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Monetary policy, credit and aggregate supply: the evidence from Italy*

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Abstract

This paper relates to the macroeconomic and monetary policy aspects of the so-called "credit channel" of monetary transmission. We present an intertemporal macroeconomic equilibrium model of a competitive economy where current production is financed by bank credit, and then we use it to identify the credit transmission mechanism in data drawn from the Italian economy. We find evidence that the "credit variables" identified by the model, the overnight rate and a measure of credit risk, have permanent effects on employment and output through the supply side of the economy by altering credit supply conditions to firms.

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To save on space, mathematical proofs, and statistical tests and data sources have been gathered in two separate appendices that can be examined on request.

J.E.L.: E2, E5

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MONETARY POLICY, CREDIT AND AGGREGATE SUPPLY: THE EVIDENCE FROM ITALY

Introduction

Research on how money affects economic activity has recently revived interest in the so-called "credit view"¹. This line of research, in general, aims at offering microfounded explanations related to capital market imperfections of the potential for monetary shocks to exert large and persistent effects on real variables (propagation mechanisms), or even permanent effects on real variables (long-run non-neutrality). This paper relates to the macroeconomic and monetary policy aspects of the credit view, and has three main motivations. First, to study the role of bank credit to firms in the determination of output, employment and inflation. Second, to examine the claim that the credit channel of monetary policy can be non-neutral on output and employment even when labour and goods markets are perfectly competitive. Third, to assess the strength and effectiveness of the credit transmission mechanism through empirical analysis. Therefore, the paper presents a monetary general-equilibrium model of a competitive credit economy, and then tests the theoretical results with data drawn from the Italian economy with quarterly data running from 1987:4 to 1997:1.

We wish to stress that our work should not be taken to imply that other channels of monetary transmission that are not included in the model do not operate altogether. We believe that credit mechanisms as well as the traditional portfolio mechanisms co-operate in the monetary transmission process, though their relative weight may vary according to different

¹General references are Greenwald-Stiglitz (1987, 1990, 1993b), Gertler (1988), Gertler-Gilchrist (1993), Bernanke (1993), Kashyap-Stein (1994), Bernanke-Gertler (1995). Early fundamental contributions to the credit view date back to Wicksell (1898), Hawtrey (1927), Keynes (1930), to name only a few. The *General Theory* (Keynes, 1936), however, in spite of Keynes's (1937) recognition of the importance of firms' "finance motive" in the demand for money, paved the way to the ascent of the "money view" in monetary theory and macroeconomics. The credit view was never fully dismissed. In the '60s it was revived by the Radcliffe Report (1959) and later by Kaldor's works on "endogenous money" (1982).

institutional environments and financial structures (see e.g. Miron et al., 1994). One of the current research strategies consists of building large-size heuristic models in which different hypotheses of monetary transmission compete (see e.g. Bagliano-Favero, 1995, for Italy). However, providing this kind of models with detailed and rigorous microeconomic structures capable of identifying and explaining precisely the various transmission mechanisms would make them analytically intractable. Hence here we present a different "Occam's razor" strategy. Our theoretical model has been conceived not as a "realistic" portrait of the many channels of monetary transmission but, quite the contrary, as an "ideal type" of a pure credit economy capable of detecting and quantifying *the presence* of the credit channel in the data under highly falsifiable theoretical premises.

The research on the credit channel has developed two complementary approaches, the "*net-worth (or balance-sheet) channel*" (NWC) and the "*bank-lending channel*" (BLC). The model we present here accommodates the latter only. The BLC is characterized by the view that a prominent source of finance for firms (or for some important classes of firms) is provided by banks as they solve the agency problems inherent in the borrower-lender relationship more efficiently than individuals or other financial intermediaries. Therefore, the level of activity (production or investment) of firms is essentially related to the price and amount of credit available, and, indirectly, to the determinants (especially policy variables) of credit supply (reference papers are Blinder, 1987; Bernanke-Blinder, 1988, Greenwald-Stiglitz, 1988, 1990, sec.1.3, 1993a, Stiglitz-Weiss, 1992)².

Following our "Occam's razor" approach, the reasons of our choice of focus have mainly been operational. First, analytical tractability and predictability suggested us to consider one single transmission mechanism. Second, models of the NWC are typically, though not necessarily, employed to examine problems of real growth and/or business cycle which are not our main concern here. Third, a large part of the macroeconomic empirical

²In the NWC approach the main source of finance for firms is seen in their internal funds and marketable assets, broadly identified with the firm's net worth or "equity base" (the reference model is Greenwald et al., 1984, and then Gertler-Hubbard, 1988, Bernanke-Gertler, 1989, Greenwald-Stiglitz, 1988, 1993a, Kyiotaki-Moore, 1997). The activity level of firms is constrained by their net worth and is conditioned by the factors that may change it (e.g. open market operations altering asset prices).

works concerned with monetary issues have so far examined the BLC³, especially as regards Italy, where, as a matter of fact, the contribution of internal marketable assets to corporate finance is much less important than elsewhere while firms' bank-dependence is much more pervasive⁴.

Among the macroeconomic models of the BLC, one can distinguish between reformulations of the IS-LM model where the bank-loan component of investment is introduced - or CC-LM models to borrow Bernanke-Blinder's terminology (e.g. Blinder, 1987; Bernanke-Blinder, 1988; Greenwald-Stiglitz, 1990, sec. 1.3), and "levered aggregate supply" models (e.g. Greenwald-Stiglitz, 1988, 1990, sec.2, 1993a) - G-S models for short - where bank loans finance production alongside with firms' internal funds. So far the CC-LM framework has been used more extensively for tests of the BLC. The results obtained are mixed for the United States (see e.g. King, 1986, Romer-Romer, 1990, Bernanke-Blinder, 1992, Bernanke, 1993, Kashyap et al. 1993, Kashyap-Stein, 1994), while they are more robust for Europe and Italy in particular (see e.g. Dale-Haldane, 1993, Buttiglione-Ferri, 1994, Bagliano-Favero, 1995).

However, the CC-LM model has some limitations. The first is theoretical. Since "most economists would agree that, *at least in the short run*, monetary policy can significantly influence the course of the real economy" (Bernanke-Gertler, 1995, p.27; italics added), the CC-LM model, being a model of how the BLC *amplifies* monetary shocks to *aggregate demand*, adds little to the fundamental issue of non-neutrality in long-run equilibrium, and in particular whether the latter depends exclusively on

³There exists, by contrast, a rich and growing *microeconomic* literature on the role of cash flows, internal funds and other liquid assets in the determination of investment in firms facing constraints on external finance. See Hubbard (1998) for a recent review.

