credit and wage contracts.

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