Economics
The Open-Access, Open-Assessment E-Journal

Discussion Paper
No. 2008-33 | November 4, 2008 | http://www.economics-ejournal.org/economics/discussionpapers/2008-33

The "Credit–Cost Channel" of Monetary Policy. A Theoretical Assessment

Roberto Tamborini

University of Trento

Please cite the corresponding journal article:
http://www.economics-ejournal.org/economics/journalarticles/2009-13

Abstract

Current macro-models based on the demand-side effects of monetary policy and sticky prices account for the observed correlations between policy interest rates, output and inflation, but they fail with regard to other empirical regularities, such as the negative effects of policy shocks on real wages and profits. Moreover, the lack in these models of an explicit role of the credit market in the transmission mechanism is now regarded as a major limitation. Drawing on the modern literature on the monetary transmission mechanisms with capital market imperfections, this paper presents a model of the "credit-cost channel" of monetary policy. The thrust of the model is that firms' reliance on bank loans ("credit channel") may make aggregate supply sensitive to bank interest rates ("cost channel"), which are in turn driven by the official rate controlled by the central bank. The model is assessed theoretically by examining whether, and under what conditions, changes in the policy interest rate produce the whole pattern of the observed relationships, with no recourse to non-competitive hypotheses and frictions. This result is obtained for parameter values in the range of available consensus estimates, with a caveat concerning labour-supply elasticity to the real wage rate.

JEL: E51, C32

Keywords: Macroeconomics and monetary economics; monetary transmission mechanisms; credit channel; cost channel

Correspondence: *Roberto Tamborini, University of Trento, Department of Economics, Via Inama 5, 38100 Trento, Italy; e-mail: roberto.tamborini@economia.unitn.it*

1. Introduction

It is now widely held that "monetary policy matters", in the sense that policy interventions (mainly activated by changes in administered rates and money-market rates) are typically followed by

- quick and large responses in short-term interest rates, monetary aggregates, total credit
- sizeable and persistent effects on different measures of real economic activity: real wages and profits, employment and output
- slow and delayed adjustments of price indexes.

Still controversial is the search for explanations of the impact of monetary policy on economic activity, and in particular for an explanation encompassing the *whole* set of stylized facts recalled above. Current macro-models based on the demand-side effects of interest-rate based monetary policy and sticky prices (e.g. dynamic stochastic general equilibrium models of the "New Keynesian" type) have proved able to account for the observed correlations between policy interest rates, output and inflation, but they fail with regard to the other empirical regularities, such as the *negative* effects of policy shocks on real wages and profits. Indeed, sticky goods prices combined with the traditional demand-side effects of monetary policy typically entail the well-known counterfactual effect that competitive real wages and profits are positively correlated with the policy interest rate (e.g. Christiano et al. (1997)). Moreover, the credit market and the related variables are no longer explicited in these models (as a consequence of the assumption of perfect capital markets). This is now regarded as a major limitation of the current theoretical framework for monetary policy (e.g. Crockett (2003), Christiano et al. (2007), Goodfriend and McCallum (2007)).

There are at least two strands of lively literature that may help address these neglected issues. First of all, the so-called *credit channel* of monetary policy. This is a long-standing view of the monetary transmission mechanism that has been revived (by earlier "New Keyensians") upon framing monetary policy in the context of imperfect capital markets (e.g. Blinder and Stiglitz (1983), Greenwald and Stiglitz (1988, 1993a), Bernanke and Blinder (1992), Bernanke and Gertler (1995)). What is relevant to this approach is that monetary policy first and foremost affects the supply of credit and bank lending rates. The credit channel may be activated by the central bank's quantity management (changes in bank reserves) as well as by interest-rate management (changes in interbank rates). This channel helps explain the large impact that monetary interventions are observed to exert on private expenditure by way of capital market imperfections, notably asymmetric information generating agency problems between the firm and its external financial suppliers. Bank credit has no perfect substitutes at the market interest rate. In line with a large body of evidence, bank credit is the first, or exclusive, choice among external sources, most likely for small firms with poor internal accumulation and with limited access to open markets (e.g. Kashyap et al. (1993, 1994), Gertler and Gilchrist (1993, 1994)). So far, however, the credit channel has been framed within the traditional demand-side effects of monetary policy, which require sticky prices as a *sine qua non* condition for monetary policy to have real effects.

Another research paths follows the theoretical argument that limiting the link between monetary policy and economic activity to aggregate-demand effects is an over-simplification of microeconomic relationships. There are, in fact, several possible links with aggregate supply as well. In the first place, besides fixed capital, also working capital may need financial resources, as current inputs should be paid before output can be sold, and these resources (liquidity, inventories, credit, etc.) carry a financial cost. Consequently, the interest rate paid on working capital affects production costs – a view largely shared by businessmen (e.g. Goodhart (1986)). Monetary policy, by altering interest rates, can influence aggregate supply. Christiano et al. (1997, 2005) Barth and Ramey (2001), Ravenna and Walsh (2003, 2006), Chowdhury et al. (2006) testify to the growing interest in this further *cost channel* of monetary policy and provide evidence of its importance for monetary transmission[1].

---

[1]The cost channel of monetary policy, too, has notable antecedents. As is well known, Keynes prior to the *General Theory* envisaged a theory of production based on firms' access to liquid means of payment of inputs (1933), and later (1937) he added firms' "finance motive" to the aggregate demand for money. Subsequent developments have led to "money-in-the-production-function" models (e.g. Simos (1981)), either by inserting money balances in the production function as a complementary factor or by adding a separable monetary counterpart of (or constraint on) demand for specific inputs (e.g. Vickers (1981), Mitchell (1984), Ramey (1989)). This latter approach is also common to production theories where firms' demand for money arises from the time mismatch between purchases of inputs and sales of output (e.g. Hicks (1973), Farmer (1984), Amendola and Gaffard (1998)).

The supply-side effects of monetary policy have several interesting implications. First of all, they help explain the empirical regularity that real wages and profits are *negatively* correlated with policy interest rates. If, say, a monetary restriction raises firms' variable costs and/or forces them to cut production, then, for a given monetary wage, prices may well increase and real wages fall (Blinder (1987), Barth and Ramey (2001)). Alternatively, firms may respond by cutting back labour demand, thus forcing real wages to fall directly (Greenwald and Stiglitz (1988, 1993a), Christiano and Eichenbaum (1992), Christiano et al. (1997)).

Second, these effects call into question the general presumption that monetary policy can only affect real economic activity as a consequence of sticky prices. As stressed by Greenwald and Stiglitz (1993b) co-movements of demand and supply after a monetary shock can provide a straightforward explanation for the observed pattern of large adjustments in quantities and small ones in prices even in competitive markets with flexible prices. This explanation also impinges upon the approach to monetary policy. Feedback rules which concentrate on inflation and ignore the supply-side effects of the rule itself may be misleading in that the actual expansion (contraction) of economic activity is barely translated into inflation signals to the central bank (Borio and Loewe (2003), Leijonhufvud (2008)). On the other hand, co-movements of demand and supply in a general-equilibrium framework offer the appropriate key to establish whether the so-called "price puzzle" (Sims (1992)) – the inflationary effect of a monetary restriction – occurs or not.

Third, Ravenna and Walsh (2006) have explored the optimal policy implications of the presence of the cost channel. Their main point is that this channel revives the key output-inflation trade-offs that are notably absent from the now standard "New Keynesian" framework, and that may modify the policy problem in important ways.

