# Long run effects of short-term non-neutrality of money

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A paper prepared for
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Abstract. The long run neutrality hypothesis of money (LRN) states that monetary policy can only affect real economic variables in the short run, but not in the long run. However, this hypothesis depends crucially on the role assigned to the labour market. This paper looks at long run effects resulting from capital accumulation that shift the labour demand curve and the Phillips curve. It is shown that an investment function based on Tobin's q can explain long-term shifts in the capital stock, which respond to short-term interest rates set by monetary policy. Empirical evidence supports the theoretical model.

JEL classification: E24, E31, E4,E5

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"Neutrality of money" is a basic tenet of economics. A model is said to exhibit money neutrality if a change in the *level* of nominal money does not affect real variables. Superneutrality applies the same concept to changes in the *rate of growth of nominal money* and asks whether such changes on capital accumulation, output and welfare (Orphanides and Solows, 1990). For reasons, which will become clear later on, I will not always distinguish between neutrality and superneutrality in this paper. The concept of neutrality of money is closely related to Friedman's and Phelps' natural rate of unemployment model. The long-run neutrality of money (LRN) hypothesis states that monetary policy can only affect real economic variables in the short run, but not in the long run. An expansionary monetary policy can help the economy to come out of a recession and return faster to its long-run equilibrium (the natural level), but it cannot sustain higher output forever. The validity of the hypothesis depends critically on the assumption that individuals are free of "money illusion", i.e. are concerned only by "real" variables and not by nominal claims - implying that prices are flexible, markets competitive and agents have full information[2]. The economy is then modelled as a system of homogeneous demand functions, where excess demand in the *real* sector depends on relative prices of goods and demand in the *monetary* sector depends on relative prices *and* the initial quantity of monetary assets, so that an excess supply of money causes the price level to rise (Patinkin, 1989). Therefore, in equilibrium money is neutral by definition.

This neutrality is reflected in the long run correlation between prices and money (Friedman and Schwartz, 1982), although this relationship does not prove causality. McCandless and Weber (1995), covering a 30-year period and 110 countries, have found that the correlation between inflation and growth of money supply is almost one, while

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[1] London School of Economics and Harvard University. I would like to thank Pedro Gomes and Antoine Nebout for research assisatance.

[2] But of course, the opposite is not true : Non-neutrality of money does not imply money illusion.

there is no correlation between these variables and the growth rate of real output. They find a positive correlation for a sub-sample of OECD-countries, where the correlation between real growth and money growth (but not inflation) is positive. However, in recent years the focus has shifted away from monetary aggregates, as monetary policy is targeting inflation and uses interest rates to preserve price stability (Woodford, 2003). Barro (1995) observed a negative correlation between inflation and growth in a cross-country sample, while Bullard and Keating (1995) found evidence for a permanent shift in inflation producing positive growth effects in low-inflation countries and zero or negative effects for high inflation countries. Fisher and Seater (1993), Logeay and Tober (2003), Kunzin and Tober (2004) also have produced evidence that money may not be neutral in the long-term.

The long-run empirical regularities of monetary economies are important for gauging how well the steady-state properties of a theoretical model match the data (Walsh, 1998). Short-run dynamic relationship between money inflation and output reflect the way in which private agents and monetary authorities respond to economic disturbances. Most economists recognize that monetary disturbances can have important effects on real variables in the short run. As Lucas (1996: 604) summarized the debate: "this tension between two incompatible ideas – that changes in money are neutral unit changes and that they induce movements in employment and production in the same direction – has been at the centre of monetary theory at least since Hume".

In this paper, I will argue that the neutrality and superneutrality of money depends on the variable under consideration. First of all, I will focus on changes in interest rates, which are the principal monetary policy instrument rather them looking at monetary aggregates. The question is how short-term shocks translate into long-term phenomena. While monetary shocks may have transitory effects on some variables, these effects may accumulate over time. This is most obvious with respect to investment. For example if prices or wages are sticky, then it is well known that monetary policy may be able to induce changes in output or investment in the short-run. Over time, as prices adjust, the system reverts to the equilibrium steady state of output and investment, although the level of output and employment may be higher. Thus, money appears superneutral with respect to the rate of growth and investment in the long-term. But the temporary increase in investment would have caused a permanent increase in the stock of capital and therefore also in the equilibrium *level* of output and employment. Money is non-neutral with respect to these variables. Monetary policy is therefore, also not neutral with respect to the natural level of unemployment.

The rest of the paper is structured as follows. I will first outline a theoretical model where monetary policy shifts the Philips curve in the long run, so that there is non-neutrality of money with respect to employment. In the second part I will provide evidence for long-term effects of monetary policy on the capital stock in a sample of European countries.

## I. The Theory of Non-Neutrality of Money

To establish the theoretical claim that short-term non-neutrality of money has long run effects, we will start with the basic assumptions of the natural rate of unemployment model, then reformulate the Phillips curve as being dependent on the profit share rather than the real wage and finally introduce the capital market in the model.

***Labour market equilibrium and the natural rate of unemployment***

If money is neutral in the long run, aggregate supply must be determined by non-monetary factors. Neoclassical economics derives the vertical long-term supply curve from equilibrium in the labour market at the so-called natural rate of unemployment, which reflects the market position where real wages equalise demand and supply for labour. Firms employ labour up to the level where real wages are covered by the marginal product of labour. Output is then determined by the technological parameters of the production function and the price level by the quantity of money.  Because wage earners are only interested in what money can buy, they bargain over real wages and there are no real effects caused by money other than creating short-term or temporary disturbances. Goods' prices and interest rates, i.e. prices in the other markets of the Walrasian system, cannot influence output or unemployment systematically[3]. However, this result depends on the fact that the labour market equilibrium is independent from other markets, especially the capital market. In neoclassical model, the monetary sector adjusts to real variables in the long run. However, it is also possible that monetary policy decisions and financial markets are the exogenous variable, taken by investors maximising the return of their asset portfolio; in this case, financial markets may have systematic effects on real variables.

*The demand for Labour*

To prove our claim, we start with a simple neoclassical model of the labour market. Firms produce output with a homogenous production function using labour (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 labour productivity, i.e. the output per employee as:

(1a) $$\Lambda = \tfrac{Y}{L} = \tau f(k) \qquad f'(k) > 0, \qquad f''(k) < 0$$

with the capital intensity $k = K/L$. $f'(k)$ is the marginal product of capital per unit of labour. $\tau$ reflects Hicks-neutral technology at constant capital intensity. Firms employ labour up to the level where short-term profits are maximised. Profits are defined as revenue minus the wage bill, so that short-term profits are maximised by equalling the marginal product of labour to real wages *at a given capital stock* $\overline{K}$:

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

with *P* the price level, *W* as the nominal wage, and $\overline{K}$ the given capital stock.

As is well known, the solution yields that profits are maximised when the real wage equals the marginal product of capital:

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

[3] A similar result is obtained by letting wage bargainers and price setters make nominal claims; the equilibrium is then obtained by the non-accelerating inflation rate of unemployment (NAIRU)

For future reference we also define the wage share as a function of real wages and productivity:

(2b) $$\sigma_w = \frac{WL}{PY} = \frac{W}{P}\frac{1}{\Lambda}$$ or in logs:[4] $$s_w = w - p - \lambda$$ (wage share)

And the *profit share* as the part of aggregate income that goes to capital.

(2c) $$\frac{\Pi}{PY} = \frac{PY - WL}{PY} = 1 - \sigma_w = \sigma_k$$ (profit share)

The profit share is the complement of the wage share and is maximised *at a given level of capital stock* when labour receives the marginal product as real wage, so that in a neoclassical setting, the profit share is determined by the ratio of marginal to average productivity of labour.[5]

The *demand for labour* by profit maximising firms is a function of the real wage and the capital stock employed.

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

By totally differentiating we get:

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

In the short run, the capital stock remains constant. The demand curve for labour is downward sloping, because $F_{LL} < 0$, but in the long-run an increase in the capital stock can shift labour demand up.

*Labour supply*

Because workers face a trade-off between leisure and consumption, *labour supply* is assumed to be an increasing function in the real wage and depending on a vector of shift parameters *X*:

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

[5] Assuming (2b), the optimal neoclassical wage share is $\frac{F_L(L^*,\bar{K})}{\tau\, f(k^*)}$, where $k^* = \bar{K}/L^*$ and L* the level of employment when the real wage equals the marginal product. If the real wage is exogenous, short term profit maximizers will adjust labour productivity by changing capital intensity.

(2f) $$L^s = \varphi\left(\frac{W}{P}, X\right)$$

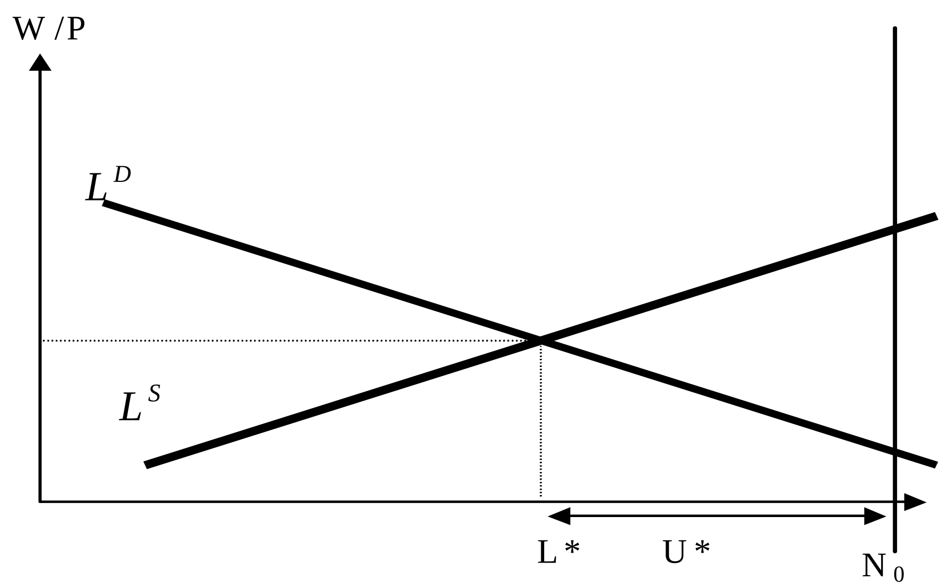
The slope of the labour supply curve $\varphi_{w/p} > 0$ is a measure for structural wage and price flexibility. The literature has produced a long list of factors *X*, which might shift the labour supply curve exogenously. Typically it includes population growth, the reservation wage, the replacement ratio, factors affecting the job match function, efficiency wages, trade union power, etc. When aggregate supply and demand match, equilibrium employment and output are determined by *the production function and the level of capital stock.* However, because of search costs, efficiency wages, and other microeconomic distortions, equilibrium employment (L*) and output levels may be lower than “full” employment of the labour force (N), so that "natural" unemployment (U*) is the difference between equilibrium and full employment as defined by the level of potential output that would occur in an equilibrium with perfectly flexible prices and wages (Woodford, 2003):

(3) U* = N – L*

Actual unemployment is:

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

**Figure 1**



Unemployment can result from temporary disequilibria or from ‘structural’ shifts of the labour supply and demand curve. Early theorists of the natural rate of unemployment assumed the equilibrium to be fixed or stable. A deviation from equilibrium would bring about wage and price adjustments, re-establishing the real wage, which corresponds to the marginal product of labour. A stable natural rate, therefore, implies a stationary profit share.