⁴It has long been thought that Italy is a good case-study for scholars interested in the BLC of monetary policy because among the major industrialized countries Italy has a less developed capital market, and an industrial structure characterized by the presence of a large number of small firms for which bank credit is the most important financial resource (Vicarelli, 1974; Angeloni et al., 1997). The role of the credit market in the monetary transmission mechanism has always been carefully monitored by the Italian monetary authorities (see e.g. Bertocco, 1997) and is explicitly included in the Bank of Italy's econometric model (1997a). Moreover, there has recently been a flourishing of empirical studies of the BLC in Italy (e.g. Buttiglione-Ferri, 1994; Bagliano-Favero, 1995; Angeloni et al., 1997; Conigliani et al., 1997).

missing adjustments of wages and prices or not⁵. A second, but related, limitation is more empirical. When price variables are simply added to the empirical specifications of the CC-LM model, the so-called "price puzzle" is typically obtained, that is a *negative* correlation between monetary policy shocks and the price level (Sims, 1992). It has been shown that this effect may be due to the lack of specification of aggregate supply (Eichenbaum, 1992, Christiano et al., 1996). As a matter of fact, bank-dependent firms typically rely on bank loans not only to finance fixed capital but also circulating capital; hence changes in credit conditions are likely to affect firms' supply conditions too (Gertler-Gilchrist, 1993, 1994, Rondi et al., 1998, Badocchi, 1998). Finally, existing empirical works on the BLC have also been found unsatisfactory due to the so-called monetary policy's "causation puzzle", that is to say whether the observed positive correlation between bank loans and output after a monetary shock are really due to *credit supply shifts* or else to *credit demand shifts* consistent with the traditional monetary transmission mechanism (see e.g. Kashyap-Stein, 1994, and the comment by Eichenbaum, 1994).

In the light of these considerations, we have based our work on a pure bank-lending version of the G-S (1993a) model, which, as far as we know, has not been reformulated in a testable way. We think that the use of such a model may shed further light on the working of the credit channel both theoretically and empirically in a way comparable with modern macroeconomic monetary models for policy analysis. In particular, 1) our model highlights the role of the *supply side* effects of changes in credit variables as far as the issue of non-neutrality is concerned, 2) it points out the structural parameters governing the strength of the real effects of credit variables, 3) having a fully specified system of demand-supply equations for the labour, credit and output markets, we are in a position to circumvent the "price puzzle" as well as the monetary policy's "causation puzzle".

Our modelling strategy has also conditioned our choice of statistical methodology. The credit channel literature largely relies on the VAR

⁵It is fair to add that some researchers are in fact content with the model's adequacy to account for observed short-run effects of monetary shocks that do not fit more traditional explanations (see e.g. Bernanke-Gertler, 1995). For a more ambitious and theoretically committed interpretation of the credit view see instead Greenwald-Stiglitz (1993b).

methodology⁶. As is clear in the evolution of the VAR technique, "the great appeal of using VARs for studying monetary policy transmission is that they appear to be able to identify the effects of policy *without a complete structural model of the economy*" (Rudebusch, 1998; our italics). This feature is however obtained at the cost of problems in identifying the exact specification of endogenous and exogenous variables, and of their structural relationships (Bernanke-Mihov, 1995, Rudebusch, 1998, Bagliano-Favero, 1998). Since we started from a fully specified general equilibrium model of the economy, and our goal was to test the long-run BLC effects indicated by the model, we preferred to perform a traditional estimation of the system of equations of the model's rational-expectations equilibrium.

Section 1 of the paper sets out the structure of a competitive credit economy by means of a sequential model of production and consumption, with bank-financed firms and overlapping generations of workers. Section 2 solves the individual optimal programmes of firms, workers, and commercial banks, with the central bank as lender of last resort. Section 3 presents the equilibrium results of the markets for labour, credit and output. This section shows how employment and output are affected, in rational-expectations equilibrium, by "credit variables", namely the discount rate controlled by the central bank and the bankruptcy probability of firms estimated by the banks. The results are used to discuss the theoretical and empirical issues mentioned above. Section 4 is devoted to empirical analysis by means of direct econometric estimation of the model's equilibrium equations with the Italian data, with a discussion of the results and of their limits. Section 5 summarizes the paper and suggests areas where further research on the macroeconomic role of credit is desirable.

1. Structure of the model economy

Our model draws on the G-S (1993a) model of "levered aggregate supply". The key ingredients of the G-S model are: 1) a sequential economy such that firms have to pay for inputs (labour) before they are able to sell

⁶See, among others, Bernanke-Blinder (1992), Bagliano-Favero (1995, 1998), Gordon-Leeper (1994), Bernanke-Gertler (1995), Christiano et al. (1996).

output, 2) firms' output price uncertainty in the form of a probability distribution of each firm's individual sale price around the average "market price" of output, 3) full "equity rationing" of firms, so that firms' demand for working capital (the wage bill) is met either by internal funds ("equity base") or by bank credit in a competitive credit market, 4) standard debt contracts between banks and firms. The wage rate, the market price level, equity rationing and standard debt contracts are assumed but are not demonstrated within the model. Moreover, central bank and monetary policy variables are absent.

In view of our purposes, we first need to extend the model to include:

- ### the labour market (i.e. the endogenous determination of the money wage rate),
- ### the output market (i.e. the endogenous determination of the average market price),
- ### a set of assumptions such that equity rationing and standard debt contracts emerge consistently
- ### the role of the central bank.

To these ends, we reformulate the G-S model in an overlapping-generation fashion with the inclusion of a costly state verification problem of firms, and a role for the central bank as lender of last resort.

Let us consider a sequential economy where discrete periods of time are indexed with t , and a constant population with overlapping generations of agents. Each agent faces 1 period of activity and 1 period of non-activity. Thus, in each period t , a constant, arbitrary large number N_a of active agents A coexist with an equal number of non-active agents of the previous generation.

Active agents can be "workers" (w), "entrepreneurs" (j) or "bankers" (b), ### w, j, b ### A. Workers are born with no endowment and are risk-averse; entrepreneurs and bankers are born with a consumable, non-storable endowment and are risk-neutral. There is no capital ownership in this economy, only organization of activity within private firms. Workers are employed in production units, entrepreneurs organize production, and bankers intermediate between workers and entrepreneurs. Each single entrepreneur runs a firm and each single banker runs a bank.

Each active worker at the beginning of each t earns the market wage rate and chooses how much to consume in t and how much in $t+1$. Entrepreneurs and bankers consume their endowment in t , and engage in

maximizing profits from production and intermediation, respectively, to be earned and consumed in $t+1$.

Firms produce competitively one single non-storable consumption good, called "the output" of the economy, by means of homogeneous labour and a decreasing-return technology. All firms have the same operation cycle with two stages: production and sales. The production stage takes one period t , regardless of the scale of output, while the sale stage takes place in $t+1$ and is virtually instantaneous. Therefore, at the beginning of each t each firm demands labour from the active population as a function of the output planned for sale in $t+1$, while it sells the output produced in $t-1$ to the active and non-active population. The entrepreneur claims on the firm's profit in $t+1$, then the firm dies out with the entrepreneur's exit from activity, and so on as in the chart below⁷.

[Figure 1]

1.1. Uncertainty

First of all, as a consequence of sequential production and sales, firms operate under price uncertainty. Here we follow the G-S modelling strategy of introducing uncertainty as ex-post random distribution of individual sale prices around the average or "market" price:

(A1) Let the individual sale price of any firm j be

$$P_{jt+1} = P_{t+1} U_{jt+1}$$

where U_{jt+1} is a random variable with density $g(U_{jt+1})$, strictly positive support, and expected value

$$E_t(U_{jt+1}) = 1$$

(A2) The function $g(\cdot)$ is common knowledge, i.e. all agents operate with rational expectations, so that

$$P^e(t)_{t+1} = E_t(P_{t+1} U_{jt+1})$$

is the economy's expected price.