Finally, it is typical in the models cited above that, one way or another, the *equilibrium* level of output (employment) comes to depend on the policy interest rate as an element of firms' real unit cost along with the wage rate (and possibly other input prices). Hence, it can no longer be taken for granted that monetary policy interventions (transmitted through the interest rate) are bound to generate mere transitory effects around, with no permanent impact on, potential output, the natural rate of unemployment, etc. (Greenwald and Stiglitz (1993a)).

The aim of this paper is to contribute to the analysis of the effects of interest-rate based monetary policy by means of a theoretical model that blends the credit and cost channels of monetary policy into a single, integrated "credit-cost channel" (CCC). As seen above, various macroeconomic models have recently been produced which include the credit channel of monetary policy, but with no link with the supply side of the economy, and others which link monetary policy to aggregate supply via the interest rate firms pay on working capital, but with no explicit consideration or explanation of the role of the banking system as lender to firms[2]. The thrust of the CCC model is that firms' reliance on bank loans (credit channel) may make aggregate supply sensitive to bank interest rates (cost channel), which are in turn driven by the official rate controlled by the central bank plus a credit risk premium charged by banks on firms. A related feature of the model is that both aggregate demand and supply are affected by monetary policy.

The CCC integration may provide both consistency and insight. Indeed, for the interest rate to be consistently treated as a production extra cost, firms should be forced to resort to external sources and pay a premium on them[3]. The capital market imperfections underlying the credit-channel literature provide a consistent framework for this fact as well as for the important role of bank credit in the production process. Moreover, the transmission from policy rates to bank rates is tight and well documented, whereas the transmission to open-market long-term rates is notoriously problematic. Thus the credit channel may be expected to act as amplifier of the supply-side impact of monetary policy[4]. Finally, credit brings with itself

---

[2] Earlier models of the cost channel, in particular those within a partial equilibrium approach at the industry level, treated the interest rate as an exogenous variable in the cost function of firms. In a general equilibrium, framework.

[3]Otherwise, in a perfect capital market firms would obtain all the liquidity they need from owners at the market rental rate (see e.g. Holmstroem and Tirole (1998)). For instance, Christiano et al. (1997) and Ravenna and Walsh (2006) present cost-channel models where financially unconstrained firms borrow from unspecified intermediaries. The resort of firms to these intermediaries instead of direct funding from households who own them is not explained.

[4] A drawback of the Christiano et al (2007) model is that the loan market is affected by quantity monetary shocks. To obtain a large impact of the monetary shock on bank loans the model introduces the so-called "liquidity effect" due to the "limited participation" assumption (that is, households cannot re-adjust their bank

the key dimensions of time and risk which are usually not present in the cost-channel models. In fact, firms borrow to finance inputs that they buy on the basis of forecasts of future product market conditions that may or may not occur, so that firms and their banks face an intrinsic default risk that plays a crucial role for both the transmission mechanism and the macroeconomic outcomes[5]. Overall the joint consideration of the credit and cost channels may overcome the weaknesses of the two separate approaches.

Before taking the model to the data abruptly (a deprecable, albeit diffuse, malpractice) this paper focuses on the preliminary "test" whether, and under what conditions, the CCC model is able to reproduce (explain) the *whole* set of phenomena that are currently regarded as the stylized facts of monetary policy. The same approach has been followed by Christiano et al. (1997) (CEE henceforth) with their flex-price model of the cost channel, where monetary policy works through the "limited participation" mechanism, and firms operate under monopolistic competition. This model yields the whole set of phenomena of interest for parameter values in line with consensus estimates, except for a relatively large labour-supply elasticity. On the other hand, the CCC model differs from that of CEE in some important elements discussed above providing a richer and more articulated structure that governs the phenomena of interest[6]. Hence the CEE model can be regarded as a benchmark against which the alternative structure put forward in the CCC model can be assessed.

To this effect, the paper follows the same method as CEE. That is to say, section 2 introduces a flex-price, competitive general equilibrium model with the CCC of monetary policy. It is built upon the key common features of models in this literature, that is, 1) production takes time, 2) firms should hire factors (labour) before output is produced and sold, hence 3) they should finance production (working capital) in advance under uncertainty. In order to integrate the credit and the cost channels into a consistent framework, I

---

deposits after a monetary shock). Leaving considerations on the weakness of this assumption aside (see e.g. Walsh (2003) ch.5), the credit channel is a simpler and more natural link between monetary policy, credit market and firms.

[5] Christiano et al. (1997), Barth and Ramey (2001), Chowdhury et al. (2006), Ravenna and Walsh (2006) all have riskless firms in that they borrow upon observing the current product market conditions (as if production and credit were timeless).

[6] The differences with the CEE model can be seen through fn. 3 and 4

have drawn on Greenwald and Stiglitz (1988, 1993a) (GS henceforth) where the single market imperfection is asymmetric information in the capital market, and firms are constrained to borrowing working capital from banks only. As a result, firms and banks face credit default risk. To this benchmark I have added explicit microfoundations of households' behaviour, and of the banks-central-bank relationship. To aim at a higher level of generality, no specific functional forms have been posited.

Then section 3 is devoted to discussion of the parametric conditions that govern the equilibrium responses of the endogenous variables of interest to exogenous changes in the policy interest rate. Following CEE and GS, the focus is on comparing the rational-equilibrium states of the economy, that is, when all the transitory adjustments have taken place. Considering the consensus estimates of the relevant (six) parameters, it is possible to establish whether the model is consistent with the above-mentioned set of outcomes. The conclusion is affirmative, confirming that the CCC improves the theoretical framework for monetary policy analysis. As in CEE, an important role is played by the extent of labour-supply elasticity; however the larger set of parameters and their interactions highlighted by the CCC model allows to qualify this requirement in that the magnitude of the labour-supply elasticity should be gauged in relation with the parameters regulating the forward-looking behaviour of households, which are not present in the CEE model.

Section 4 adds a short note on the policy implications, mainly in view of further developments. Section 5 provides a summary of results and conclusions.

2. A model the "credit-cost channel" of monetary policy

2.1. The economy

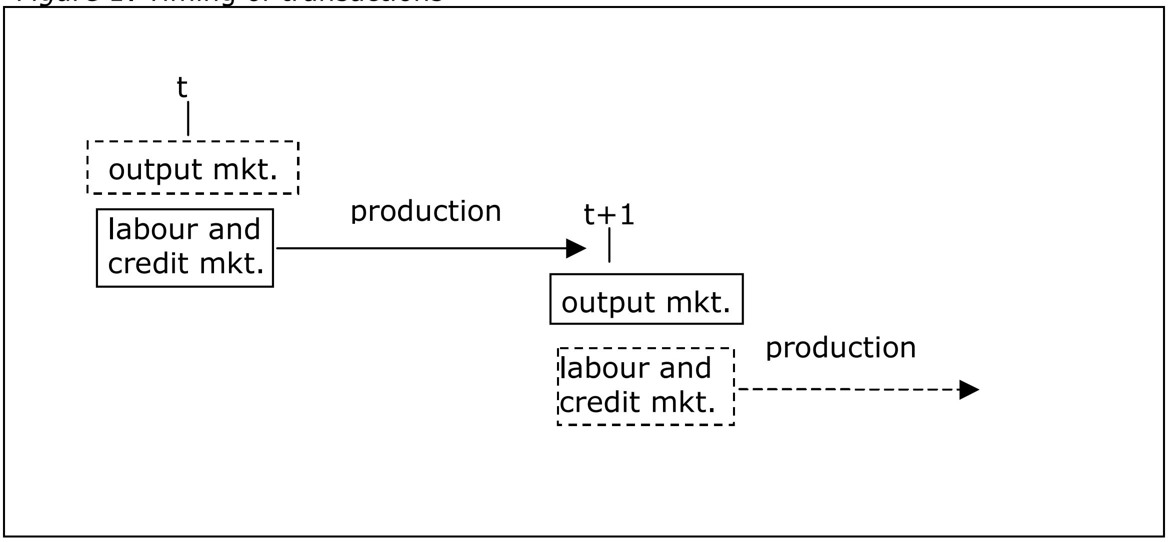
- The economy consists of three competitive markets, for labour (the single input of production), for credit, and for final consumption (the single output of production); there are three representative classes of agents, households, firms and banks, and a central bank as the single policy authority.
- The economy operates sequentially along discrete time periods indexed by t, t+1, ..., where production takes 1 period of time regardless of the scale of production. Firms can start a new production round only after