In what follows, I will take the labour supply curve as given and focus on labour demand, not because changes in the shift vector X are negligible, but because I believe the vast literature on structural reforms in the labour market has unduly neglected the labour demand curve. This curve shifts with changes in the capital stock. Positive net investment is pushing the labour demand curve up, and given the full employment level, natural unemployment will be reduced. But why would the capital stock change? Given that firms pay workers their marginal product as the real wage, there are no profit opportunities, which would attract higher investment. We could, of course, assume *ad hoc* exogenous shocks to productivity, which would require adjustment, but from a theoretical point of view this is unsatisfactory. I will therefore suggest a theory of investment, which links profit margins to the capital market, with labour demand as the adjustment variable. I will argue that short-term volatility in profit margins causes movements *on* the Phillips curve, while variations in the long run profit margins *shift* the Phillips curve horizontally.

### ***A reformulated Phillips curve***

We now assume that workers negotiate with firms about nominal wage contracts, although they are interested in the purchasing power of their money wages. Firms set nominal prices with a mark up over wages. Note, however, that this mark up can be modelled as a monopolistic competition mark up, as is customarily done in NAIRU-models (see Layard, Nickell and Jackman, 1991), or in a perfect competition model, where the mark up covers fixed costs. Equilibrium in the labour market therefore reflects a balance of nominal claims at which inflation is not accelerating (the NAIRU). Workers take into account inflation expectations, secular productivity increases and actual unemployment relative to equilibrium (as a measure for labour market tightness) when determining wage increases. Firms set prices with a mark up on wages to cover the cost of capital and profits.

*Wage setting*

Wage bargainers follow a simple rule. If there is excess demand for labour, nominal and real wages will rise relative to productivity and the profit share will fall:

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

$\Delta w$ stands for the proportional rate of wage increases and $\Delta p^e$ for the expected rate of inflation and $\Delta\lambda$ is the secular growth in labour productivity. ($u^*$-$u$) is excess demand for labour: when the demand for labour exceeds the natural rate, unemployment falls below the equilibrium level and the bracketed expression turns positive. Assuming rational expectations, the coefficient $\alpha_1$, a parameter for *nominal wage rigidity*, is equal to 1 (Sargent, 1971). Nominal wages are then adjusted to inflation and wage bargaining is about the real wage (Friedman, 1968).[6] If contracts are staggered (Fischer, 1977; Taylor, 1979), which can be explained by imperfect knowledge (Ball and Cechetti, 1988), prices and wages are sticky, and $\alpha_1$ may be less than 1 – at least temporarily. Inflation will then increase the profit share. The coefficient $\alpha_2$, sometimes called *real wage rigidity*, is a measure for the responsiveness of overall wages to excess demand in the labour market. In our model this coefficient will determine the slope of a log-linear short-term Phillips-curve.[7]

[6]Hence, we have:

(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)

[7] There are good theoretical reasons, supported by empirical evidence, to think that both $\alpha_1$ and $\alpha_2$ 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. They may also be related to wage bargaining regimes. Empirical estimates usually show $\alpha_2$ to be significantly below $\alpha_1$.

Assuming rational expectations ($\alpha_1 = 1$) and labour market equilibrium ($u^*=u$), equation (4) has two implications: First, as is well known, the short-run Phillips curve for nominal wages shifts upward with rising inflation. Second, because the real wage is identically equal to the rate of average labour productivity times the wage share,[8] real wages follow the secular trend of productivity growth. Otherwise wage bargainers would systematically mispredict inflation and the labour market would be in persistent disequilibrium. Thus, the natural rate model and, therefore, the neutrality hypothesis, predict stable wage and profit shares in the long run.

*Price setting*

We re-define the inverse of the wage share as the mark-up[9]

(5a) $c = -s_w$

and obtain the price equation

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

Firms set prices so that they will cover at least the cost of capital and we obtain the corresponding *targeted* mark-up:

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

Inserting (4) into (5c) yields the modified Phillips curve, where the targeted mark up is a function of labour market disequilibria.[10]

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

This equation states that *if firms set prices in accordance with their rational inflation expectation, a change in the targeted mark-up requires a change in labour market*

[8] See equation (2b).

[9] I repeat that this is different from the conventional definition of mark-up reflecting monopolistic rents. Our mark-up combines the competitive return on capital *and* rents. An increase in monopolistic market power has the same effect as an increase in competitive returns on capital. In a model of perfect competition, the mark up will only cover the return on capital and not on rents.

[10] The classical Phillips curve related changes in *nominal* prices and wages to (un)employment. Milton Friedman showed that the expectation augmented Phillips curve shifts upwards because workers bargain for real wages. Thus, the Phillips curve in the real wage–employment space is fixed. Our modified Phillips curve relates the change in targeted profit shares to employment. By normalizing our system on productivity, (5d) expresses the relation between the (targeted) changes in real wages relative to productivity and the labour market. But contrary to Friedman's fixed natural rate system, our modified Phillips curve can be shifted horizontally.

*conditions*. A higher targeted mark-up would require excess supply of labour, i.e. actual unemployment must rise above the natural rate. When the targeted mark-up is constant ($\Delta c^T = 0$), the labour market is in equilibrium and unemployment is at its "natural" level.

Note the direction of causality. If the *natural rate is exogenous* and fixed, the mark-up is stationary. Surprise inflation creates temporary deviations from the equilibrium mark-up to cover fix costs, due to the unexpected fall in real wages. In the short-term, firms will employ more labour until profits are maximized. But as workers seek to restore the purchasing power of their wages (adaptive expectations, see Friedman, 1968) or try to recuperate the wage share (the 'justice motive', see Hahn and Solow, 1995), the temporary excess employment is removed and the system returns to equilibrium. Because price setters target a constant mark-up, prices will increase with rising wage costs (the wage-price spiral), but the labour market will return to the 'natural' rate of unemployment. Thus, surprise inflations reduce unemployment only temporarily, while changes in nominal variables are permanent.

The story is different, however, if we take the *targeted mark-up as the exogenous* variable and labour market adjustment as endogenous. Assume that for some reasons discussed in the next section firms will increase their targeted mark-up level permanently. According to (5d), an increase in $c^T$ requires unemployment to rise above the natural rate. But once mark-ups have met their new targeted *level*, the increase in the targeted mark-up becomes zero, at which point the higher *actual* rate of unemployment will become the new *natural* rate.

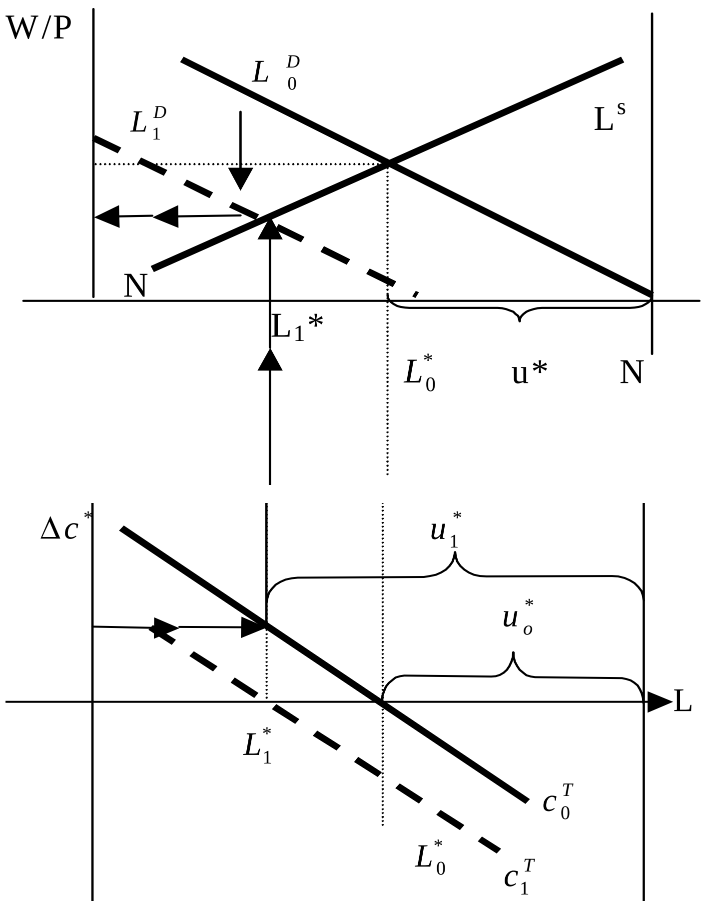
What has caused the shift in equilibrium unemployment? The endogeneity of the labour market requires the labour demand curve to shift downward. Given that firms maximise profits, this is only possible if the capital stock falls.[11] The lower capital stock will increase the marginal product of capital and the profit share, while reducing real wages and the wage share.

[11] See equation (2e).

*The modified Phillips curve*

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

**Figure 2**




If there are adjustment costs to investment and/or the targeted mark-up quickly returns to the initial position, we would move along the $c_o^T$ - curve, which cuts through the zero-line at the natural rate $u_o^*$. But if the targeted mark-up increases permanently, a permanently lower wage share is required, which can only be obtained by shifting the labour 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 stabilised because the lower capital stock has reduced employment. *The natural rate of unemployment has permanently increased and the Phillips curve has shifted horizontally.*

The difference between the two explanations is fundamental for the conduct of monetary policy. If the natural rate (or the NAIRU) is exogenously given, it can anchor monetary policy; surprise inflation could only temporarily stimulate employment by reducing the real wage (increasing the mark-up), but in the long run money is neutral. But if the mark-up is exogenous, the labour market has a continuum of equilibria and the natural rate does not provide much guidance for monetary policy. We therefore need a theory for explaining the exogeneity of the mark-up, if we want to go beyond the LRN-hypothesis.