⁷One might object that two-periods life cycles of firms and workers are implausible in a production problem without "long-run" accumulation. We are aware of this objection, but we wish to draw attention to the fact that, theoretically, the problem our economy should solve is in fact a problem of capital borrowing and lending, though it is *circulating* instead of fixed capital (on this point see also Greenwald-Stiglitz, 1993). Indeed a two-period intertemporal setup is common to most models of credit relationship on which we draw in this paper, whereas infinite-time models usually run into unsurmountable difficulties, one being that they exclude by assumption that an agent may go bankrupt (see e.g. Hahn-Solow, 1995).

However, like in standard limited information market models, we add the assumption that the *individual* sale prices can only be observed after incurring a cost. As a consequence:

(A3) Information about the true state of a firm after realization of P_{jt+1} can be obtained by any external agent only at a cost.

1.2 Contracts

A second crucial implication of the time structure of transactions in this economy is that firms need to finance production (the wage bill) in advance at the beginning of each period t . In principle, in our economy one might assume that active agents lend to firms in a well developed bond market in period t to be reimbursed with interests in period $t+1$. Following the G-S approach, we wish to examine the case in which firms are "equity rationed", that is no capital market exists where active agents are willing to finance firms directly. Indeed, under assumption (A3) the so-called "ex-post verification problem" arises between lender and borrower⁸. In fact, since each borrower's ability to repay interest and capital is contingent on his/her firm's actual revenue, and this is not freely observable, each lender faces the eventuality that the borrower may cheat unless he/she bears the monitoring cost⁹. On the other hand, as shown by Diamond (1984) and others, the ex-post verification problem cannot have an efficient solution in a competitive bond market for two reasons. The first is the existence of a free-riding problem (each private lender has no incentive to bear the cost of monitoring the actual state of the borrower if that information is to be immediately revealed to all the others). Alternatively, the second reason is a magnification of costs (it is not socially efficient that all lenders monitor the same borrower separately). For these reasons no market for firms' bonds may ever be established.

Townsend (1979) and Diamond (1984) have also shown that in the class of one-period contingent contracts with risk-neutral parties, it is

⁸We shall ignore for simplicity the parallel information problem that agents face as consumers with no loss of generality. Simply assume that consumers choose from which firm to buy randomly thus avoiding search costs. Nonetheless, if an agent lends to a specific firm, then he/she can no longer ignore the ex-post verification problem.

⁹Note that this eventuality, unlike actuarial risk due to firms' stochastic price, is not diversifiable because *any* entrepreneur may cheat with *any* lender.

optimal for lenders to delegate state-verification to a specialized intermediary which offers "standard debt contracts" to borrowers and sight deposits to lenders, that is essentially a bank. The standard debt contract is the efficient solution to the ex-post verification problem for two reasons: I) it induces the borrower to declare his/her true state, II) it minimizes the monitoring costs¹⁰. Consequently, we assume the following:

(A4) Each entrepreneur can borrow on a competitive credit market at the beginning of each t by subscribing one-period standard debt contracts, i.e. the entrepreneur j receives the contractual amount of credit B_{jt} against his/her commitment to pay in $t+1$

$B_{jt}I_t$ if the solvency state $R_{jt+1} \geq B_{jt}I_t$ is declared

R_{jt+1} if the default state $R_{jt+1} < B_{jt}I_t$ is declared, with deterministic monitoring¹¹,

where $R_{jt+1} = P_{jt+1}Y(t)_{jt+1}$ is revenue in $t+1$, $Y(t)_{jt+1}$ is output produced in t and sold in $t+1$, and I_t is the gross interest rate.

(A5) Correspondingly, let the j -th entrepreneur's earnings scheme be the following:

$$\max(Z_{jt+1}, 0) \text{ in } t+1$$

where $Z_{jt+1} = R_{jt+1} - B_{jt}I_t$ is profit, and $Z_{jt+1} < 0$ is a state of bankruptcy. A bankrupt firm exits from the market and may be replaced by another at no social cost¹².

Finally, as regards banks in the above contractual relationships, having introduced a monitoring cost associated with each defaulting firm, we should consider the firm's revenue net of this cost, $R'_{jt+1} = R_{jt+1} - M_{jt+1}$. Hence:

(A6) Each bank b will obtain in return to loans,

¹⁰Following Williamson (1987), we prove these propositions in the Mathematical Appendix M.1.

¹¹Deterministic monitoring means that the firm is monitored and its true state is observed with certainty.

¹²Note that under (A4)-(A5), bankruptcy does not entail a net loss in the entrepreneur's earnings scheme. This is an implication of standard debt contracts that simplifies analysis considerably. By contrast, the G-S model assumes that the bankruptcy procedure is costly to the entrepreneur in such a way that he/she is forced to discount the expected bankruptcy cost in his/her firm's production plan. Nonetheless, we shall see that the key variable -the bankruptcy probability of firms- may still be made effective at the macroeconomic level through the banks' credit supply.

$$R_{bt+1} = \begin{cases} B_{bjt} I_t & \forall Z_{jt+1} \geq 0 \\ R'_{jt+1} & \forall Z_{jt+1} < 0 \end{cases}$$

2. Individual plans

2.1. Firms

Entrepreneurs active in each period t are risk neutral and seek to maximize profit. Since there are neither personal assets nor firm's internal funds at the beginning of activity, each entrepreneur should finance production with bank loans, i.e. $B_{jt} = S_t L_{jt}$, where S_t is the market money wage rate and L_{jt} is the level of employment in the firm¹³.

The structure of contracts in (A4) and (A5) is such that he/she faces two possible states in $t+1$, one with positive payoff (the solvency state) and one with zero payoff (the bankruptcy state). From (A4), it follows that the bankruptcy state occurs whenever

$$P_{jt+1} \leq S_t L_{jt} I_t / Y(t)_{jt+1} \quad \text{###} \quad V_{jt}$$

where V_{jt} is the firm's debt/output ratio. Given the probability distribution of prices in (A1), the bankruptcy probability for any firm j as of time t is:

$$(2.1a) \quad \text{###}_{jt} \quad \text{###} \quad \text{Prob}(P_{jt+1} \leq V_{jt})$$

Define $U^*_{jt+1} \quad \text{###} \quad V_{jt} / P^e(t)_{t+1}$ (i.e. the *real* debt/output ratio). Hence the bankruptcy probability can be re-written as:

$$(2.1b) \quad \text{###}_{jt} \quad \text{###} \quad \text{Prob}(U_{jt+1} < U^*_{jt+1}) \\ = \int_0^{U^*_{jt+1}} g(\bullet) dU_{jt+1} = G(U^*_{jt+1})$$

The entrepreneur's risk-neutrality and the fact that he/she bears no direct bankruptcy costs entail that his/her problem is simply one of expected profit maximization, i.e.¹⁴:

$$(2.2) \quad \max_L E_{jt}(Z_{jt+1}) = P^e(t)_{t+1} Y(t)_{jt+1} - S_t L_{jt} I_t$$

under the market entry condition

$$(2.3) \quad P^e(t)_{t+1} \geq \min(V_{jt})$$

and given the production function

¹³The two-period lifetime of entrepreneurs and firms implies that their cash-flow in the second period is fully exhausted by the entrepreneur's profit and/or debt repayment, so that each new production period should start with zero internal funds. This is equivalent to the usual "no Ponzi game" constraint.