"closing accounts" (i.e. the entire output has been sold and all various claimants paid)[7].

- At the beginning of period *t* firms plan production for sale at *t*+1. They face uncertainty about revenue from output sales, and the true realization of revenue is private information of each firm. Firms hire workers in the labour market; in order to pay for the planned labour input they should borrow the wage bill in the credit market. Households are paid their wage bill in the form of bank deposit, and production takes place.
- Banks grant standard debt contracts to firms *vis-à-vis* zero interest deposits from households. They can also insure against credit risk by borrowing reserves from the central bank at a given official rate[8].
- At the beginning of period *t*+1 output is sold for consumption and firms should pay back their loans. Afterwards, a new production round starts.

The sequence of events is reproduced in *Figure 1*.

Figure 1. Timing of transactions



2.2. Firms and banks

The core of the model is firms' bank dependence *à la* GS. First, firms produce under revenue uncertainty. The simple and convenient treatment of

[7] This assumption is not essential, but it avoids undue complications arising from overalpping firms' cash flows and expenditures and allows for more clear-cut firm-bank relationships. GS relax this condition.

[8] To simplify analysis on a non-essenatial point households are not allowed to borrow against future incomes. Thus available deposits act as a cash-in-advance constraint.

revenue uncertainty proposed by GS is that a firm j starts production at time t for sale af t+1, $Q(t)_{t+1}$. Yet the unit revenue (sale price) at time t+1 is a random draw from a probability distribution with density $f(\widetilde{P}_{jt+1})$, cumulative function F, and expected value $E_t(\widetilde{P}_{jt+1}) = P_{t+1}$ for all j, where P_{t+1} will be the actual price index. Second, the economy's description above embeds an ex-post verification problem of firms' lenders about the true state of firms. The true realization of revenue is private information of the firm and can only be observed at a cost. This information asymmetry is sufficient to preclude efficient direct lending by households, and makes it efficient to delegate lending and monitoring to specialized intermediaries, i.e. banks[9]. In this context, banks offer standard debt contracts to firms of the following form[10]. Against a loan L_t, the firm is committed to paying in t+1

- L_tR_t if the solvency state $\widetilde{P}_{jt+1}Q(t)_{t+1} \geq L_tR_t$ is declared
- $\widetilde{P}_{jt+1}Q(t)_{t+1}$ if the default state $\widetilde{P}_{jt+1}Q(t)_{t+1} < L_tR_t$ is declared, with deterministic monitoring

In this setup, let each firm j produce a homogeneous output by means of a common labour technology with decreasing marginal returns and one-period production time,

(1) $$Q(t)_{jt+1} = Q(N_{jt}), \qquad Q'(N_{jt}) > 0,\ Q''(N_{jt}) < 0$$

For any level of labour input N_{jt}, and nominal wage rate W_t, the corresponding wage bill determines the amount of working capital that the firm should finance, $L^d_t = W_tN_{jt}$. Since the debt contract has no bankruptcy costs[11], the stream of future expected profits for any firm j in any period t is the sequence:

$$E_t\{Z_{jt+1}, \ldots, Z_{jt+s}, \ldots.\}$$

with

(2) $$E_tZ_{jt+s} = E_t(\widetilde{P}_{jt+s})Q(t)_{jt+s} - W_{t+s-1}N_{jt+s-1}R_{t+s-1}, \qquad s = 1, \ldots$$

and where, $R_t \equiv (1 + r_t)$ is the gross nominal interest rate charged by banks.

Now let us denote the current real wage rate with $\underline{W}_t \equiv W_t/P_t$, the one-period expected price growth factor (expected inflation for short) with

[9]As shown by Townsend (1979) and Diamond (1984) among others.

[10] Fiorentini and Tamborini (2002) show that in a firm-lender problem like the present one the standard debt contract is the optimal one.

[11] These costs play an important role in the GS models as they bring default risk into the picture; here they are not necessary becaus default risk is introduced through bank's credit supply.

$E_t\Pi_{t+1} \equiv E_t(\widetilde{P}_{jt+1})/P_t = P_{t+1}/P_t \equiv (1 + \pi_{t+1})$, and the gross (expected) real interest rate with $\underline{R}_t \equiv E_t(R_t/\Pi_{t+1})$. Given that the firm can start a new production round only after "closing accounts", the intertemporal profit maximization problem can be split into independent one-period problems. Along the optimal production path the following first order condition for maximum real profit should hold in each period t

$$Q'(N_{jt}) = \Gamma_t \equiv \underline{W}_t \underline{R}_t$$

This condition states that the firm in each period t employs labour up to the point where its marginal product equals its *expected real unit cost* Γ_t, which is the compound real cost of labour and credit. Under standard assumptions concerning the production function, the labour demand function can be written as

(3) $$N^d_{jt} = N^d(\Gamma_t) \qquad N^{d\prime}(\Gamma_t) < 0$$

Output supply is derived from labour demand by means of the production function, i.e.:

(4) $$Q(t)_{jt+1} = Q(N^d(\Gamma_t)) \qquad Q'(N^d) > 0$$

2.3. Households

As a consequence of the missing market for direct firms' financing, we can also assume that firms are self-owned by individual entrepreneurs, who do not distribute profits which they retain for self-consumption. Consequently, households only consist of workers who only earn wages, while market demand for output only comes from workers' consumption.