***Capital market equilibrium and the mark-up***

The strength of the long-term neutrality of money hypothesis lay in the policy recommendations for price stability. However, many economists have recognised the 'divorce' between monetary theory emphasising the link between monetary aggregates and prices, and central bank practice focusing on interest rate variations (Goodhart, 1995:97). Recently this has led to reformulations of monetary policy as an interest rate policy (Woodford, 2003). *If the neutrality of money hypothesis is to be maintained, one has to show under which conditions changes in interest rates have no long run effects.* I will do this in this section. It requires modelling the capital market as the space where monetary policy is transmitted to the 'real' economy. Here are the essential features.

We assume a world, where money is the means of payment, i.e. the sole asset that extinguishes debt. The net wealth of an economy consists of all claims for real assets. Because ownership and possession of real assets do not necessarily coincide, the financial assets of one are the liabilities of another. The private non-banking sector (PNB) has a choice of holding its wealth in the form of perfectly liquid financial claims, i.e. money (currency and deposits) and as less liquid claims to the possession of real assets, called private capital.[12] The price for giving up liquidity in terms of money is the interest rate. In order for money to have utility as a liquid store of wealth, from which the motive to hold

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

currency is derived, the real interest rate must be positive.[13] Money is endogenously generated by banks lending to firms at the prevailing interest rate or by firms' demand for loans or financial institutions' demand for liquidity (base money). As the marginal supplier of liquidity, the central bank is the monopoly price setter for money (Friedman, B. 1999) and not a quantity setter (Woodford, 2003; Riese, 2001). Assuming for simplicity that all private sector liabilities are close substitutes, we may talk about *the* interest rate as the price for liquidity. However, over the full life of the loan, interest rates may be fixed as for bonds, or variable as for overdraft facilities. Financial claims held by the central bank earn interest that is serviced by PNB-payments. This fact creates the structural shortage of 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 pay their workers and suppliers with money and borrow from banks as long as they expect to earn a profit at least sufficient to service their liabilities. Hence, the capital share must cover the aggregate interest and repayment cost of the economy's capital stock. The excess of profits over the cost of capital is *entrepreneurial profit Q*.

An important implication of this model of the monetary economy is that increases in wealth and the creation of income depend on private capital, i.e. *monetized real assets*, rather than *resource endowment*. Hence the monetarist dichotomy of a real and a monetary sphere disappears and prices are no longer determined by the quantity of money. How is the aggregate price level determined in such a model?

*Determining the price level*

I our world, as for Keynes (1936:41), the labour market determines nominal values by anchoring the wage unit in the real economy; it does not determine aggregate output, as

[13] At least this is true over the long run, i.e. the real interest rate should be a stationary time series with a positive mean. The unit root tests shown below for the American real short term interest rate show that to be the case, except for the 1935M04-1950M12 period.

in Friedman (1968). In early Keynesian models, prices were linked to wages by constant mark-ups, an assumption that spilled over into the natural rate hypothesis, as we saw. Recent models of monopolistic competition have derived more or less fixed mark-ups from micro-foundations in goods markets (Blanchard and Fischer, 1989; Carlin and Soskice, 1990; Coricelli, et alt., 2003). Yet, Keynes' (1930) theory of the mark-up focussed on the capital market. The link between the wage unit, prices and profitability was formulated in his fundamental equation.[14] 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). [15] These *Q*-profits can also be translated into Tobin's *q* so that *q* = 1 when entrepreneurial profits are zero.[16] Tobin's *q* is 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.

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

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. $\Delta p$ 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

[14] See Keynes, 1930: chapter 10. In the General Theory Keynes hid his variable 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 competition model see Dullien, 2004.
[15] 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
[16] 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.

interest rate $i$, which is controlled by the central bank.[17] The effect of monetary policy on $q$ is:[18]

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

$R_i$ 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 *(* $R_i < 0$ *)*[19], 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 labour cost W/Λ) and the (rental) cost of capital per unit of output ($i*b$),[20] Keynes' fundamental equation can be reformulated as:

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

Or in logs, because of (5b):

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[17] 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.

[18] 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).

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

[20] 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 $(i*+\delta)b$. To simplify our notation, we will use $i$ to denominate all cost of capital, including depreciation.

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

We have now a theory for the mark up. Prices are determined by unit labour costs and the mark-up, which covers the cost of capital and entrepreneurial profits. 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.

The mark-up is determined by the cost of capital and the margin of entrepreneurial profits, given unit labour 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 condition reflects therefore the "normal" or equilibrium capacity utilisation of the firm and $i*$ represents Wicksell’s “natural rate of interest”, which determines also the natural rate of unemployment. But, as Woodford (2003:20) rightly points out, various types of real disturbance can create temporary fluctuations in the “natural rate of interest” and the level of nominal interest rates required to stabilise both inflation and output varies over time.

The equilibrium price level ($P*$) is determined by unit labour costs ($W/\Lambda$) and the “normal” cost of capital per output.

(7a) $$P* = \frac{W}{\Lambda} + i*b$$ or in logs $$p* = w - \lambda + c^T*$$

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, which firms need to target in order to service their debt liabilities. This explains why the mark-up is set as the exogenous variable in our system by the capital market and, more precisely, by monetary policy. *Firms must set prices so that they cover their cost of capital, and the labour market will have to adjust*. However, note that $q$ may also drive a wedge between the actual and the required mark up, if entrepreneurial profits are positive or negative.

This wedge is transitory, but has long-term effects for the level of the capital stock and may therefore explain shifts in the Phillips curve.

*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 call $\beta$ the *transmission coefficient* and write the inflation equation:[21]

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

Inflation is determined by unit labour cost increases and monetary policy. An interest rate hike $\Delta i$ operates through two channels: (i) because $q_i < 0$, it reduces demand and actual prices. But if interest rates are flexible, it also increases capital costs. On balance, a rise in rates by the central bank will lower inflation, if the demand effect dominates the cost effect. We assume that this is generally the case, so that $\beta < 0$. [22] (ii) However, the larger the share of flexible rates in the economy, the larger will be the cost effect and the lower will be the transmission coefficient $\beta$, by which inflation responds to monetary policy. Thus, financial structure matters for the transmission of monetary policy. As long as there are some flexible rate credit contracts, a rate hike also increases the required mark-up $c^{T*}$ needed for firms to service their debt. Thus, the total change in the targeted mark-up is:

(5e) $$\Delta c^T = \Delta c^{T*} + \beta \Delta i \qquad \textit{for } \beta < 0$$

If all loans were fixed rate contracts, $\Delta c^{T*} = 0$ and monetary policy would only affect profits, but not capital cost. Firms will then only target an increase in the mark-up to recuperate the demand induced losses, but not higher costs of capital. In any case, a rising interest rates (*$\Delta i$)* will depress effective demand, because $q_i < 0$. The price level and actual mark-up then fall below their expected equilibrium level ($p < p^*$). To service their

---

[21] The coefficient $\phi$ reflects the share of fixed interest rate bonds in the aggregate credit volume. See Collignon, 2002 for details. $\phi = 1$ implies that all loans carry fixed interest rates.

[22] For a formal derivation of this statement see Collignon, 2002.

debt, firms have to target higher mark-ups, causing higher unemployment. If profit margins respond with high elasticity to changes in employment, while adjustment costs and uncertainty will cause the capital stock to adjust only slowly, disequilibrium unemployment will be high. But if the demand-induced fall of actual mark-ups below equilibrium levels leads to a reduction in the capital stock, the labour demand curve will shift to the left until the mark-up has attained the level necessary to service capital. See figure 2. The equilibrium rate of unemployment will have risen as a consequence of a *persistent*[23] one-off increase in interest rates.[24] The opposite movement occurs when the central bank cuts interest rates. Thus, by setting the marginal interest rate, the central bank determines the required mark-up and monetary policy has long run real effects.

*Determining the capital stock*

The capital market is the place where changes in monetary policy will translate into adjustment of the capital stock. The capital market is in equilibrium when investment neither increases nor decreases.[25] At this point the labour market also is in equilibrium. The adjustment can be modelled by using Tobin's investment function. In the long run firms 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.[26] 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 Tobin's $q(i^*) = 1$. Hence, there are an infinite number of natural rates of interest and unemployment.

---

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

[24] For a model explaining the NAIRU as an autoregressive process with hysteresis see Taheri, 2000

[25] This is Wicksell's natural rate, where planned savings are equal to planned investment (Wicksell, 1965:xiii).

[26] Investment may already stop at an earlier rate, say $\bar{q}$, if a minimum profit rate is required for investment. See Collignon, 2002.

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 can be modelled as a function of Tobin's $q$ (Tobin and Brainard, 1997):

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

In a neoclassical model, autonomous investment grows at the rate of the labour force. Investment is stimulated if mark ups exceed the cost of capital, so that entrepreneurial profits are positive and $q(i)>1$. Monetary policy can therefore stimulate investment by cutting the interest rate. Excess demand will then push the price level above the equilibrium P*. But *Q*-profits are only temporary. They 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' 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.[27]

Thus, monetary policy affects prices in the short-run (via demand $q_i$, and via the borrowing costs $i^*$), and output and employment in the long-run (via investment). But while the impact ceases once $q$ has returned to the level of $\bar{q}(i^*)$, the consequences are durable. Because the capital stock has grown (or fallen) during the entire adjustment period, the *effects of a persistent interest variation are transitory on investment, but permanent on the capital stock, employment and equilibrium output*. The short-term non-neutrality of money has long run effects.

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

This implies, on the other hand, that the hypothesis of long run neutrality of money only holds if interest rate variations are not persistent. In other words, the *long-term neutrality of money implies that real interest rates are stationary*, meaning that although fluctuating, they revert to a constant mean. This may be true in the very long run, but hardly over the period, which is necessary for the capital stock to adjust to changes in interest rates. If shocks to the interest rate exhibit variations in the mean or are highly persistent, i.e. if their time series have a constant trend or a unit root or are close to a unit root, monetary policy is not neutral. In fact, the very concept of monetary *policy*, i.e. of a *sequence* of decision rules followed by the Central Bank, implies that today's variation of interest rates are not independent from previous ones. Only over the very long may decisions to raise and to lower interest rates balance out. Thus, for realistic time frames in real life, it is reasonable to give up the hypothesis of long run monetary neutrality.[28] However, the degree to which monetary policy has real effects depends on real wage rigidity, adjustments coats of investment and the financial structure of the economy.