¹⁴Proof: see Mathematical Appendix M.2.

$$(2.4) \quad Y(t)_{jt+1} = L_{jt}$$

with $0 < \beta < 1$.

Since all firms hold the same expected price, use the same technology, and face the same market values of the wage rate and the interest rate, they will implement the same production plan. It will be convenient to work with individual labour demand as representative of the whole market demand. From (2.2) we obtain for all j :

$$L_t^d = \left(\frac{S_t I_t}{\eta P^e(t)_{t+1}} \right)^{-\frac{1}{1-\eta}}$$

Note that this result implies $U_{jt}^* = \beta$ for all j . Therefore, all firms face the same bankruptcy probability $\beta_t = G(\beta)$ ¹⁵.

It will be convenient for us to work with log-linear equations (unless otherwise stated, the logarithm of each variable will be denoted by converting the notation from capital to small-case letters). The labour demand equation is therefore

$$(2.5) \quad l_t^d = \delta - \gamma(s_t - p_t + i_t \beta q^e(t)_{t+1})$$

with $\delta = \ln \eta / (1 - \eta)$, $\gamma = 1 / (1 - \eta)$, and where $q^e(t)_{t+1} = p^e(t)_{t+1} \beta p_t$ is the economy's expected inflation rate.

Note the following features of our "levered" firm's labour demand. First, because of the time lag between production and sale, the firm's employment decision is ruled by its *expected* real marginal cost (the second term on the RHS), not the current one. Second, the expected real marginal cost is the compound value of the *current* real wage rate and the *expected* real interest rate.

2.2. Workers

The structure of transactions in the economy allows a worker entering a contractual relationship with a firm to choose his/her preferred distribution of leisure and consumption over life cycle. As we shall see, this is another important feature of the model. In fact, any active worker w

¹⁵This result obviously depends on the assumed form of the production function. There may be cases in which the bankruptcy risk of firms is not independent of endogenous variables (in particular, the wage rate and the lending rate). See the G-S model for a discussion of this point. However, a fully exogenous bankruptcy risk is quite useful in view of our empirical task.

A at the beginning of time t observes the current price of output P_t and the market money wage rate S_t , and knows the economy's expected price $P^e(t)_{t+1}$. Then, given no endowment, he/she should choose how much labour to sell in period t , and how to distribute his/her period- t labour income between t , when output produced in $t-1$ is available, and $t+1$, when output produced in t will be available, knowing that interest-free bank deposits are the only asset in the economy. A worker w is assumed to choose rationally labour supply and consumption as follows¹⁶:

$$(2.6) \quad \max_{C,L} u_{wt} = (C(t)_{wt})^a (C(t)_{wt+1})^{1-a} - cL_{wt}^b$$

subject to

$$(2.7a) \quad L_{wt} \leq H$$

$$(2.7b) \quad P_t C(t)_{wt} + D_{wt} = S_t L_{wt}$$

$$(2.7c) \quad P_{t+1} C(t)_{wt+1} = D_{wt}$$

with $0 \leq a \leq 1$, $b > 1$, $c > 0$, where L_{wt} is labour supply in t , H is social maximum working time, D_{wt} are deposits, and $C(t)_{wt}$, $C(t)_{wt+1}$ are, respectively, consumption in t and $t+1$ of the t -th generation.

Again, we can take the solution to the above problem as the representative of the economy's labour supply function, whose log-linear form results to be:

$$(2.8) \quad \ln s_t = \alpha + \beta_1 (s_t - p_t) - \beta_2 q^e(t)_{t+1}$$

with $\beta_1 = 1/b-1$, $\beta_2 = 1-a/b-1$

Note that the worker's choice between leisure and consumption *and* between present and future consumption is ruled by the current real wage rate $(s_t - p_t)$ and the expected inflation rate $q^e(t)_{t+1}$. The cross-elasticity between *present* leisure and *future* consumption is not nil: higher expected inflation shifts resources from future to current consumption of goods (i.e.

¹⁶This utility function entails that leisure and consumption are normal substitutable goods, and therefore it has been employed in many recent macroeconomic studies of the labour market (see e.g. Dixon-Rankin, 1995). It can usually be found in one-period problems with real money balances as an argument, but it is clear that in our present setup real money balance are only a store of value for future consumption (see 2.7c) Moreover, (2.6) and the related optimization problem can also be considered as a specialization of the general life-cycle model of consumption and leisure choices proposed by Lucas-Rapping (1969) and Sargent (1986).

output and leisure) so that output demand is increasing and labour supply is decreasing in the expected inflation rate¹⁷.

2.3. Central bank and commercial banks

In the present framework, as explained in section 1, commercial banks (banks for short) intermediate between workers, who are unwilling to lend to firms directly, and firms, which need funds to pay for their wage bill. Bank deposits are the only asset in this economy, which allows workers to solve their desired intertemporal distribution of consumption. We have seen above that (risk-neutral) profit-maximizing firms under standard debt contracts need *not* discount their bankruptcy probability. As we shall see below, it is the banks that should internalize this event, and consequently, whenever a default state materializes the defaulter's illiquidity is transmitted to the bank and eventually to its depositors. Protection of depositors against this eventuality is ensured by the central bank's acting as lender to banks. In modelling the commercial banks, we shall introduce this particular connection with the central bank, which also provides the connection between the central bank and the economy.

We consider a competitive credit market where each bank b is a risk-neutral individual agent $b \in A$ allowed to operate as follows:

- ### lend to firms (B_{bt}) at the market gross rate I_t ;
- ### supply the deposit service (D_{bt}) at no cost and zero interest;
- ### borrow reserves from the central bank (BR_{bt}) at the gross rate K_t .
- ### hold reserves with the central bank (BD_{bt}) at zero interest (there are no mandatory reserves).

Therefore, the bank's outstanding assets and liabilities in any t are:

$$(2.9) \quad B_{bt} + BD_{bt} = D_{bt} + BR_{bt}$$

¹⁷See again Sargent (1986). Note that the labour supply function that we have obtained nests two noteworthy special cases. The first is the well-known New Classical function à la Sargent-Wallace where labour supply only depends on *the expected real wage*, which obtains if $a = 0$, $\beta_2 = \beta_1$, i.e. if workers ignore current consumption (or the present time is virtually nil). The second is the G-S function in the (1993) paper where labour supply only depends on *the current real wage*, or $a = 1$, $\beta_2 = 0$, i.e. workers ignore future consumption. Both special cases seem to impose unwarranted restrictions.

Here we do not study the composition of reserves, which is of minor importance for our purposes, and instead assume that all reserves are borrowed; hence we set $BD_{bt} = BR_{bt}$ which implies $B_{bt} = D_{bt}$ ¹⁸.

The bank's assets and liabilities at time t give rise to the following intertemporal budget constraint:

$$(2.10) \quad D_{bt} = B(t)_{bt+1} + BR_{bt}$$

where $B(t)_{bt+1}$ is repayments (principal) at time $t+1$ of loans (capital) of period t . This budget constraint arises from the fact that in each t the bank lends B_{bt} to firms and receives D_{bt} from workers. Thus the bank must ensure that its depositors are able to withdraw as much as they want in the next period. The assumed sequential structure of transactions implies that workers spend all their deposits by the end of $t+1$ (see par.2.2). To this end, in $t+1$ the bank can rely on the principal of loans of period t $B(t)_{bt+1}$, and on its own reserves BR_{bt} carried over from t .