Households perform three activities: labour supply, output demand and saving. The latter only consists of deposits with banks. At any point in time t, the plan of household h consists of labour supply to be realized in each production period (N_{ht}, N_{ht+1}, …) and of consumption demand to be realized *at the end* of each same production period (C_{ht+1}, C_{ht+2}, …). Remember, also, that consumption has to be realized before the new production starts, labour market transactions take place and the relevant wage bill is paid. Hence note that C_{ht} is constrained by available deposits from the previous period and cannot exceed D_{ht-1}/P_t, while nominal deposits evolve according to $D_{ht} = D_{ht-1} - P_tC_{ht} + W_tN_{ht}$. The general representation of the household's problem at the beginning of any production period t is a sequence of choices

$$\{N_h: N_{ht}, N_{ht+1}, \ldots\}, \{C_h: C_{ht+1}, C_{ht+2}, \ldots\},$$

such that

(5) $\max_{C,N} U_{ht} = U(C_h, N_h)$, $U'(C_{ht}) > 0$, $U''(C_{ht}) < 0$, $U'(N_{ht}) < 0$, $U''(N_{ht}) < 0$, all t[12]

s.t. $P_{t+1}C_{ht+1} \leq D_{ht}$

$D_{ht} = D_{ht\text{-}1} - P_tC_{ht} + W_tN_{ht}$

This timing has two consequences. First, the household operates under the first expenditure constraint, which is equivalent to a cash-in-advance constraint (with no borrowing against future wealth). The possibility that the coinstraint is not binding arises because at the end of each period the household cannot spend more than available deposits, but may choose to spend less and carry more resources to the next period depending on intertemporal preferences (see below). Second, the vector of allocations C_h, N_h is realized conditional upon all available information in t, which at that point in time includes possible credit and labour market innovations (notably interest rates), i.e. E_t should be read as the expectation conditional upon $\Omega_t \equiv \{k_t, r_{t,}, \ldots\}$. Since we are considering permanent changes in the monetary policy stance, it is consistent for households to hold that $E_t[\Pi_{t+1+s} | \Omega_t] = \ldots = E_t[\Pi_{t+1} | \Omega_t]$. For notational simplicity Ω_t will be dropped.

Using P_t as numeraire, the generic form of the solution to the foregoing problem at any t along the optimal path includes the following first-order conditions:

$$-U'(N_t) = \underline{W}_t E_t[\Pi_{t+1}]^{-1} U'(C_{t+1})$$

$$U'(C_{t+1}) = E_t[\Pi_{t+1}]^{-1} U'(C_{t+2})$$

The first condition yields the optimal work-consumption choice, which, owing to the transaction timing, is such that the *current* working time N_{ht} during t is the means to buy consumption C_{ht+1} at the *end* of the production period. It indicates that labour supply is therefore regulated by the current real wage rate deflated by $E_t[\Pi_{t+1}]$ *vis-à-vis* C_{ht+1}. Since $U'(N_{ht}) < 0$, $\underline{W}_t$ has a positive, while $E_t[\Pi_{t+1}]$ has a negative, effect on N_{ht} (incentive effect). On the other hand, the second condition yields the value of C_{ht+1} along the optimal consumption path as of time t. For regular utility functions, a higher $E_t[\Pi_{t+1}]$ (the inflation rate expected to prevail from t+1 *onwards*) redistributes consumption towards C_{ht+1}, which, in turn, reduces

---

[12] The single restriction that we impose onto (5) is that $U'(C_{ht})$ is independent of $N_{ht\text{-}1}$ and $U'(N_{ht})$ is independent of C_{ht+1}. The standard additive separable intertemporal utility function satisfies this restricion.

N_{ht} (substitution effect)[13]. We can thus write a labour supply function taking the form:

(6) $N^s_{ht} = N^s(\underline{W}_t, E_t\pi_{t+1})$ $N^{s\prime}(\underline{W}_t) > 0,\ N^{s\prime}(E_t\pi_{t+1}) < 0$

Looking at the constraints of the household's problem we can also deduce a generic function for consumption, which at the end of each period t cannot exceed the real value of deposits. This function should respond positively to the expected real value of deposits at time t+1, $E_t(D_t/P_{t+1}) = E_t(\underline{D}_t/\Pi_{t+1})$, with $\underline{D}_t \equiv D_t/P_t$, (income effect) as well as to $E_t[\Pi_{t+1}]$ (intertemporal substitution effect). Thus we can also write

(A1) $C_{ht+1} = C(\underline{D}_t, E_t\pi_{t+1})$ $C'(\underline{D}_t) > 0,\ C'(E_t\pi_{t+1})$?

The partial derivative $C'(E_t\pi_{t+1})$ has ambiguous sign because it is the result of two opposite effects of expected inflation, the real income effect (with negative sign) and the intertemporal subsitution effect (with positive sign).

2.4. Banks and central bank

In order to obtain bank's credit supply, let us first compute the probability of default on loans.

Since firms are ex-ante homogenous, banks have no screening problems. However, they bear monitoring costs whenever a firm defaults on payments. Since the incentive to monitor firms exists up to equality between credit recovery and monitoring cost, without loss of generality we can set the net revenue from defaulting firms to zero.

Default occurs in all states such that

(7) $\tilde{P}_{jt+1} < V_t$

where $V_t \equiv L^d_t R_t / Q(t)_{t+1}$ is the firm's debt-output ratio at time t. Since, by the assumption of rational expectations, the probability distribution of $\tilde{P}_{jt+1}$ is unique and common knowledge, and by the assumption of firms' ex ante

---

[13] Note that forward iteration of the first condition implies that $U'(C_{t+2}) = -U'(N_{t+1})\ E_t[\Pi_{t+1}]\underline{W}_t^{-1}$. Substituting this expression into the second condition, and then $U'(C_{t+1})$ back into the first yields

$$U'(N_t) = (\underline{W}_t\ /\underline{W}_{t+1})E_t[\Pi_{t+1}]^{-1}U'(N_{t+1})$$

This expression measures the intertemporal substititution of labour supply and has been largely employed in the real business cycle literature. Again, it implies that, *cet. par.*, an increase in expected inflation redistributes work effort from the the present to the future (in standard models where households receive a positive interest rate on wealth, this corresponds to the well-known principle that labour supply is increasing in the real interest rate) homogeneity V_t is the same for all firms, the default probability is also the same for all firms and can be computed as

(8) $$\phi_t = \text{Prob}(\widetilde{P}_{jt+1} < V_t) = F(V_t)$$

From these premises, we can now obtain the competitive interest rate on loans charged by banks. Because of the time structure of the economy, banks' balance sheets evolve intertemporally over production periods. At the beginning of each t, a bank b can grant loans $L^s{}_{bt}$. Loans finance the wage bill for period t which is redeposited on behalf of households. Hence the resulting balance sheet is

(9) $$L^s{}_{bt} = D_{bt}$$

In view of the fact that households will claim on D_{bt} one period later, the bank should secure itself a sufficient amount of liquid resources. This requirement acts as a liquidity constraint on the bank's decision problem[14]. The bank expects a gross return from loans $E_t Z_{bt+1}$. As is clear from (9), if all firms repaid capital, the bank would be certain that its liquidity constraint would be satisfied. Yet each loan at time t embodies (the same) default risk ϕ_t. Therefore, recalling that the bank expects zero net revenue at time t+1 from each defaulting firm, it anticipates a liquidity risk (the probability of capital repayments falling short of deposits) equal to $L^s{}_{bt}\phi_t$ associated with its loans portfolio. The bank can insure itself against this risk by borrowing reserves BR_t from the central bank at the gross official interest rate $K_t \equiv (1 + k_t)$, i.e. it can cover all illiquidity states $L^s{}_{bt}\phi_t$ under the obligation to repay $L^s{}_{bt}\phi_t K_t$ in t+1.

Hence the bank's expected gross return on the loan portfolio at the market gross rate R_t is $E_t Z_{bt+1} = L^s{}_{bt} R_t (1 - \phi_t)$, while its expected net profit is

(10) $$L^s{}_{bt} R_t (1 - \phi_t) - L^s{}_{bt} K_t \phi_t - L^s{}_{bt} \geq 0$$

Competitive pressure will drive this expression to equality, with the bank gross interest rate equal to[15]

(11) $$R_t = \frac{1 + \phi_t K_t}{1 - \phi_t}$$

---

[14] The amount of liquid resources is generally given by the statistical expectation of withdrawals, i.e. the aggregation of the individual withdrawals $C(D_{ht}) \leq D_{ht}$ from our households' model. Having assumed $C(D_{ht}) = D_{ht}$ for all h, the bank's liquidity constraint should strictly hold as equality.