## II. Empirical Evidence for Non-Neutrality of Money

We will now look at empirical evidence for long run effects from monetary policy on investment and employment. We will first discuss our data, then evaluate Tobin's investment function and finally estimate our modified Phillips curve.

### *The data*

In this section, I will give an overview of some relevant data that throw light on our theoretical argument. We will use available data for 15 OECD industrialized countries, most of them being members of the Euro area today. Unless indicated differently, I use

[28] Breedon et alt (1999) found that real interest rates in leading developed countries for the 1967-1988 period do not appear to be stationary. 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 after-effects 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*.

the annual data set provided by the European Commission's AMECO. The relevant codes are shown in appendix 1.

*Interest rates*

We have argued that long-term neutrality of money implies stationarity of real interest rates. Figure 3 shows monthly short-term real interests for the USA.[29] We clearly distinguish periods of monetary turbulence in the late 1930s and 40s and in the 1970s.

**Figure 3. USA: 3-month Treasury Bills, CPI inflation and Real Interest Rates**

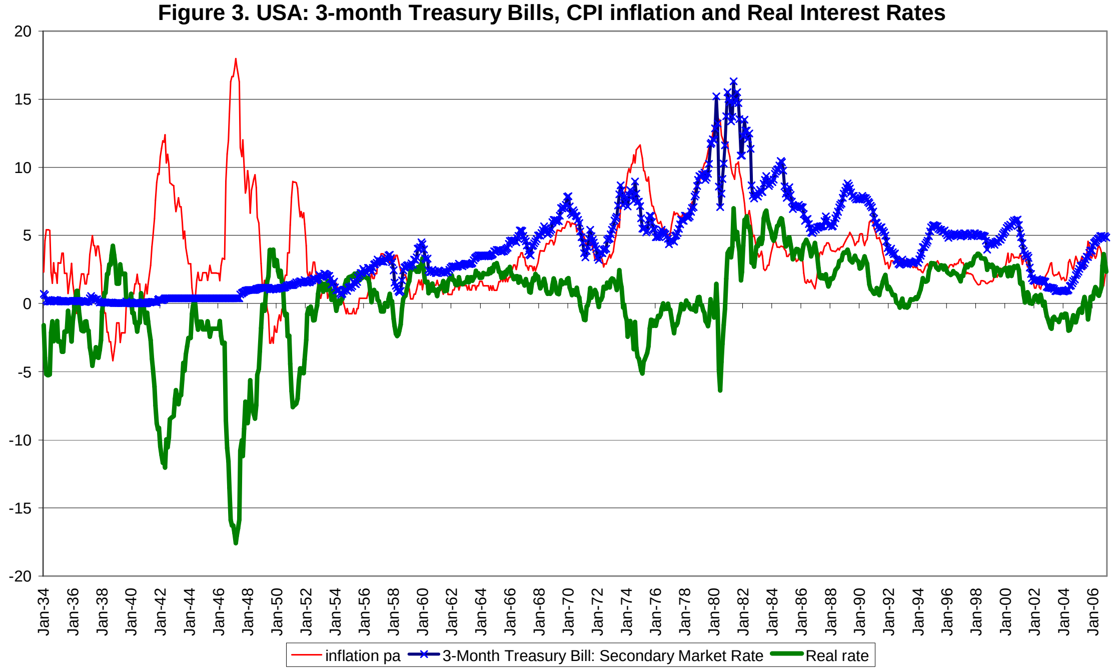



Table 1 shows the unit root tests for some selected periods. It rejects the hypothesis of a unit root for the very long run, but less convincingly, or not at all, for shorter periods. Furthermore, the autoregressive coefficient in the ADF test is close to zero, indicating long persistence in the mean reverting dynamics. For example, a coefficient of -0.029 means that only 2.9% of a real interest rate deviation from the long-term mean is

---

[29] Data for this time series are obtained from the Federal Reserve Bank of St. Louis Economic Data (http://research.stlouisfed.org/fred2/). Inflation is calculated from Consumer Price Index for All Urban Consumers: All Items, nominal short term interest rates are: Series: TB3MS, 3-Month Treasury Bill: Secondary Market Rate.

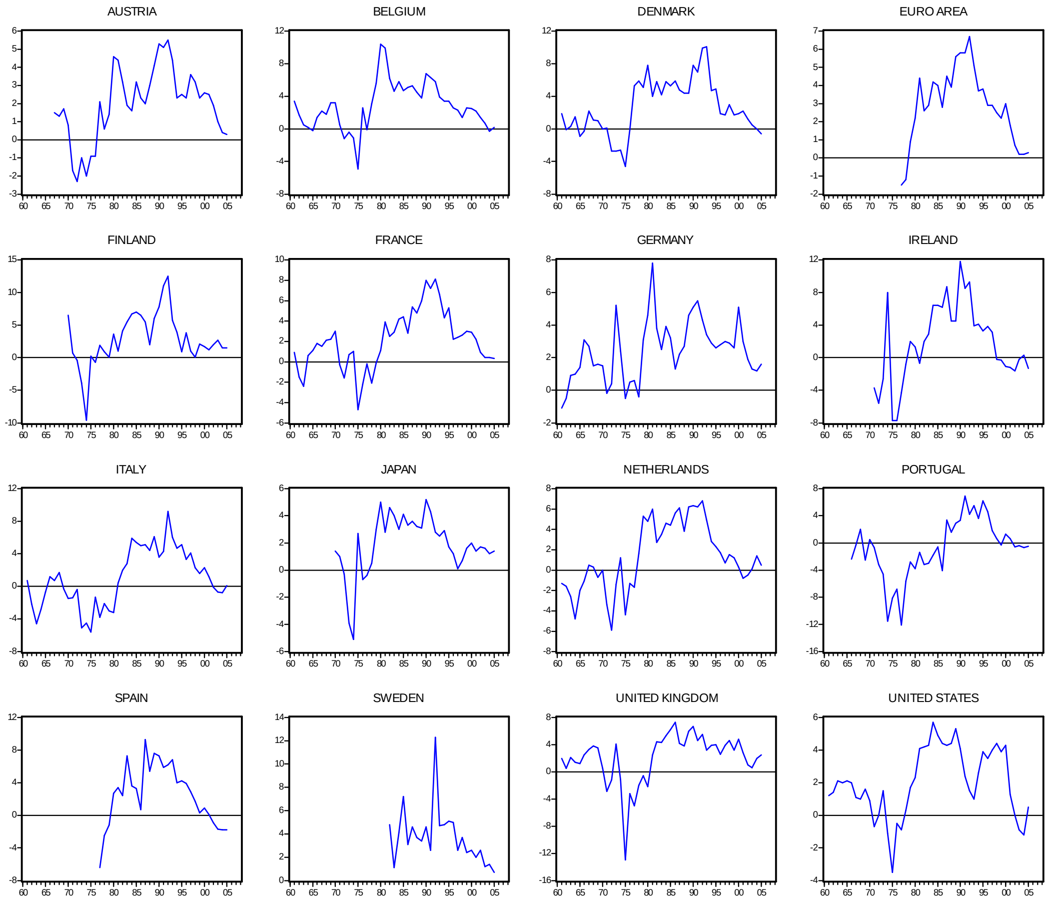
corrected in any one year. Thus, it takes a long time until a shock to interest rates reverts to long-term-steady state – if it does so at all.

**Table 1. USA Short-term Real Interest Rate Unit Root Tests**

| | **ADF Test** | | | **Phillips Peron Test** | |
|---|---|---|---|---|---|
| *Period* | *t-statistic* | *p-value* | *AR-coefficient* | *t-statistic* | *p-value* |
| 1935M04-2006M12 | -4.325468** | 0.0004 | -0.029074 | -14.47508** | 0.0000 |
| 1935M04-1950M12 | -3.152358* | 0.0245 | -0.053005 | -2.470366 | 0.1243 |
| 1950M12-1972M12 | -3.284211* | 0.0166 | -0.048807 | -2.719887 | 0.0720 |
| 1972M12 1992M12 | -2.693803 | 0.0765 | -0.044178 | -2.282534 | 0.1785 |

Figure 4 shows the annual short-term real interest rates for our selected 15 OECD countries, as far as data are available. Over a 45 year period short-term real interest rates variations have been quite persistent. Hence we would conclude from these observations that monetary policy must have had significant long-term effects on investment and employment.

**Figure 4. Annual Short-Term Real Interest Rates**




*Investment*

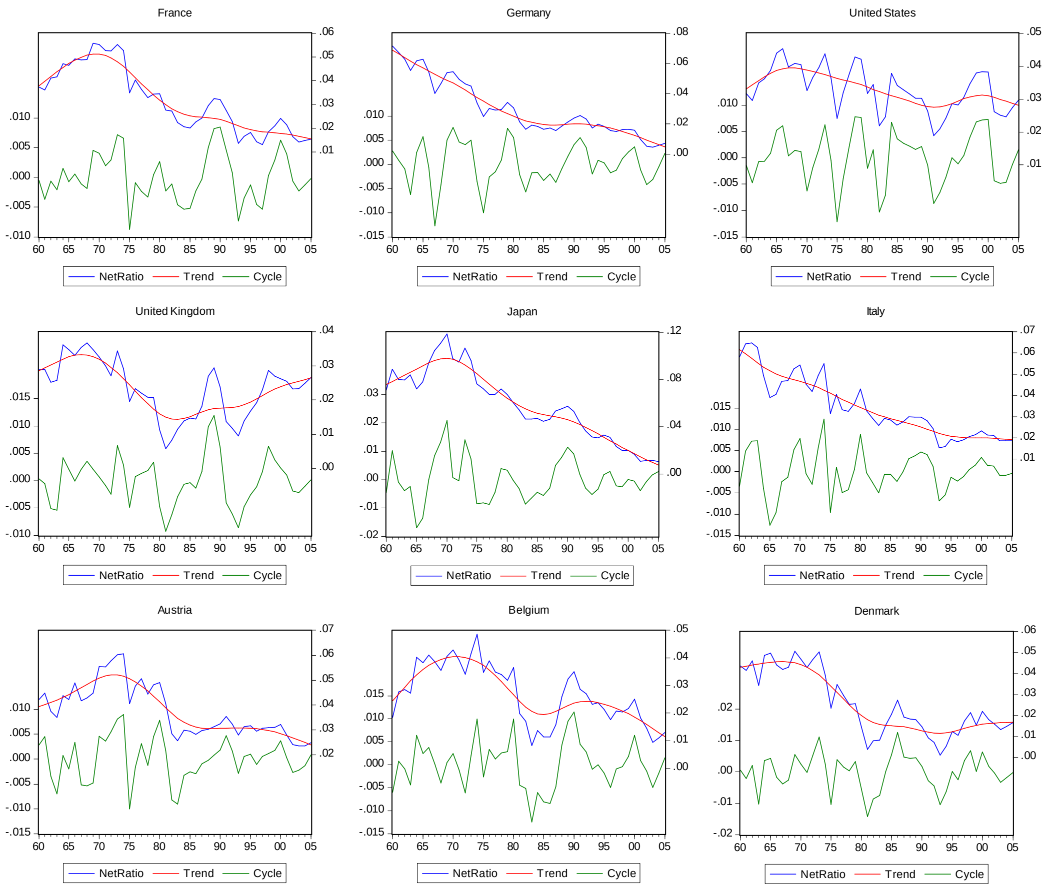
According to our theoretical model, investment is the critical variable that responds transitorily to monetary policy, while the capital stock determines the equilibrium rate of (un)employment. Figure 5 shows the growth rate of the capital stock, calculated as the net ratio of gross capital formation minus capital consumption at 1995 prices divided by the capital stock.

$$NetRatio = \frac{P_k I}{PY}\frac{P}{P_k}\frac{Y}{K} - \delta,\ where\ \delta = \frac{Y}{K}\frac{K_{deprec}}{PY}\frac{P}{K_k}$$

$P_k$ is the price deflator for gross fixed capital formation, $P_k K_{deprec}$ is capital consumption at current prices and PY is GDP at market prices. The period covered is 1960 to 2005.