Therefore, given D_{bt} , I_t and K_t , the banker should choose BR_{bt} in order to maximize his/her expected profit $E_{bt}(Z_{bt+1})$ given by the gross expected revenue from loans $E_{bt}(R_{bt+1})$ after repaying reserves and deposits, i.e.:

$$(2.11) \quad \max_{BR} E_{bt}(Z_{bt+1}) = E_{bt}(R_{bt+1}) - BR_{bt}K_t - D_{bt}$$

subject to (2.10)

To solve this problem, let us first compute the expected revenue from loans $E_{bt}(R_{bt+1})$. Given assumptions (A4)-(A5)-(A6), the bank will obtain

$$R_{bt+1} = \begin{cases} B_{bjt} I_t & \forall Z_{jt+1} \geq 0 \\ R'_{jt+1} & \forall Z_{jt+1} < 0 \end{cases}$$

As to the relevant probabilities, recall expression (2.1) and that $U^*_{jt+1} = G(\phi_{jt})$ for all j , so that all firms face the identical bankruptcy probability, $\phi_{jt} = G(\phi_{jt})$. Under assumption (A1), banks too are in a position to know the correct bankruptcy probability in the economy, and hence they all discount the same bankruptcy probability of borrowers $\phi_{bjt} = \phi_t$, all b, j . Hence we

¹⁸Since the banker is risk-neutral, this assumption holds as long as the central bank's rate K_t does not exceed to opportunity cost of subtracting reserves from loanable deposits given by the market rate I_t .

may call ϕ_t the *systemic bankruptcy risk*¹⁹. Therefore, the bank's expected revenue from loans to solvent firms is

$$(1 - \phi_t)B_{bt}I_t$$

whereas its expected revenue from to defaulting firms is:

$$\int_0^{U^*} (Y(t)_{jt+1} P^e(t)_{t+1} - M_{jt+1}) g(\bullet) dU_{jt+1}$$

The latter can be simplified as follows²⁰:

$$\rho_t B_{bt},$$

where

$$\rho_t \equiv \frac{1}{\eta} \int_0^{U^*} U_{jt+1} g(\bullet) dU_{jt+1} - m$$

corresponds to the expected return rate to loans to defaulting firms (i.e. the excess of the average unit real revenue of defaulting firms over the unit real monitoring cost m). Note that a necessary and sufficient condition for the bank to be willing to monitor its defaulting borrowers and thus to recover the above amount is that the nominal monitoring costs should not exceed the borrower's nominal debt, which is equivalent to $\rho_t \geq 0$ ²¹. In order to simplify specification in view of empirical analysis, we may assume that $\rho_t = 0$ ²². Consequently, the bank's expected revenue from loans coincides with the revenue from solvent firms:

$$(2.12) \quad E_{bt}(R_{bt+1}) = (1 - \phi_t)B_{bt}I_t$$

This result also implies non-zero reserves. First note that at t , the bank faces a source of uncertainty over its future budget: $B(t)_{bt+1}$. Since $B_{bt} = D_{bt}$, as is clear from (2.10) a positive demand for borrowed reserves exists

¹⁹This result is consistent with the principle that in a competitive credit market there will be a tendency for efficiently managed loans to face a common systemic (undiversifiable) risk reflected in the common estimated value ϕ_t .

²⁰We exploit the following relationships previously given, the debt/output ratio $B_{jt}/Y(t)_{jt+1} = \rho P^e(t)_{t+1}$ (see par.2.1), which implies $Y(t)_{t+1} P^e(t)_{t+1} = B_{jt}/\rho$, and the nominal monitoring cost $M_{jt} = mY(t)_{t+1} P^e(t)_{t+1}$ (see Mathematical Appendix, M.1).

²¹See Mathematical Appendix M.1, equation (1*)

²²As we see from equation (2.11) the consequence is an underestimation of the expected return to loans of banks. However, in practice, the ability of banks to recover bad loans is limited and the legal procedures are quite costly (this is especially true in Italy); hence ignoring this component is close to banks' practices and is of minor quantitative importance.

to the extent that the expected principal of loans falls short of the amount of loans themselves, i.e.:

$$(2.13) \quad BR_{bt} = B_{bt} \mathbb{E}_{bt}(B(t)_{bt+1})$$

Equation (2.12) entails that the bank should expect to recover the fraction $(1 - \phi_t)$ of loans B_{bt} . Substituting it into (2.13), we obtain the optimal amount of borrowed reserves as a fraction of loans, $BR_{bt} = \phi_t B_{bt}$

We are now able to compute the bank's expected profit as follows:

$$(2.14) \quad \mathbb{E}_{bt}(Z_{bt+1}) = (1 - \phi_t)B_{bt}I_t - \phi_t B_{bt}K_t - B_{bt}$$

Imposing the competitive condition of zero expected profit, all banks will display a flat supply function at the competitive interest rate, whose log-linear expression is²³:

$$(2.15) \quad i_t = k_t + \lambda_t$$

where $\lambda_t = \ln((1 + \phi_t)/(1 - \phi_t))$ $\in [0, \infty]$. That is to say, credit supply is fully determined by demand whereas the interest rate is an increasing function of the central bank's rate plus a "risk premium" proportional to the systemic bankruptcy risk²⁴.

3. Macroeconomic equilibrium and testable implications

At the beginning of each new operation cycle t , the equilibrium equations for the labour and credit markets obtained in the previous section are, respectively:

$$(3.1) \quad \delta - \gamma(s_t - p_t + i_t - q^e(t)_{t+1}) = \alpha + \beta_1(s_t - p_t) - \beta_2 q^e(t)_{t+1}$$

$$(3.2) \quad b_t = s_t + I_t$$

$$(3.3) \quad i_t = k_t + \lambda_t$$

Therefore, the labour and credit markets determine the nominal wage rate s_t , the level of employment I_t , the bank interest rate i_t , and the amount of bank loans b_t , given the central bank's rate k_t , the credit risk premium λ_t , and the economy's expected inflation rate $q^e(t)_{t+1}$.

At the end of the operation cycle, in $t+1$ firms sell output on the goods market. Since output is perishable it has to be sold out. Aggregate demand will consist of two components: one coming from the population active in period t (real savings and real profits), one coming from the workers active

²³For precision, we have taken the first-order Taylor expansion of

$$i_t = \ln((1 + K_t \phi_t)/(1 - \phi_t))$$

around $K_0 = 1$, where $k_t = 1 - K_t$ is the net central bank's rate

²⁴Note that $d\lambda_t/d\phi_t > 0$.

in period $t+1$ (current consumption). Real savings coincide with workers' real deposits carried over from the previous period. Hence aggregate demand in period $t+1$ is:

$$D_t/P_{t+1} + Z_{t+1}/P_{t+1} + C(t+1)_{t+1}$$

Under the assumption that the exogenous variables (k_t, ϕ_t) evolve stochastically from one period to the next, the market-clearing output price in $t+1$ entails the following inflation rate²⁵

$$(3.4) \quad q_{t+1} = q_o - \frac{b-\eta}{\eta a} (\theta_t + k_t) + \alpha' \omega_{t+1}$$

where α' is a vector of coefficients and ω_{t+1} is a vector of i.i.d. zero-mean stochastic disturbances to the exogenous variables.