[15] Note that the following result is independent of expected inflation. In fact, if we take the bank's expected real net profit and deflate (10) by expected inflation, we still obtain (11).

A simple algebraic manipulation allows a more transparent interpretation of this result. The actual interest rates can be approximated by $r_t \approx \log R_t$ and $k_t \approx \log K_t$. In addition, if k_t is a small fractional number, i.e. around $K_t = 1$, the logarithm of expression (11) is closely approximated by

(12) $r_t \approx \rho_t + k_t$

where $\rho_t = \log \frac{1+\phi_t}{1-\phi_t}$ is a proxy for credit risk increasing in ϕ_t. Hence, r_t can be interpreted as the sum of the official rate plus a credit risk premium providing the link between the policy rate and aggregate supply.

3. Macroeconomic equilibrium and the effects of monetary policy

The relationships obtained in the previous section can be summarized as follows

Labour market

(13) $N^d(\Gamma_t) = N^s(\underline{W}_t, \mathrm{E}_t\pi_{t+1})$,

Credit market

(14) $L_t = W_t N_t$

(15) $D_t = L_t$

(16) $r_t \approx \rho_t + k_t$

Output market

(17) $Q(N^d(\Gamma_t)) = C(\underline{D}_t, \mathrm{E}_t\pi_{t+1})$

(18) $\mathrm{E}_t\pi_{t+1} = \mathrm{E}_t(\widetilde{P}_{jt+1}/P_t) - 1 = P_{t+1}/P_t - 1$

This model indicates that, for any given change in the policy interest rate k_t or in credit risk ρ_t, macroeconomic general equilibrium implies a corresponding set of values for output, inflation, real wage rate, and nominal and real interest rates. The aim of the forthcoming analysis is to detect whether, with no ancillary hypotheses like monopolistic competition or price stickiness, variations of k_t can, under certain conditions that will be discussed below, modifiy macroeconomic equilibirum in a way that is consistent with the set of stylized facts that are regarded as the *explanandum* of monetary macro-models. Namely,

- negative correlation between the policy rate and the real wage ,$\mathrm{d}\underline{W}_t/\mathrm{d}k_t < 0$, (future) output $\mathrm{d}Q(t)_{t+1}/\mathrm{d}k_t < 0$[16], and inflation, $\mathrm{d}\pi_{t+1}/\mathrm{d}k_t < 0$
- output reacting more than prices, $|\mathrm{d}Q(t)_{t+1}/\mathrm{d}k_t| > |\mathrm{d}\pi_{t+1}/\mathrm{d}k_t|$

To bigin with, Appendix A1 shows that the model can be expressed in terms of total "rates of change" of the endogenous variables $\hat{\mathrm{d}}\,\underline{W}_t$, $\hat{\mathrm{d}}\,Q(t)_{t+1}$ and $\hat{\mathrm{d}}\,\pi_{t+1}$, with respect to a (permanent) change in the policy rate $\hat{\mathrm{d}}\,k_t$ at time t. The system's behaviour is regulated by six parameters corresponding to the elasticties of the relevant functions, that is (defining $Y_x \equiv \partial Y/\partial X \div Y/X$): $-N^d_\Gamma$ (labour demand w.r.t. real unit cost), Q_N (output w.r.t labour input), N^s_w (labour supply w.r.t. real wage), $-N^s_\pi$ (labour supply w.r.t. expected inflation), C_D (consumption w.r.t. real deposits), C_π (consumption w.r.t. expected inflation). Other availabe models of the credit or cost channel usually include subsets of these parameters (see the literature in the Introduction), depending on the structure of the model economy and on the specific utility and production functions assumed. Our first result is that the present model of the integrated CCC encompasses the desired adjustment pattern of the endogenous variable as a possible result of *particular combinations* of values of *all* these parameters. To gain insight, we may resort to the consensus estimates of some critical elasticities that we can find in the literature.

First of all, it is generally the case in industrialized countries that $Q_N < 1$, and that Q_N is consistent with the labour coefficient of a Cobb-Douglas production function, say α. If we accept this restriction, then it follows that $-N^d_\Gamma = -1/(1-\alpha)$. A consensus value of Q_N may be around 0.6 (e.g. CEE, p.1232), which implies $-N^d_\Gamma = -2.5$.

Given these two parameters, the signs of the total variations of the endogenous variables eventually depend on the relative size of the parameters governing household behaviour, namely N^s_w, N^s_π, C_D, C_π. These represent a much more controversial issue especially on empirical grounds.

---

[16] Since output is a positive function of employment, this condition includes the observed effects of the policy rate on employment. Absent sticky prices, the present model suggests that the other well-known fact of the time lag between the monetary intervention and the change in output and inflation can be traced back to the production gestation time. This is of course a matter of empirical analysis, as it is the sticky price assumption, that will not be addressed here. Moreover, the analysis will be run by comparing rational-expectations equilibrium states of the economy, that is to say, when all transitory adjustments due to frictions and imperfections have petered out.

To begin with, let us see the conditions that are required to obtain the desired adjustment pattern (with elasticities appearing in absolute values)

- $\alpha < C_D < 1$
- $C_\pi < \dfrac{\alpha(1-C_D)}{1-\alpha}$
- ${N^s}_w > \dfrac{C_D(1+\alpha N^s_\pi)}{\alpha(1-C_\pi)-C_D(1-\alpha)}$

(note that the third condition is necessary only for $|\mathrm{d}Q(t)_{t+1}/\mathrm{d}k_t| > |\mathrm{d}\pi_{t+1}/\mathrm{d}k_t|$).

As to C_D it should first be noted that in our model (with zero nominal interest rate and non-human wealth, and no borrowing against future incomes) the t+1 real value of deposits as of time t ($\mathrm{E}_t(\underline{D}_t/\Pi_{t+1})$) is equivalent to the present value of total wealth in the standard, permanent income consumption model. Hence, $0.6 < C_D < 1$ is consistent with wide empirical evidence, a major example coming from the "λ model" by Mankiw and Campbell (1991). "λ" is meant to capture various imperfections in households' consumption planning relative to the standard model (where $\lambda = 0$), and $1 - \lambda$ is the corrected elasticity of consumption w.r.t. permanent income. Mankiw-Campbell estimates of λ for various countries, broadly confirmed in subsequent independent works, imply that $C_D = 0.7$ may be regarded as a representative size of this parameter.

Secondly, as recalled above, given $\mathrm{E}_t(\underline{D}_t/\Pi_{t+1})$, standard consumption theory indicates that C_{t+1} may also respond to intertemporal subsititution incentives, which, with zero interest rate, arise from the expected *subsequent* path of inflation. After a permanent monetary shock at the beginning of t, households (rationally) figure out a new expected inflation path with $\mathrm{E}_t\pi_{t+1}$ remaining constant from t+1 onwards. Thus C_π represents the elasticity of intertemporal substitution. Early investigations at the macro-level converged to the conclusion that this elasticity is unlikely to exceed 0.1-0.2 and may well be zero (e.g. Hall (1988), and Hahm (1998) for a survey). Mankiw-Campbell joint estimates of this elasticity with λ confirmed this finding. Recent calibrations of this parameter fall in the same range of values (see e.g. Woodford (2003, ch. 5). Hahm (1998), however, obtained significant values of about 0.3 for both durables and non-durables. Higher significant values were instead found in the micro-data (e.g. Attanasio and Weber (1995)).