We are interested in the long-term effects of short-term variations, assuming that the long-term trend of investment may follow more fundamental factors like population growth, structural changes in the world economy etc. The long-term trend has been calculated by applying the Hodrick-Prescott Filter (with lambda=100) to the data. Figure 5 shows the results, as well as the short-term cyclical deviations from the long-term trend. We observe a marked reduction in long-term investment trend in all countries. It has fallen to remarkable low levels in France, Germany, Japan, Belgium and the Netherlands and less so in the USA, UK, Ireland, Spain and Portugal. The cyclical variations around the trend oscillate with a margin of plus/minus 10%. For the sake of this paper, we are not interested in the explanation of the trend, but in the long-term effects of the short-term cyclical variations. The long-term effects on the investment rate will depend on a number of other factors, which we do not discuss in this paper, notable, the role of fiscal policy and public investment or globalisation (see Collignon, 2008 – forthcoming).

**Figure 5. Investment growth**

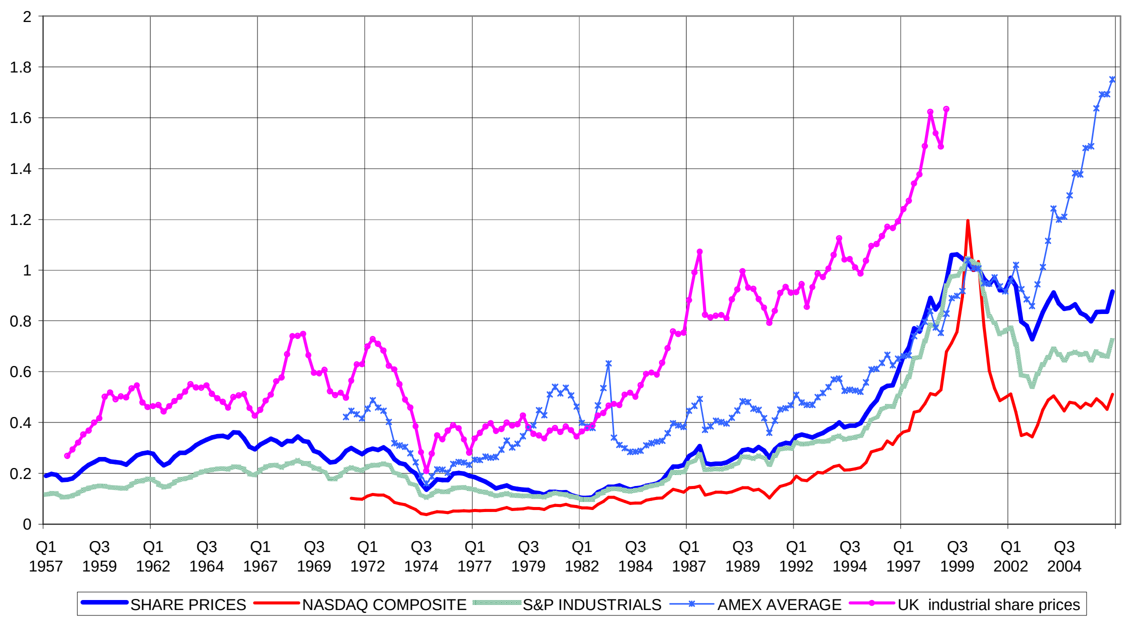



*Tobin's q*

From a theoretical point of view, Tobin's investment function describes the dynamics of investment behaviour as a function of *q* adequately. Empirical work, however, has encountered difficulties since the early 1990s. This may be due to the statistical indicators used in such work. Tobin defined *q* in terms of "the ratio of the market valuations of capital assets to their replacement costs, for example the prices of existing houses relative to costs of building comparable new ones. For corporate business the market valuations are made in the securities markets" (Tobin, 1986). Subsequently many researchers used the ratio of a country's stock exchange to the producer price index as an indicator for

Tobin's *q*. Figure 6 gives the example of a number of US as well as the UK industrial share price indeces.[30]

**Figure 6. Share price index deflated by producer prices: USA and UK**




It is immediately obvious and confirmed by formal unit root tests that these indicators are not stationary, contrary to what *q*-theory would lead us to expect. Especially in the early 1990 a rapid acceleration occurs, which has made these indicators useless as a proxy for Tobin's *q*. The reason is probably that economic liberalisation and globalisation have benefited large publicly quoted companies in the tradable sector, while small businesses especially in the non-tradable sector are lacking behind, so that a deflated share price index would be a distorted proxy for Tobin's *q*. I therefore propose to derive empirical indicators for Tobin's *q* from equation (6), using the AMECO data base for macroeconomic variables. Our formula is:

$q = \frac{P(1-\sigma_w)}{(i+\delta)P_k K/Y}$, where $P$ stands for the GDP deflator, $\sigma_w$ for the wage share, $i$ for nominal short-term interest rates, $\delta$ for the depreciation rate, $P_k$ the price deflator for gross fixed capital formation and $K/Y$ the capital-output ratio or the inverse of capital productivity. Hence $q$ is the ratio of profits per output to the cost of capital per output. Figure 7 shows the results.

[30] Source: IMF International Financial Statistics

**Figure 7. Tobin's *q* in some selected OECD countries**[31]


These data seem more consistent with theory. Although they, too, show a clear improvement in entrepreneurial profits after 1992, the rapid growth in entrepreneurial profits at the end of the period now simply appears as a return to levels that prevailed in the early 1960. However, our time series is too short to assume stationarity. We have

[31] Eview's software has transformed small *q* into *Q*.

therefore detrended the series by the Hodrick-Prescott filter and use the trend deviations as the policy proxy, which reflects monetary policy. Note also, that by construction, our measure for *q* is dependant on interest rates. An increase in interest rates lowers *q*. We have calculated our *q* by using short-term nominal rates, as they are under the control of monetary authorities. We will now estimate how such shocks to Tobin's *q* have affected investment and the level of the capital stock.

### *The long-term effects of short-term variation in Tobin's* q

We have argued that if monetary policy can affect Tobin's *q*, it will have a long-term impact on the capital stock, which in return determines the demand for labour and therefore equilibrium unemployment. We will now look at the long-term adjustment process of the capital stock. In the next section we will then analyse short-term adjustment in the labour market.

*The VAR model*

We obtain evidence for long run effects from estimating a Vector Autoregression (VAR) relating transitory shocks from Tobin's *q* to the growth rate of investment. The cumulated effects of such shocks determine the long run evolution of the capital stock and therefore of equilibrium employment. The VAR consists of two variables: *q* and NetRatio (the ratio of net investment to the capital stock). As mentioned, the series were not stationary; we therefore detrended the variables by applying the HP-filter. The VAR can be written as follows:

$$Y_t = A_1 Y_{t-1} + ... + A_q Y_{t-q} + C\zeta_t$$

Where $C$ is a 2×2 upper triangular matrix with diagonal terms equal to unity, and $\zeta_t$ is a 2-dimensional vector of zero-mean, serially uncorrelated shocks with diagonal variance-covariance matrix. This means that *q* responds contemporaneously to shocks in NetRatio, but investment doesn't respond contemporaneously to a shock in *q*. The lag length of the VAR was chosen based on the Likelihood Ratio test. Since the series were detrended with the HP-Filter, their mean is zero, so no constant was used for efficiency purposes.

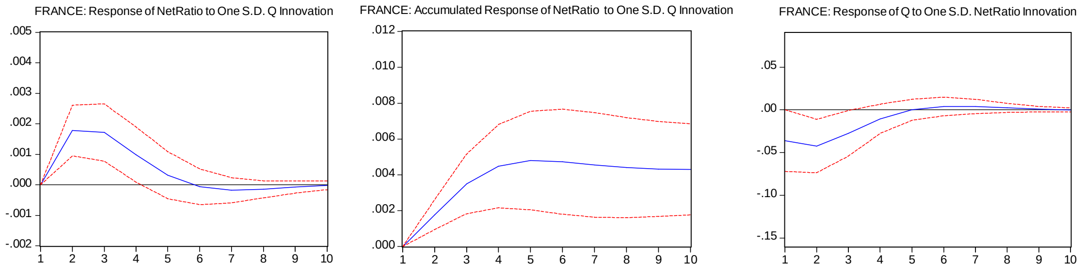
The coefficients of $A_1 \ldots A_q$, C and the variances of each element $\zeta_t$, where estimated using Ordinary Least Squares. All details can be found in the appendix.