According to the rational-expectations hypothesis in assumption (A1), given p_t we should set $q^e(t)_{t+1} = E_t(q_{t+1})$. The resulting RE macroeconomic equilibrium at time t is given by the following system:

$$(3.5a) \quad \begin{bmatrix} s_t^* \\ i_t^* \\ y^*(t)_{t+1} \end{bmatrix} = \begin{bmatrix} s_0^* \\ i_0^* \\ y_0^* \end{bmatrix} + \frac{1}{\Delta} \begin{bmatrix} \Delta - (b-\eta)^2(a^{-1}-1) & -(b-\eta)^2(a^{-1}-1) \\ 0 & \Delta \\ 0 & -\eta b \end{bmatrix} \begin{bmatrix} p_t \\ k_t \\ \theta_t \end{bmatrix}$$

System (3.5) expresses the RE equilibrium values of the endogenous variables at time t as a function of the two credit variables (k_t, θ_t) . These values should be understood as the equilibrium values that the relevant variables take after a permanent change in the exogenous variables. System (3.5) and equation (3.4) give the model's complete solution.

Our result can be used to examine and discuss theoretical and empirical issues in the credit view. Here we limit ourselves to two main testable implications of our model. The first concerns the non-neutrality of credit variables, the second concerns the correct identification of the credit channel for empirical analysis.

First of all, system (3.5) yields the following non-neutrality proposition:

(P1) *The RE-equilibrium real variables, employment and output, are negatively correlated with the credit variables*²⁶.

²⁵Proof: see Mathematical Appendix M.3

This is, for obvious reasons, the most controversial issue. As a matter of fact, the idea that the new microfoundations of imperfect capital markets would lead to non-neutrality results, even in the presence of full price flexibility and rational expectations, was one of the main motivations behind the revival of the "credit view" (Greenwald-Stiglitz, 1993b). However, some authors hold that for the credit variables to have real effects some form of price stickiness should still be present (see e.g. the discussion in Kashyap-Stein, 1994). This seems obvious insofar as the BLC is viewed as an amplifier of monetary shocks to aggregate demand like in the CC-LM models. Our model, where neither price stickiness nor "money illusion" are present, sheds light on the conditions under which non-neutrality holds.

First, the transmission mechanism from the credit variables to the real ones is quite different from the IS-LM mechanism (old and new) since it involves *the supply side* of the economy. The responsiveness of the real variables to changes in the credit variables depends on output's elasticity to labour inputs η , and on the labour-supply elasticities β_1 , β_2 ²⁷.

The economic meaning of the parameters β_1 and β_2 in the labour supply function, or of the underlying parameters a and b in the workers' utility function, should be examined carefully. The standard assumption that $0 < a < 1$, $b > 1$ implies that $\beta_1 > \beta_2$, which means that the utility-maximizing labour supply displays a weak intertemporal substitution effect -i.e. it reacts more to changes in the current real wage than in the expected inflation rate (see also section 2.2 above). The consequence is the following. Assume the economy is in equilibrium at points A in figure 2, and consider the case of a rise in the systemic bankruptcy risk ϕ_t . Since $d\phi/d\phi > 0$, this displaces the credit supply function (left-hand panel), raises i_t and generates a higher (expected) real interest rate for firms (due to higher i_t and lower q^e_{t+1}). Hence labour demand shifts downwards (right-hand panel). This effect is less than compensated by the fall in the current real wage rate, thus leaving the firms with a higher real marginal cost. The reason is that the effect of expected deflation on s_t is weaker the smaller is

²⁶Since $b > 1$, and $\phi < 1$, ϕ is necessarily positive. Note that in the present model the labour market clears, so that employment may be high or low but there is never Keynesian unemployment.

²⁷More generally, we may expect these factors to operate for all the production means that are purchased by debt.

$\epsilon_{2,t}$, i.e. the higher is a above zero, which gives rise to *seemingly* "sticky" adjustment of s_t . The new equilibrium is at points B with lower credit and lower employment.

A noteworthy feature of our model is that the monetary policy variable has the same effects on credit supply and economic activity as the risk variable. Hence the thrust of our analysis is that monetary policy through the credit channel has permanent effects on employment and output to the extent that 1) it induces banks to change their lending rate, 2) firms (rationally) revise their expected value of the real interest rate (indirectly, the central bank is capable of altering the real lending rate for firms), and 3) the labour market mechanism cannot guarantee that the change in the expected real interest rate is exactly offset by the opposite change in the current real wage rate. Therefore, we should be aware that testing for the non-neutrality of the credit variables implies testing for the parameters that rule the response of labour demand and supply to changes in the nominal prices of labour and credit and in the expected inflation rate.

[Figure 2]

We now come to the second issue, the "causation puzzle" in relation to the correct identification of the credit channel of monetary policy. Current empirical research has clarified that

to find evidence of the lending channel, [...] you need to make a set of identifying assumptions to argue that the supply, rather than the demand for credit, has moved in response to a monetary policy shock (Eichenbaum, 1994, p.257).

A full system of demand-supply equations like (3.5) with two distinct sources of shocks can help in this identification task²⁸. To begin with, our null hypothesis is that the credit channel operates *vis-à-vis* the alternative hypothesis that it does not.

1) H_0 : *the credit channel operates*. Under this hypothesis, we may further assume that whereas the risk variable $\epsilon_{2,t}$ necessarily activates the credit channel, the policy variable k_t may or may not. Hence:

H_{00} : the credit channel of monetary policy operates

²⁸A widely used identification strategy consists of disaggregating the economy in two sets of agents one of which is bank-dependent (e.g. small firms) while the other is not (e.g. large firms), and inferring the presence of the BLC from the differential response of the two sets to a monetary policy shock (see e.g. Gertler-Gilchrist, 1993, 1994, Rondi et al., 1998). Here we have sought for a methodology consistent with a parsimonious aggregate specification of the model economy.

H_{01} : the credit channel of monetary policy does not operate

The identifying signal given by system (3.5) is the sign of the comovements between the lending rate and output consequent to each of the exogenous shocks. If H_{00} holds, both $###_t$ and k_t exert the same negative effect on credit supply, thus after a policy shock i_t should *rise* as $y(t)_{t+1}$ *falls*. If the policy variable instead affects aggregate demand and hence credit demand, but not credit supply, that is H_{01} holds, i_t should *not rise* (and might possibly fall) as a consequence of a reduced credit demand and a constant credit supply.

An analogous exercise can be done with the wage equation (3.5a). Again, under H_{00} both k_t and $###_t$ have a negative effect on s_t as they induce changes in labour demand as explained above. Under H_{01} , k_t can only have real effects as long as s_t fails to adjust.

2) H_1 : *the credit channel does not operate*. If this hypothesis holds we expect that our data first of all reject the significance of coefficients of $###_t$ for s_t and $y(t)_{t+1}$ ²⁹.

Our identification scheme of the credit channel is summarized in table 1. As can be seen, the various cases do not overlap so that identification can be reliable³⁰.