Let us now turn to the parameters in the labour supply function. The wage elasticity N^s_w is discussed at lenght in the CEE paper. They warn that the size of this paremeter is yet another contentious issue. In this case, microeconometrics tend to yield negligible values whereas macroeconometrics point to sizeable estimates, generally well above 1. CEE choose 1 as the benchmark value for their comparative exercises. Closely related to this issue is the one concerning the labour-supply intertemporal counterpart of consumption, that is, N^s_π. This parameter is absent from the CEE model, but it drew quite an amount of attention spurred by the early real business cycle literature. Overall, the widespread opinion seems that N_π is probably close to zero (e.g. Mankiw (1989)), and hence we may take 0.1 as tentative value.

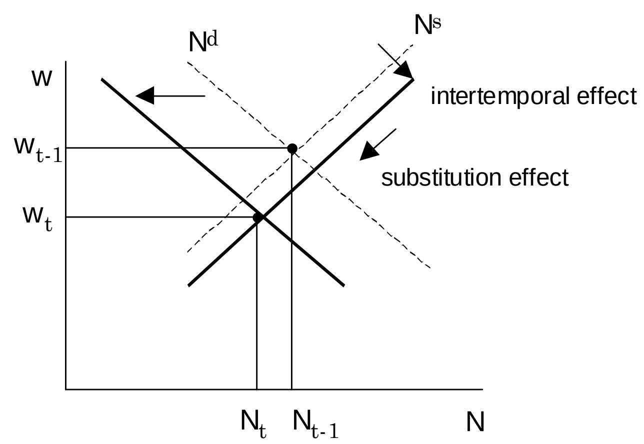
Inserting the foregoing values of $\alpha = 0.6$, $C_D = 0.7$, $-N^s_\pi = -0.1$ into the inequality conditions above we obtain $C_\pi < 0.45$, $N^s_w > 18.5(15-8C_\pi)^{-1}$. In the first place, the two inequalities are mutually consistent with C_π and N^s_w being both positive. Secondly, the order of magnitude required for C_π is in line with the empirical regularities discussed above. If we consider the relatively high value $C_\pi = 0.3$ proposed by Hahm, it follows that $N^s_w > 5.3$. This latter result seems to confirm CEE's conclusion that quite a large wage elasticity of labour supply is necessary for the cost channel to generate larger adjustments in quantities than in prices. However, the CCC model shows that this conclusion should be qualified in that N^s_w interacts with the other parameters, in particular those governing households' forward-looking behaviour, which are absent in the CEE model. This same point is made for instance by Pfajfar and Santoro (2007), who find that the ratio between N^s_w and C_π should be gratear than one. In this respect, it should be noted that the threshold value of N^s_w falls as C_π and N^s_π fall. For instance if C_π and N^s_π were actually close to zero, the threshold value for N^s_w would fall to 2.1. This is a figure in the range of estimates at the macro-level, and is a comforting result with respect to the real business cycle approach, where it is generally required that N^s_π and N^s_w are both large. Other factors that reduce the value of N^s_w that yields the desired outcome are a larger labour elasticity of output α and/or a smaller propensity to consume C_D.

Overall, we may conclude that our general representation of the CCC is likely to generate the pattern of adjustments typically observed after a monetary shock under plausible empirical conditions, in particular small intertemporal elasticities of substitution for consumption and labour supply.

Moreover, the choice of not considering goods and labour market imperfections has only been dictated by reasons of theoretical nature, namely to show that these are not necessary to obtain results that match the observed facts. Nonetheless, these imperfections are pervasive in real economies, and adding them to the basic model may enhance its likelihood. As far as equilibrium states of the economy, rather than transitory dynamics, are concerned, so-called "real rigidities" are more relevant than nominal ones. For instance, as also suggested by CEE, the presence of a real rigidity in the labour market may yield the desired pattern of outcomes even with a very low labour-supply elasticity to the wage rate.

At this point it may be useful to examine the adjustment process under the above conditions[17]. Assume that the economy is in equilibrium and consider the case that, as the labour and credit markets are opened at the beginning of period t, the central bank raises the policy rate k_t. First of all, the nominal bank rate r_t increases. The key point is how firms react, and this depends on the real interest rate *vis-à-vis* the real wage rate (see *Figure 2*).

Figure 2. The labour-market response to an increase in the bank interest rate



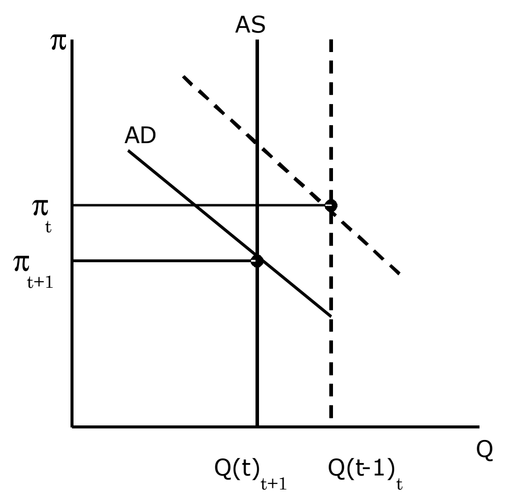
Suppose firms expect that a higher r_t will lower inflation, then they anticipate a higher *real* interest rate, which leads them to cut labour demand. As the current wage rate falls, households are induced to supply less labour (according to $N^s{}_w$), while the expected lower inflation induces them to supply more (according to $N^s{}_\pi$), imposing further competitive pressure on $\underline{W}_t$. If the overall fall of the real wage rate does not offset the

[17] Compare with the graphical analysis in CEE, sec. 4.

rise in the real interest rate (N^s_π is relatively small, N^s_w is relatively large), firms are left with higher real unit costs. The consequence is a net cut in employment and production.

Moving to the output market (see *Figure 3*), this therefore opens with less supply than in the previous period (in the (π, *Q*) space, aggregate supply is vertical because the quantity produced can no longer be changed). Parallely, less employment at a lower wage rate has generated fewer bank loans and deposits: this reduces aggregate demand too (according to C_D). Demand may also be displaced further by the fact that anticipated deflation shifts consumption from *t*+1 to the future (according to C_π). The rational expectations hypothesis implies that the component of supply and demand changes due to anticipated deflation should be consistent with the actual fall in the inflation rate. The comovement of demand and supply is the key factor in the CCC transmission mechanism that impinges upon the response of the price index. Since aggregate demand and supply are both negatively affected by the policy rate (and supply is non-decreasing in the inflation rate), then 1) inflation falls with output (no "price puzzle") as the shift of aggregate demand is larger than that of aggregate supply[18]; 2) the less inflation falls than output the flatter is the aggregate demand curve.

Figure 3. The output-market response to an increase in the bank interest rate



[18] Note that this condition is modified in models with price-making firms such as those of the Ravenna and Walsh (2006) type. In this type models the relationship between the policy rate, the inflation rate and output is intermediated by the relative movement of marginal costs and optimal markup in the face of policy shock. See e.g. Chowdhury et al. (2006).

4. A note on policy implications

Though monetary policy implications and prescriptions fall outside the scope of the present paper, it is worth adding a short note with a view to possible developments.