*Results*

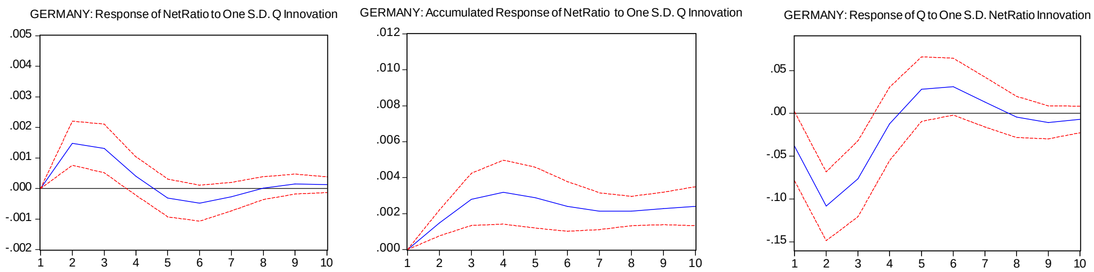
Our objective is to determine the path of NetRatio after a one-standard-deviation shock in *q* and its cumulative effect, as well as the response of *q* after a one-standard-deviation shock in NetRatio. According to our theoretical model, we would expect short-term non-neutrality, but long-term neutrality of *q*-shocks on investment; short-term variations in investment accumulate to long-term changes in the capital stock. As the capital stock increases, extra profits are eliminated and *q* is returning to its equilibrium value. Figure 8 shows the results.