Table 1. Testable hypotheses

H_{00}	ρ_t	k_t	$###_t$
s_t		###	###
i_t		+	+
$y(t)_{t+1}$		###	###
H_{01}	ρ_t	k_t	$###_t$
s_t		0	###
i_t		###, 0	+
$y(t)_{t+1}$		###, 0	###

²⁹We wish to exclude a priori that the credit channel may operate via the policy variable but not via the risk variable.

³⁰By contrast, our analysis confirms that observing the comovements between a policy variable and output or between output and bank loans is not sufficient to establish that the credit channel of monetary policy works because the sign of comovement is the same as under the traditional monetary channel.

H_1	p_t	k_t	$###_t$
s_t		0	0
i_t		###, 0	+
$y(t)_{t+1}$		###, 0	0

In addition, our theoretical model contains a stronger null hypothesis on coefficients, namely that the coefficients of the two credit variables are equal under H_{00} . We tested this further restriction separately.

4. Empirical analysis

In this section we turn our attention to an empirical analysis of the theoretical model described in the previous section. We have estimated the complete model's solutions given by system (3.5) and equation (3.4) with quarterly Italian data running from 1987:4 to 1997:1³¹.

4.1. Preliminaries

As we have recognized at the beginning, the *modus operandi* of money supply, credit supply and monetary policy is highly sensitive to the institutional setup and the market structures of an economy. The relative importance and impact of the different channels of monetary transmission may vary over time. Italy monetary institutions and markets have undergone substantial changes in the last decades. We have chosen a relatively short time span for our sample -at the cost of losing observations - because it was only by the mid-'80s that the most important money-market reforms had been accomplished in connection with full participation to the European Monetary System (EMS). Other financial innovations certainly took place in the course of our sample period. However, the microfounded structural specification of our model is meant to capture the invariant characteristics of the economy as much as possible (this point will further be considered below with reference to central bank's behaviour). The most sensitive characteristic behind our model is firms' bank-dependence, but many studies that we have mentioned in previous parts of the paper show

³¹ The data set is described in the Statistical Appendix S.4.

that this characteristic has not been substantially reduced by recent financial innovations.

In the empirical implementation of our model we had to solve some important data problems. The first derives from the time structure of the model. We have chosen to work with a 4-quarters "production period", that is to say, we have assumed that the output data, the real GDP quarterly time series, embody firms' decisions made on the basis of 4-quarters price expectations. After preliminary trials this turned out to be a good approximation to our theoretical time structure. As it is shown in figure 3, after a long period of stable growth, starting from the first quarter of 1992, the real GDP declined for 5 quarters up to the middle of 1993. After then, the GDP reverted to its increasing path. 1992 was indeed a crucial year with a crucial monetary "experiment" due to the deterioration of the position of the lira in the EMS, the speculative attack in September and the increasingly restrictive stance of the Bank of Italy.

[Figure 3]

Likewise, the specification of the inflation equation (3.4) should be consistent with the theoretical time structure of the model. Therefore, for each time t we have chosen a 4-quarters lead for the inflation rate. Moreover, considerations concerning series' stationarity (see below par.4.2), and symmetry with the specification of the other equations in the system, have suggested us to estimate equation (3.4) in the price level instead of the first difference, i.e.:

$$(4.1) \quad p_{t+1} = p_0 + p_1 p_t + p_2 k_t + p_3 \pi_t + \pi_{t+1}$$

knowing that the model implies the restrictions $p_1 = 1$, $p_2 = p_3$

A second problem concerned the measure of the two exogenous credit variables. As to the policy variable, a lot of empirical work has recently been developed in search of a reliable measure of policy stance in the context of VAR models³². The problem faced by these models is that the observed time series of policy variables may be thought of as the result of an endogenous part (i.e. the central bank's reaction function to other macroeconomic variables in the model) and a genuine exogenous part. Typically these models do not estimate a fully specified structural model of the economy (i.e. they do not contain agents' optimal reaction functions to market signals);

³²Bernanke-Mihov (1995), Christiano et al. (1996), Rudebusch (1998), Bagliano-Favero (1998), De Arcangelis-Di Giorgio (1998).

therefore, in force of the Lucas' critique *it is assumed* that only the exogenous (unanticipated) component of policy variables matters in order to gauge the effects of monetary policy, and the identification of this component is left to statistical analysis (see e.g. Rudebusch, 1998, p.907). As far as this problem is concerned, we do have a structural model of the economy, where all private agents' optimal reaction functions to market signals are specified, whose result is that the *observed* changes in the policy variable have real effects after taking into account rational expectations. In other words, the distinction between anticipated (endogenous) and unanticipated (exogenous) changes in the policy variable is not crucial in our setup. Granted that central banks do have reaction functions themselves which may ideally be part of a complete model, we have preferred to exploit the non-neutrality property of our model and use the observed time series of the policy variable directly, rather than imposing any joint hypothesis from outside between "what really matters" and "what does not".

Moreover, there are a priori considerations supporting the hypothesis that the policy rates were largely independent of the domestic macroeconomic variables over the sample period, the main reason being that Italy was a member of the EMS and was engaged in the convergence process towards admission to the single currency, which imposed strong exogenous constraints on monetary policy. Independent analyses have shown no significant responsiveness of policy interest rates to domestic macroeconomic variables (e.g. Angeloni, 1994, Visco, 1995).

To measure the policy variable we have relied on existing evidence and practice in Italian studies pointing to the overnight rate as a good measure of the monetary policy stance in Italy (De Arcangelis-Di Giorgio, 1998, Buttiglione-Ferri, 1994). As shown by figure 4, where the discount rate, the overnight rate and the average lending rate of banks are reported, the whole set of rates tends to move concomitantly. From the end of 1990 the overnight rate has been closely following the discount rate, and therefore gives us a good indication of the policy followed by the Italian monetary authorities. Finally, the overnight rate has also passed the test of weak-exogeneity that we have run among other estimation diagnostics³³.

[Figure 4]

³³See the Statistical Appendix S.4.

As to the risk variable, this is a theoretical variable which is not directly observable, and hence it has been necessary to extract information about it using some indirect method. Main credit risk indicators currently used in empirical applications have several drawbacks from our viewpoint, not least too low time frequency³⁴. Since the economic meaning of $###_t$ in our model is the identification of exogenous shifts of credit supply, we have used as a proxy the residuals of an independent econometric regression of a credit equation consistent with our theoretical model, after controlling for the demand-side component of credit data and for the orthogonality with other regressors³⁵. The plot of the residuals that we have obtained (figure 5) follows closely the time profile of estimated bank risk given by other sources of information (see e.g. Banca d'Italia, 1997b, Morelli-Pittaluga, 1997). It is interesting to note that our proxy in figure 5 reacts to the 1992 episode with about 3 quarters lag. In fact, after a three years period of decline, in the second quarter of 1993 the proxy starts to increase and stabilizes after 1995. Such a behaviour is consistent with the deterioration of the Italian firm profitability that followed the exit of the lira from the EMS and with the fact that Italian firms' profits recovered after 1995. Of course, we cannot take it for granted that our proxy captures *only* credit risk as implied by the theoretical model, but if it identifies credit supply shocks correctly, the pattern of correlation signs of this variable with the endogenous ones should be consistent with those expected under the null hypothesis in table 1³⁶.