If the conditions indicated by the theoretical model hold, the basic policy message is that managing the interest rate is an effective means to curb inflation to the extent that the agents *anticipate* that the *real* interest rate will be raised sufficiently (relative to the real wage rate). This is in line with the majority view as expressed for instance by Woodford (2003, ch. 4)[19]. On the other hand, as argued by Ravenna and Walsh (2006), the cost channel of monetary policy generates the typical output-inflation trade-off which makes disinflation a non-trivial policy problem contrary to the "divine coincidence" that makes it disappear in the standard New-Neoclassical-Synthesis framework with the sole demand-side effects.

Though not developed here (see e.g. Passamani and Tamborini (2007)), it is also worth considering the interplay between the policy interest rate and credit risk – a hot issue in this moment. As can easily be seen, the latter has essentially the same macroeconomic effects as the former. Consequently, there is a clear scope for monetary policy as a means to offset shifts in credit risk with undesirable macroeconomic consequences. Note, also, that to this end it may not be sufficient for the central bank to monitor only inflation, since it may react too little to large adjustments in economic activity due to the co-movement of aggregate demand and supply. As argued by an increasing number of scholars, it seems necessary that central banks include credit-market indicators into their information apparatus, and make it clear to the public that they may react to these indicators too (e.g. Crockett (2003), Christiano et al. (2007), Goodfriend and McCallum (2007))

5. Conclusions

In this paper I have put forward a CCC model of monetary policy. This model combines bank credit supply, as a means whereby monetary

---

[19] Woodford (e.g. ch. 1) also stresses the change of perspective in the modern theory of monetary policy from shocking the economy unexpectedly to steering the economy by means of systematic, fully anticipated, policy conduct.

policy affects economic activity (credit channel), and interest rates on loans as a cost to firms (cost channel). The thrust of the model is that firms' reliance on bank loans makes *aggregate supply* dependent on credit variables, namely the official rate controlled by the central bank and a credit risk premium charged by banks on firms. The joint consideration of the two channels offers a few attractive features: it may overcome the weaknessess of models that consider each channel separately, it brings the banking sector back to the forefront, it highlights the role of credit risk at the macroeconomic level.

As far as monetary policy is concerned, it has been shown that under plausible values of the relevant parameters, an exogenous change in the policy interest rate in the CCC model yields a pattern of relationships broadly consistent with the set of empirical regularities that are today regarded as the *explanandum* of monetary macroeconomics – with particular regard to the labour market – with no recourse to additional goods and labour market imperfections or other *ad hoc* frictions. Moreover, the presumption arises that the CCC may also have permanent, rather than transitory, effects on real variables. Addition of goods or labour market imperfections, however, in particular in the form "real rigidities" in the labour market, may further enhance the explanatory power of the model.

Another line of development concerns policy implications. The CCC model indicates three main issues. First, the need for monetary-policy models to include supply-side effects. Second, the importance of an explicit treatment of the banking sector as a link between monetary policy and the supply side. Third, the inclusion of credit-market indicators among the signals upon which the central bank is expected to react.

This paper was devoted to the theoretical assessment of the CCC model. Of course, its applicability and explanatory power in specific economies eventually depend on their structural and institutional features, and should be matter of emprical investigation by means of appropriate econometric techniques.

References

Amendola, M., Gaffard J.L. (1998), *Out of Equilibrium*, Oxford, Clarendon Press.

Attanasio O.P., Weber G. (1995), "Is Consumption Growth Consistent with Intertemporal Optimization? Evidence form the Consumer

Expenditure Survey", *Journal of Political Economy*, 103, pp.1121-1157.

Barth M.J., Ramey V. (2001), “The Cost Channel of Monetary Transmission”, in Bernanke B., Rogoff K. (eds.), *NBER Macroeconomics Annual 2001*, Cambridge Mass., MIT Press.

Bernanke B., Blinder A. (1992), "The Federal Funds Rate and the Channels of Monetary Transmission", *American Economic Review*, 82, pp. 901-21.

Bernanke B., Gertler M. (1995), "Inside the Black Box: the Credit Channel of Monetary Policy Transmission", *Journal of Economic Perspectives*, 9, pp. 27-42.

Blinder A., Stiglitz J.E. (1983), "Money, Credit Constraints and Economic Activity", *American Economic Review*, 73, 297-302.

Blinder, A. (1987), "Credit Rationing and Effective Supply Failures", *Economic Journal*, 97, 327-352.

Borio C., Lowe P. (2002), "Asset Prices, Financial and Monetary Stability: Exploring the Nexus", BIS Working Papers, no. 114.

Chowdhury I, Hoffmann M., Schabert A. (2006), "Inflation Dynamics and the Cost Channel of Monetary Transmission", *European Economic Review*, 50, pp. 995-1016.

Christiano L.J., Eichenbaum M. (1992), “Liquidity Effects and the Monetary Transmission Mechanism”, *American Economic Review*, 80, 703-725.

Christiano L.J, Eichenbaum M., Evans C.L. (1997), “Sticky Price and Limited Participation Models of Money: A Comparison”, *European Economic Review*, 41, 1201-1249.

Christiano L.J., Eichenbaum M., Evans, C.L. (2005), "Nominal Rigidities and the Dynamic Effect of a Shock to Monetary Policy", *Journal of Political Economy*, 113, pp. 1–45.

Christiano L. J., Motto R., Rostagno M. (2007), "Two Reasons Why Money and Credit May Be Useful in Monetary Policy", Paper presented at the 4th ECB Central Banking Conference, Frankfurt, November 9-10, 2006.

Crockett A. (2003), "International Standard Setting in Financial Supervision", Institute of Economic Affairs Lecture, Cass Business School, mimeo.

Diamond D.W. (1984), "Financial Intermediation and Delegated Monitoring", *Review of Economic Studies*, 51, 393-414.

Farmer R. (1984), "New Theory of Aggregate Supply", *American Economic Review*, 74, 920-930.

Fiorentini R., Tamborini R. (2002) "Monetary policy, credit and aggregate supply", *Economic Notes*, 31, pp.1-48.

Gertler M., Gilchrist S. (1993), "The Role of Credit Market Imperfections in the Monetary Transmission Mechanism: Arguments and Evidence", *Scandinavian Journal of Economics*, 93, 43-64.

Gertler M., Gilchrist S. (1994), "Monetary Policy, Business Cycles and the Behaviour of Small Manufactoring Firms", *Quarterly Journal of Economics*, 109, 309-340.

Goodfriend M., McCallum B. T. (2007). “Banking and interest rates in monetary policy analysis: A quantitative exploration” *Journal of Monetary Economics,* 54, pp. 1480-1507.

Goodhart C.A. (1986), “Financial Innovation and Monetary Control”, *Oxford Review of Economic Policy*, 2, 75-91.

Greenwald B. C., Stiglitz J. E. (1988), "Imperfect Information, Finance Constraints and Business Fluctuations", in Kohn, M., Tsiang S.C. (eds.)*, Finance Constraints, Expectations, and Macroeconomics,* Oxford, Claredon Press, 103-140.

Greenwald B.C., Stiglitz J.E. (1993a), "Financial Market Imperfections and Business Cycles", *Quarterly Journal of Economics*, 108, 77-113.

Greenwald, B.C., Stiglitz, J.E. (1993b), "New and Old Keynesians", *Journal of Economic Perspectives*, 7, 23-44.