## Figure 8. The Impact of short-term variations of Tobin's q on investment and capital

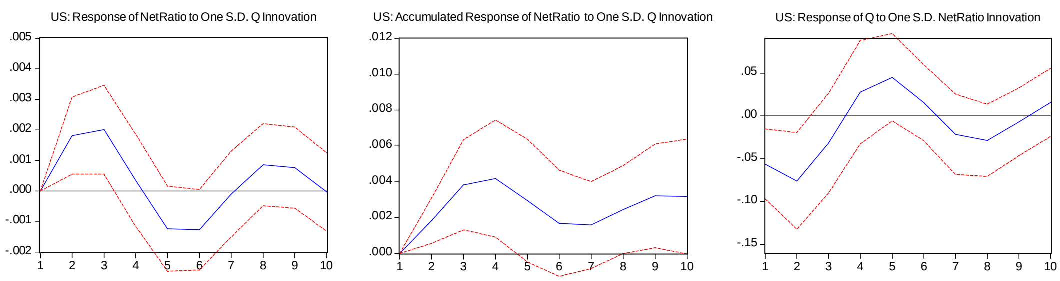
France



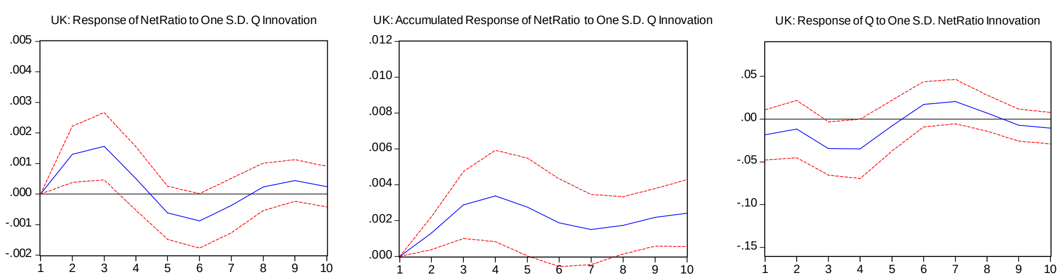

Germany



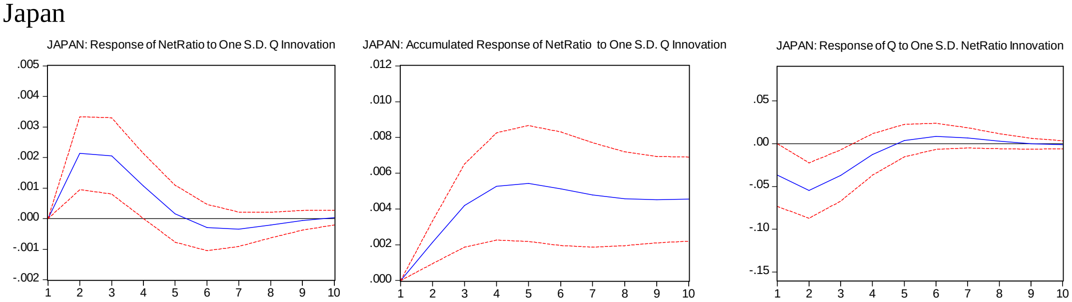

US



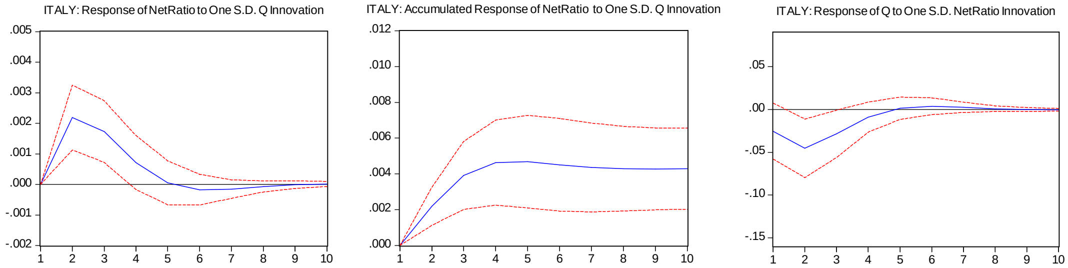

UK



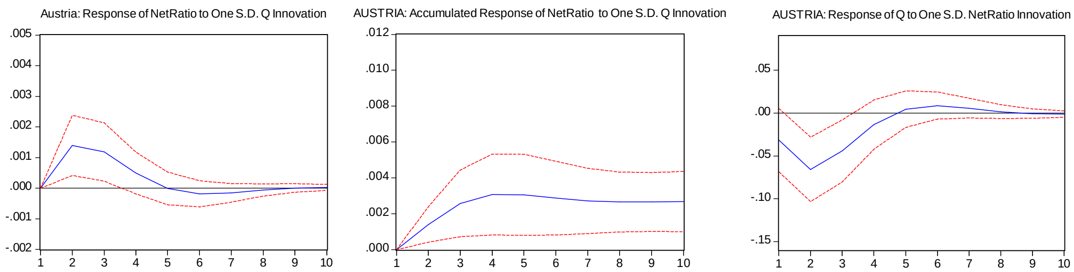

Japan



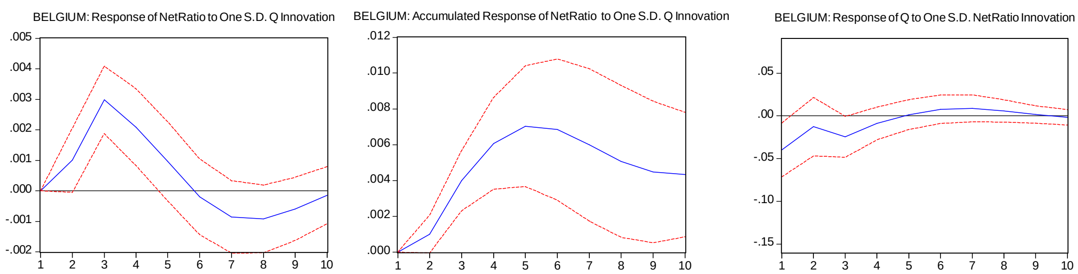
Italy



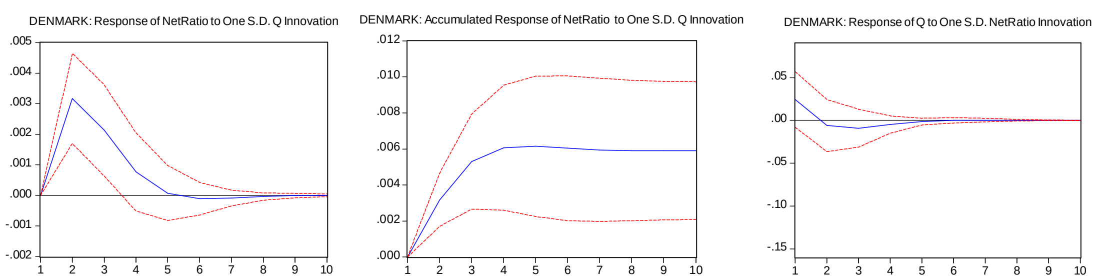

Austria



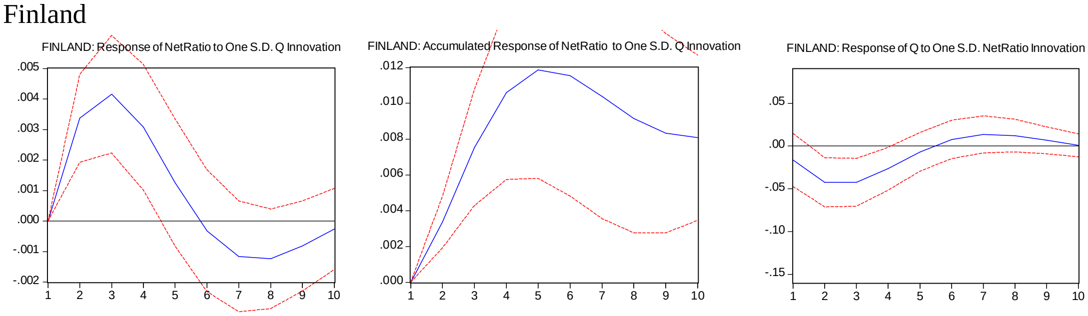

Belgium



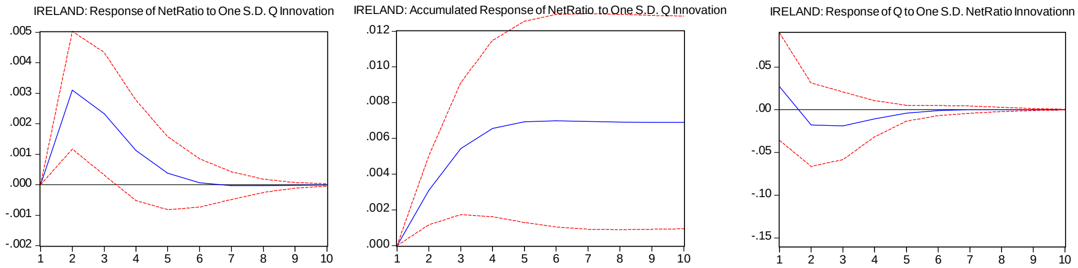

Denmark



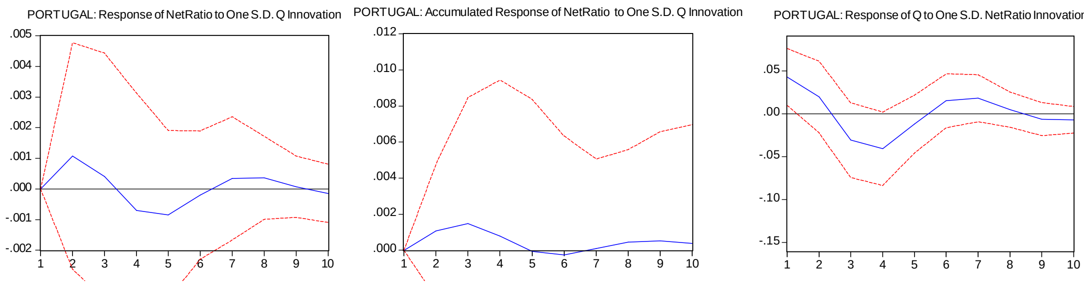

Finland



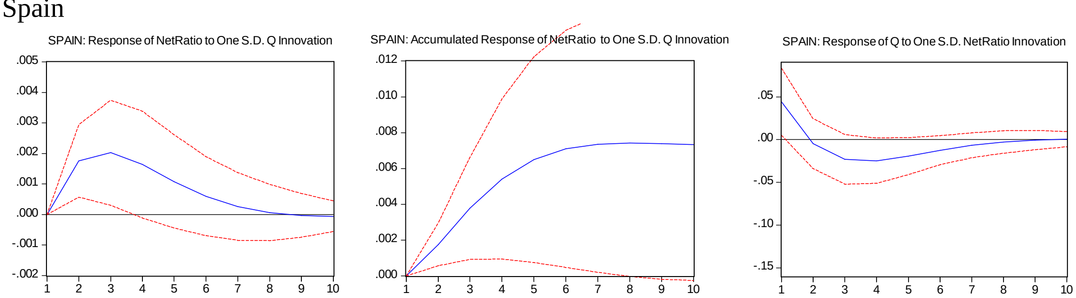
Ireland



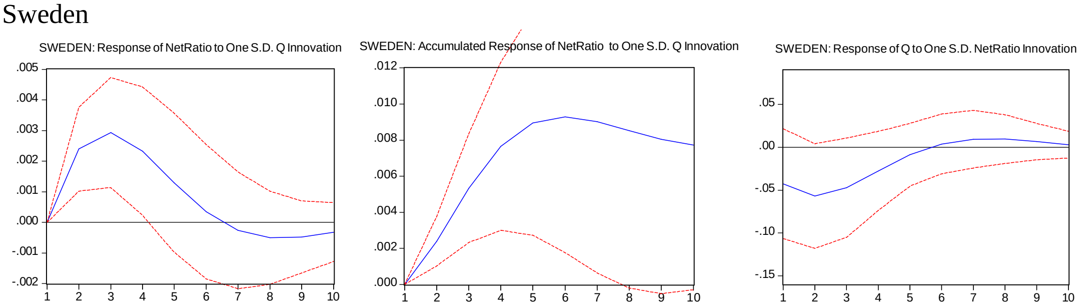

Portugal



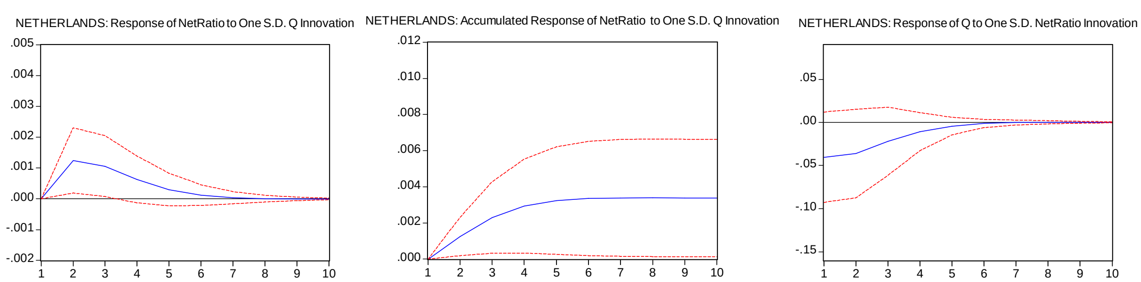

Spain




Sweden




Netherlands




These results show a remarkable similarity across countries. An initial shock of $q$ has a tendency to peter out after 4 to 6 years and its effect on investment after 5 to 7 years, but the cumulative effect on the capital stock is in all cases positive. The only exception is Portugal, where the results cannot be judged as significant. In most countries the effect of a positive shock of one standard deviation of $q$ will raise the aggregate capital stock by about one half of a percentage point. Therefore monetary policy will have long-term consequences for employment, even if its effect on investment is only transitory.

### *Estimating the modified Phillips curve*

We will now discuss short-term Phillips curve dynamics. We are interested to find out how employment will respond to a change in the targeted mark up. There are two mechanisms of adjustment. In the long run, the Phillips curve will shift horizontally with the capital stock; in the short run movements can take place along the Phillips curve. One explanation may be economic uncertainty. For example, if interest rate variations are volatile, the profit shares to be targeted by price setters are uncertain and investment may not respond strongly (Dixit and Pindyck, 1994). However, firms may still need to adjust employment to the changed profit environment in order to service their debt.

*The ARMA model*

In order to find the short run movements on the Phillips curve, we estimate the following ARMA($p$,$q$) model:

$$d \ln L_t = a_0 + a_1 d \ln Invest_t + a_2 ds_t + u_t$$

$$u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + ... + \rho_p u_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + ... + \theta_q \varepsilon_{t-q}$$

Where *ln* stands for a log variable, *d* is the first difference of the time variable, *L* is employment, s is the log of the profit share and *Inves*t is gross investment. We regress the growth rate of employment on the rate of investment growth and the percentage rate of change of the profit share. We take employment growth as a proxy for excess demand for labour, which is justified by introducing the constant $a_0$, We also use the growth rate of investment, rather than the capital stock, as the latter is a *I(2)* time series. Testing for unit roots confirmed that all variables are stationary.[32] The coefficient $a_2$ in our regression is a measure of the inverse of the slope of the modified Phillips curve.

*The results*

The AR(*p*) is the autoregressive term in the unconditional residual, MA(*q*) is its moving average representation. In order to establish the true structure of the residuals in the ARMA(*p*,*q*) process, we first OLS-regressed the employment growth rate on the two explanatory variables without lags and then tested the residuals for stationarity and white noise for each of the 14 countries. After this preliminary work we determined the possible ARMA form of the residuals using the autocorrelograms (normal for *q*, partial for *p*), and then checked for the significance of the higher order coefficients of the ARMA estimation. At last, we regress the growth rate of employment on the rate of investment growth and the percentage rate of change of the profit share constraining the residual to the predetermined ARMA(p,q).[33] This regression yielded the coefficients reported in Table 2.

[32] For the regressions in Table 2, we used the up-dated annual time series 1960-2008 from AMECO, published in December 2006, which include forecasts until 2008.

[33] When the residual were of an AR(p) form only, we used the maximum likelihood estimation with SAS software; We used least square iterative method of Eviews in the other cases.

**Table 2. Phillips curve estimates**

| | constant | Δc: profit share growth | investment growth rate | Constrained residual structure |
|---|---|---|---|---|
| **Denmark** | 0.0003 | -0.099 | 0.106 | AR(15) |
| *s.e.[p-value]* | *0.001* | *0.055 [0.08]** | *0.014**** | *only AR15 non zero coeff* |
| **Germany** | 0.002 | -0.165 | 0.103 | AR(1) |
| *s.e.[p-value]* | *0.002* | *0.065[0.0149]*** | *0,021**** | |
| **Spain** | 0.001 | -0.09 | -0.024 | ARMA(1,4) |
| *s.e.[p-value]* | *0.007** | *0,015[0.00001]**** | *0.01* | *only AR1,MA1,MA4 non zero coeff* |
| **France** | 0.003 | -0.139 | 0.085 | 0.065(15,15) |
| *s.e.[p-value]* | *0.0009**** | *0.059[0.059]** | *0.013**** | *only AR1, AR15, MA15, MA16 non-zero* |
| **Ireland** | 0.008 | -0.116 | 0.115 | AR(1) |
| *s.e.[p-value]* | *0.003*** | *0,066 [0.088]** | *0,031**** | |
| **Italy** | 0.007 | -0.107 | 0.076 | ARMA(1,2) |
| *s.e.[p-value]* | *0.001**** | *0.058[0.072]** | *0,025*** | |
| **Netherland** | 0.01 | -0.099 | 0.091 | AR(1) |
| *s.e.[p-value]* | *0.003**** | *0,007[0.177]* | *0,028**** | |
| **Austria** | 0.002 | -0.053 | 0.051 | AR(1) |
| *s.e.[p-value]* | *0.002* | *0.021[0.014]*** | *0,014**** | |
| **Portugal** | 0.0007 | -0.052 | 0.051 | AR(3) |
| *s.e.[p-value]* | *0.0002* | *0.017[0.004]**** | *0,014**** | |
| **Finland** | -0.0004 | -0.049 | 0.092 | AR(1) |
| *s.e.[p-value]* | *0.002* | *0.041[0.24]* | *0,02** | |
| **Sweden** | 0.002 | -0.106 | 0.092 | AR(14) |
| *s.e.[p-value]* | *0.001* | *0.05[0.044]*** | *0,02**** | |
| **UK** | 0.001 | -0.136 | 0.093 | AR(1) |
| *s.e.[p-value]* | *0.002* | *0.047[0.005]**** | *0.022**** | |
| **USA** | 0.011 | -0.259 | 0.140 | AR(1) |
| *s.e.[p-value]* | *0.002**** | *0.059[<0.0001]**** | *0.015**** | |
| **Japan** | 0.0003 | -0.049 | 0.084 | AR(1) |
| *s.e.[p-value]* | *0.0002* | *0,025[0.059]** | *0,019**** | |

For the confidence intervals: * between 5 and 10%; ** between 1 and 5%; *** less than 1 %.

The results are consistent with our theoretical model. All coefficients have the right sign, with the exception of investment in Spain which is also statistically insignificant. The responsiveness of employment to changes in the profit share is negative and statistically significant in all cases except Finland. It is highest in the USA (our modified Phillips curve is flat) and rather large in Germany, France and UK; it is small (the modified Phillips curve is steep) in Austria, Portugal, Finland and Japan. Thus, short-term monetary shocks are likely to have larger effects on disequilibrium unemployment in the bigger OECD countries (except Japan). In a typical country like Italy or the Netherlands, a 10 % increase in the required profit share would lower the growth rate of employment by 1 percentage-point, thereby wiping out the autonomous growth of investment. Similarly, a reduction in the growth rate of investment by one percentage-point would also cause stagnation in employment. These are non-trivial numbers. Of course, once the transitory effects have ceased, autonomous growth resumes, but from a lower equilibrium level of employment and permanently increased equilibrium unemployment. On the other hand, a sequence of interest rate cuts will have the opposite effect, raising the capital stock and lower the NAIRU.