Hahm J. (1998), "Consumption Adjustment to the Real Interest Rates: Intertemporal Substitution Revisited", *Journal of Economic Dynamics and Control*, 22, pp.293-320.

Hall R.E. (1988), "Stocjastic Implications of the Life-Cycle Permanent Income Hypothesis. Theory and Evidence", *Journal of Political Economy*, 86, pp. 971-987.

Hicks, J. R. (1973), *Capital and Time*, Oxford, Clarendon Press.

Holmstroem B., Tirole J. (1998), "Private and Public Supply of Liquidity", *Journal of Political Economy*, vol.106, pp.2-40.

Kashyap A.K., Stein J.C., Wilcox D.W. (1993), "Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance", *American Economic Review*, 83, pp.78-79.

Kashyap A.K., Lamont O., Stein J. (1994), “Credit Conditions and the Cyclical Behavior of Inventories”, *Quarterly Journal of Economics*, 109, 565-92.

Keynes J.M. (1933), "A Monetary Theory of Production", in *The Collected Writings of John Maynard Keynes*, ed. by E. Moggridge, London, Macmillan 1987, vol.XIV.

Keynes J.M. (1937), "Alternative Theories of the Rate of Interest", in *The Collected Writings of John Maynard Keynes*, ed. by E. Moggridge, London, Macmillan, 1973, vol.VIII.

Leijonhufvud A. (2008), "Keynes and the Crisis", CEPR Policy Insight, n. 23.

Mankiw G.N. (1989), “Real Business Cycles: A New Keynesian Perspective”, *Journal of Economic Perspectives*, 3, pp.79-90.

Mankiw G.N., Campbell J. Y. (1991), "The Response of Consumption to Income: A Cross-Country Comparison", *European Ecconomic Review*, 35, pp- 723-756.

Mitchell D.W. (1984), "Macro Effects of Interest-Sensitive Aggregate Supply", *Journal of Macroeconomics*, 6, pp.43-56.

Myatt A., Scarth W.M. (1995), "Can Fiscal Spending Be Contractionary When Interest Rates Have Supply Side Effects?", *Journal of Macroeconomics*, 17, 289-301.

Passamani G., Tamborini R. (2007) "The macroeconomic effects of firms' bank dependence and default risk", in Arestis P., Zezza G. (eds.), *Advances in Monetary Theory and Macroeconomics*, London, Palgrave Macmillan.

Pfajfar D., Santoro E. (2007), "Credit Market Distortions, Asset Prices and Monetary Policy", University of Cambridge, October, mimeo.

Ramey V. (1989), “Inventories as Factors of Production and Economic Fluctuations”, *American Economic Review*, 30, 171-193

Ravenna F., Walsh C.E. (2003), “The Cost Channel in a New Keynesian Model: Evidende and Implications”, mimeo.

Ravenna F., Walsh C.E. (2006), "Optimal Monetary Policy With the Cost Channel", *Journal of Monetary Economics*, 53, pp. 199-216.

Simos E.O. (1981), "Real Money Balances as a Productive Input. Further Evidence", *Journal of Monetary Economics*, 7, 207-225.

Sims C. 1992, "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy", *European Economic Review*, 36, pp. 975-1000.

Townsend R. (1979), "Optimal contracts and competitive markets with costly state verification", *Journal of Economic Theory*, 20, 265-93.

Vickers D. (1981), "The Money Capital 'Factor'", *Journal of Post-Keynesian Economics*, 4, pp.260-65.

Walsh C.E. (2003), *Monetary Thoery and Policy*, Cambridge (Mass.),m MIT Press, 2nd ed.

Appendix

Let us consider the complete model given by the intertemporal equilibrium conditions of the labour and credit markets in each period *t,* and of the output market in the subsequent period t+1.

(A1) a) $N^d(\Gamma_t) = N^s(\underline{W}_t, \mathrm{E}_t\pi_{t+1})$

b) $L_t = W_t N_t$

c) $D_t = L_t$

d) $r_t \approx \rho_t + k_t$

e) $Q(N^d(\Gamma_t) = C(\underline{D}_t, \mathrm{E}_t\pi_{t+1})$

f) $\mathrm{E}_t\pi_{t+1} = \mathrm{E}_t(\widetilde{P}_{jt+1}/P_t - 1) = P_{t+1}/P_t - 1$

We can now examine the response of the system to variations in what we may call the "CCC variables": k_t, which represents the monetary policy variable, and ρ_t, which represents an autonomous component of credit supply. The effects on the real wage rate $\underline{W}_t$, output $Q(t)_{t+1}$ and the inflation rate π_{t+1} are obtained by totally differentiating the equations of the system around the steady state. This yields the Jacobian marix of system (A1). It may be convenient to skip the formulation with all generic partial derivatives and move to the formulation in terms of elasticities.

Under suitable conditions (or normalization of initial values) the partial derivatives in the Jacobian matrix of system (A1) can be translated into elasticities, i.e. $Y_x \equiv \partial Y/\partial X \div Y/X$. Accordingly, the appropriate measure of total variations is in realtive terms or "rates of change" denoted by $\hat{\mathrm{d}}X_t \equiv \mathrm{d}X/X$. Secondly, let the production function be of the Cobb-Douglas class, with α denoting the labour-input coefficient. Then, $Q_N = \alpha$, while the total variation of employment is $\hat{\mathrm{d}}N^d{}_t = -N^d{}_\Gamma \hat{\mathrm{d}}\Gamma_t = -(1-\alpha)^{-1}(\hat{\mathrm{d}}\underline{W}_t + \hat{\mathrm{d}}k_t - \mathrm{E}_t\hat{\mathrm{d}}\pi_{t+1})$. Moreover, as explained above, the total variation of consumption can be split between the income effect (with elasticity C_D) and the intertemporal susbtitution effect (with elasticity C_π), i.e. $\hat{\mathrm{d}}C_{t+1} = C_D(\hat{\mathrm{d}}\underline{D}_t - \mathrm{E}_t\hat{\mathrm{d}}\pi_{t+1}) + C_\pi\ \mathrm{E}_t\hat{\mathrm{d}}\pi_{t+1}$. Remember that by definition $\hat{\mathrm{d}}\underline{D}_t = \hat{\mathrm{d}}\underline{W}_t + \hat{\mathrm{d}}N^d{}_t$. Since the transmission mechanism of the two CCC variables is the same, let us focus on k_t. Imposing the rational expectations contraint, $\mathrm{E}_t\hat{\mathrm{d}}\pi_{t+1} = \hat{\mathrm{d}}\pi_{t+1}$ we obtain

(A2)
$$\begin{bmatrix} \hat{\mathrm{d}}\underline{W}_t \\ \hat{\mathrm{d}}Q(t)_{t+1} \\ \hat{\mathrm{d}}\pi_{t+1} \end{bmatrix} = \frac{1}{\Delta}\begin{bmatrix} N_\pi^s(\alpha - C_D) + C_\pi - C_D \\ C_\pi N_w^s - (N_w^s - N_\pi^s)C_D \\ N_w^s(\alpha - C_D) - C_D \end{bmatrix} \hat{\mathrm{d}}k_t$$

$$\Delta = \alpha(N_w^s - N_\pi^s)(1 - C_D) - C_\pi(1 + N_w^s(1 - \alpha))$$

The signs of the total variations are ambiguous and depend on the particular values taken by the elasticities. The discussion of the solutions for empirically-based values of elasticities is developed in the paper.