## Conclusion

This paper has argued that the validity of long-term neutrality of money hypothesis required that real interest rates are stationary. Empirically this seems to be only the case over very long time periods. Over the span of several decades, monetary policy can be non-neutral. The mechanism through which the setting of interest rates affects real economic variables such as output and employment is Tobin's investment function, which models entrepreneurial profits as a function of short-term real interest rates. We provided empirical evidence from several OECD countries that showed that the long-term effect of an interest rate induced increase in the ratio of the return on capital to the cost of capital will permanently increase the stock of capital and therefore output and employment. Short-term disequilibrium unemployment depends on Phillips curve dynamics and seems to be larger in the big OECD countries outside Japan.

These results should stimulate further research. In particular, given that the empirical estimates are based on annual data, it would be interesting to test the long-term neutrality hypothesis of money with higher frequency data.

28.2.2007

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# Appendix

## *Data*

Annual data, from 15 countries, were taken from the European Commission's AMECO data base. The time period is between 1960 and 2004, though for some countries the first observations are unavailable. The variables used are in the following table:

| Name | Title | Code | Units |
|---|---|---|---|
| GDP Deflator *(P)* | Price deflator gross domestic product at market prices | PVGD | (National currency: 1995 = 100) |
| Capital Deflator $(P^k)$ | Price deflator gross fixed capital formation: total economy | PIGT | (National currency: 1995 = 100) |
| GDP *(PY)* | Gross domestic product at current market prices | UVGD | (National Currency) |
| Investment $(P^kI)$ | Gross capital formation at current prices: total economy | UITT | (National Currency) |
| Capital Consumption $(P^kK^d)$ | Capital consumption at current prices: total economy | UKCT | (National Currency) |
| Capital Productivity *(Y/K)* | GDP at constant market prices per unit of net capital stock, total economy | AVGDK | Gross domestic product at 1995 market prices per unit of net capital stock (National Currency) |
| Interest Rates *(i)* | Nominal short-term interest rates | ISN | In percentage points |
| Real interest rates *(r)* | Real short-term interest rates, deflator GDP | ISRV | In percentage points |
| Wage Share *(w)* | Adjusted wage share: total economy | ALCD0 | As percentage of GDP at current market prices |
| Employment | Employment, persons: total economy | OITT | 1000 persons |

## *VAR*

| France | | |
|---|---|---|
| N. of obs. | | 44 |
| N. Lags | | 1 |
| $R^2$ | Q | 0.26 |
| | NetRatio | 0.52 |
| | Lag Order | p-value |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* |
| | 2 | 0.063 |
| | 3 | 0.129 |
| | 4 | 0.066 |
| VAR Residual Serial Correlation LM Tests | 1 | 0.165 |
| | 2 | 0.189 |
| | 3 | 0.363 |
| | 4 | 0.117 |

| Germany | | | |
|---|---|---|---|
| N. of obs. | | 44 | |
| N. Lags | | 1 | |
| $R^2$ | Q | 0.59 | |
| | NetRatio | 0.46 | |
| | Lag Order | p-value | |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* | |
| | 2 | 0.015 | * |
| | 3 | 0.085 | |
| | 4 | 0.104 | |
| VAR Residual Serial Correlation LM Tests | 1 | 0.519 | |
| | 2 | 0.008 | * |
| | 3 | 0.777 | |
| | 4 | 0.377 | |

| United States | | |
|---|---|---|
| N. of obs. | | 40 |
| N. Lags | | 2 |
| $R^2$ | Q | 0.58 |
| | NetRatio | 0.44 |
| | Lag Order | p-value |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* |
| | 2 | NA* |
| | 3 | 0.260 |
| | 4 | 0.108 |
| VAR Residual Serial Correlation LM Tests | 1 | 0.502 |
| | 2 | 0.173 |
| | 3 | 0.757 |
| | 4 | 0.078 |

| United Kingdom | | | |
|---|---|---|---|
| N. of obs. | | 40 | |
| N. Lags | | 2 | |
| $R^2$ | Q | 0.58 | |
| | NetRatio | 0.58 | |
| | Lag Order | p-value | |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* | |
| | 2 | NA* | |
| | 3 | 0.487 | |
| | 4 | 0.116 | |
| VAR Residual Serial Correlation LM Tests | 1 | 0.972 | |
| | 2 | 0.363 | |
| | 3 | 0.969 | |
| | 4 | 0.048 | * |

| Japan | | | |
|---|---|---|---|
| N. of obs. | | 32 | |
| N. Lags | | 1 | |
| $R^2$ | Q | 0.47 | |
| | NetRatio | 0.51 | |
| | Lag Order | p-value | |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* | |
| | 2 | 0.023 | * |
| | 3 | 0.069 | |
| | 4 | 0.224 | |
| VAR Residual Serial Correlation LM Tests | 1 | 0.037 | * |
| | 2 | 0.039 | * |
| | 3 | 0.531 | |
| | 4 | 0.941 | |

| Italy | | | |
|---|---|---|---|
| N. of obs. | | 44 | |
| N. Lags | | 1 | |
| $R^2$ | Q | 0.36 | |
| | NetRatio | 0.39 | |
| | Lag Order | p-value | |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* | |
| | 2 | 0.172 | |
| | 3 | 0.095 | |
| | 4 | 0.132 | |
| VAR Residual Serial Correlation LM Tests | 1 | 0.239 | |
| | 2 | 0.230 | |
| | 3 | 0.136 | |
| | 4 | 0.375 | |

| Austria | | | |
|---|---|---|---|
| N. of obs. | | 37 | |
| N. Lags | | 1 | |
| $R^2$ | Q | 0.41 | |
| | NetRatio | 0.33 | |
| | Lag Order | p-value | |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* | |
| | 2 | 0.278 | |
| | 3 | 0.686 | |
| | 4 | 0.855 | |
| VAR Residual Serial Correlation LM Tests | 1 | 0.744 | |
| | 2 | 0.218 | |
| | 3 | 0.974 | |
| | 4 | 0.898 | |

| Belgium | | | |
|---|---|---|---|
| N. of obs. | | 42 | |
| N. Lags | | 2 | |
| $R^2$ | Q | 0.44 | |
| | NetRatio | 0.62 | |
| | Lag Order | p-value | |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* | |
| | 2 | NA* | |
| | 3 | 0.357 | |
| | 4 | 0.508 | |
| VAR Residual Serial Correlation LM Tests | 1 | 0.687 | |
| | 2 | 0.756 | |
| | 3 | 0.683 | |
| | 4 | 0.505 | |

| Denmark | | | |
|---|---|---|---|
| N. of obs. | | 41 | |
| N. Lags | | 1 | |
| $R^2$ | Q | 0.24 | |
| | NetRatio | 0.48 | |
| | Lag Order | p-value | |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* | |
| | 2 | 0.223 | |
| | 3 | 0.519 | |
| | 4 | 0.071 | |
| VAR Residual Serial Correlation LM Tests | 1 | 0.669 | |
| | 2 | 0.156 | |
| | 3 | 0.858 | |
| | 4 | 0.014 | * |

| Finland | | | |
|---|---|---|---|
| N. of obs. | | 34 | |
| N. Lags | | 1 | |
| $R^2$ | Q | 0.57 | |
| | NetRatio | 0.69 | |
| | Lag Order | p-value | |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* | |
| | 2 | 0.038 | * |
| | 3 | 0.092 | |
| | 4 | 0.090 | |
| VAR Residual Serial Correlation LM Tests | 1 | 0.310 | |
| | 2 | 0.095 | |
| | 3 | 0.528 | |
| | 4 | 0.218 | |

| Ireland | | | |
|---|---|---|---|
| N. of obs. | | 31 | |
| N. Lags | | 1 | |
| $R^2$ | Q | 0.08 | |
| | NetRatio | 0.51 | |
| | Lag Order | p-value | |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* | |
| | 2 | 0.094 | |
| | 3 | 0.263 | |
| | 4 | 0.304 | |
| VAR Residual Serial Correlation LM Tests | 1 | 0.098 | |
| | 2 | 0.256 | |
| | 3 | 0.771 | |
| | 4 | 0.496 | |

| Portugal | | | |
|---|---|---|---|
| N. of obs. | | 37 | |
| N. Lags | | 2 | |
| $R^2$ | Q | 0.48 | |
| | NetRatio | 0.27 | |
| | Lag Order | p-value | |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* | |
| | 2 | NA* | |
| | 3 | 0.419 | |
| | 4 | 0.485 | |
| VAR Residual Serial Correlation LM Tests | 1 | 0.677 | |
| | 2 | 0.210 | |
| | 3 | 0.969 | |
| | 4 | 0.501 | |

| Spain | | |
|---|---|---|
| N. of obs. | | 27 |
| N. Lags | | 1 |
| $R^2$ | Q | 0.24 |
| | NetRatio | 0.74 |
| | Lag Order | p-value |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* |
| | 2 | 0.104 |
| | 3 | 0.221 |
| | 4 | 0.302 |
| VAR Residual Serial Correlation LM Tests | 1 | 0.583 |
| | 2 | 0.221 |
| | 3 | 0.651 |
| | 4 | 0.574 |

| Sweden | | |
|---|---|---|
| N. of obs. | | 20 |
| N. Lags | | 1 |
| $R^2$ | Q | 0.44 |
| | NetRatio | 0.68 |
| | Lag Order | p-value |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* |
| | 2 | 0.178 |
| | 3 | 0.366 |
| | 4 | 0.313 |
| VAR Residual Serial Correlation LM Tests | 1 | 0.267 |
| | 2 | 0.646 |
| | 3 | 0.755 |
| | 4 | 0.104 |

| Netherlands | | |
|---|---|---|
| N. of obs. | | 44 |
| N. Lags | | 1 |
| $R^2$ | Q | 0.17 |
| | NetRatio | 0.29 |
| | Lag Order | p-value |
| VAR Residual Portmanteau Tests for Autocorrelations | 1 | NA* |
| | 2 | 0.326 |
| | 3 | 0.463 |
| | 4 | 0.143 |
| VAR Residual Serial Correlation LM Tests | 1 | 0.242 |
| | 2 | 0.499 |
| | 3 | 0.599 |
| | 4 | 0.054 |