[Figure 5]

³⁴Data on banks overdue bills made available by the Italian central bank are often used in this connection. This indicator has several shortcomings, the most serious one being that it refers to current or past deterioration in banks' accounts rather than to future expected risk. Moreover, reports of banks on overdue bills may reflect banks' own accounting strategies and have only recently been introduced in Italy.

³⁵This methodology goes back to the identification of "news" in exchange-rate models and is also largely employed in current models with monetary policy "innovations" (see e.g. Rudebusch, 1998). Furthermore, it should be recalled that Pagan (1984) showed that when residuals from auxiliary regressions are used as generated regressors in other equations, the estimators are consistent, efficient and valid inference can be made. The estimation procedure is explained in the Statistical Appendix S.1.

³⁶Alternatively, suppose that our proxy is affected by credit *demand*, instead of supply, shocks. Then, it should result to be *positively*, not negatively, correlated with output and the wage rate.

4.2 Estimation procedure

It is well known that macroeconomic time series often contain unit roots and display non-stationary behaviour. Since the presence of non-stationarity in the data has important implications for the choice of an appropriate estimation technique, we have run a preliminary test for stationarity.

In the following table 2, we report the results of Phillips-Perron unit-root tests. In the test equations we alternatively included an intercept and an intercept plus a trend. The second and fourth columns of the table present tests on the log-level of the series, while the third and fifth ones report unit-root tests on the first difference of the variables. According to the table, with the exception of the overnight rate k , all series contain unit roots and are $I(1)$ since their first differences are stationary. An implication of such a result is that cointegration among variables may exist.³⁷

Table 2: Phillips-Perron Unit root test

	Intercept		Intercept and trend	
	x	dx	x	dx
s	-2.06	-5.69	-0.85	-6.30
i	-1.23	-4.17	-2.02	-4.27
y	-2.12	-5.06	-2.33	-5.22
k	-3.39	-9.39	-3.92	-9.35
###	-2.39	-7.08	-2.34	-7.11
p	-0.98	-3.58	-2.07	-3.59
5% critical values	-2.94		-3.53	

Given the existence of non-stationarity and cointegration in our data set, we have not estimated the equations system with OLS because OLS standard errors would not be consistent and could not be used for hypothesis testing. Furthermore, even if OLS estimates of parameters in cointegrating equations are “super-consistent”³⁸, they nonetheless suffer

³⁷We have also performed a Johansen multivariate ML cointegration test, which supports the hypothesis that three cointegrating vectors exists. The results of tests based on Johansen's methodology are presented in the Statistical Appendix S.3.

³⁸ Given a sample size T , “super-consistency” means that OLS estimates of a cointegrating vector $\hat{\beta}$ converge to the “true” parameter vector ### as **Error! Bookmark not defined.** at a rate T rather than **Error! Bookmark not**

from a “second order” bias due to the fact that OLS do not take into account serial correlation and long run endogeneity among the regressors (see Phillips, 1995). However, Phillips has shown that with suitable corrections to OLS it is possible to obtain an efficient and consistent estimator of systems with $I(1)$, $I(0)$ and cointegrated regressors even in the absence of knowledge of the exact number of cointegrating vectors³⁹. Phillips' "Fully Modified -OLS" estimator has several useful properties that we have exploited in our work.

1) First of all, it allows researchers to treat equations like those in our system as time series regressions with no need to model the short run dynamics of the system or even pre-test the data for unit root and cointegration as in the Johansen approach⁴⁰. From this point of view, Montecarlo studies⁴¹ show that even though the Johansen ML and the Phillips FM-OLS estimators share the same asymptotic distribution, in finite samples the FM-OLS estimator compares well and often seems to behave better than the more popular Johansen's one. This is mainly due to the fact that the latter estimator may suffer from the difficulties involved in the correct short run dynamic specification of the model. This problem is avoided in the Phillips approach, since it treats the short run dynamics non parametrically, so that the researcher may concentrate on the long run properties of the system.

2) Crucial to FM-OLS estimation is instead the absence of any cointegrating link among the regressors and the choice of a suitable kernel estimator of the long-run covariances. As to the first requirement, we have run the ADF Engle-Granger (EG) and Johansen Trace cointegration tests on the three regressors (k_t , $###_t$, p_t). The results are reported in table 3. In

defined., as it happens in the standard case of OLS estimates with stationary variables.

³⁹Phillips' procedure is summarized in the Statistical Appendix S.2.

⁴⁰ “Our approach is designed to enable an investigator to treat (...) as a time series regression without pre-testing the regressors for unit root and cointegration (...) Under broad conditions we find the rather surprising outcome that the limiting behavior of [the coefficient matrix] is the same as it would be if we knew the stationary and nonstationary directions of [the regressors] and modified the estimator accordingly” (Phillips, 1995, pp.1030 and 1034).

⁴¹ See among others Cappuccio and Lubian (1993, 1994a, 1994b, 1996), Hansen and Phillips (1990) and Hargreaves (1994),

no case we can reject the null hypothesis of no cointegration, since both the Trace and EG test are below their 5% critical levels .

Table 3: Engle-Granger and Johansen Trace Test on the regressors set

	Engle-Granger ADF cointegration test (Augmented Dickey-Fuller test on cointegrating regression residuals)			Johansen Trace test
	$k_t = \alpha + \beta t + \gamma$	$\alpha_t = \alpha$	$\rho_t = \alpha + \beta t + \gamma$	
Cointegrating regressions (EG test)	-2.671	-2.636	-3.229	22.60
cointegration	-3.501	-3.478	-3.478	29.68
	<i>5% critical values</i>			

As to the second requirement, Phillips (1995) shows that the Parzen, Tukey-Hanning, Bartlett and quadratic spectral kernels may be used to accomplish such a task. The estimation programme we have used, among others provides all the above kernel.

3) Another difference with the Johansen's approach is that, while in the latter cointegrating vectors are normalized after they are estimated, in the Phillips' approach normalization is in some sense "imposed" before estimation. In our case the distinction among endogenous and exogenous variables is based on a priori theoretical reasons and is the result of the formal analysis of the model we wish to test. It is important to note, however, that such a normalization is also compatible with the results of the Johansen methodology⁴².

4.3 Estimation results

In this section and in tables 4 and 5 we report our FM-OLS estimate of the equations system (3.5) and equation (4.1), along with a set of tests on the restrictions that our theoretical model places on them⁴³. We first present and comment on the results, then we also discuss some caveats.

⁴²This is shown in the Statistical Appendix S.3.

⁴³ We estimated our model using the COINT 2.0 package written by Ouliaris and Phillips for GAUSS. In particular, we used the FM-OLS instruction with a Parzen kernel and automatic bandwidth.

Main results. Starting from table 4, we note that the estimated coefficients are correctly signed and all but one are significant. Furthermore, the explanatory power of the wage and output equation measured by the R^2 statistic seems to be good. From this point of view, the behaviour of the interest-rate equation is not satisfactory. In fact, though all the coefficients are significant, R^2 is extremely low. A closer analysis of the data, however, shows that, in general, the k_t series displays a higher variability than the i_t series. This was particularly evident in the third quarter of 1990, when k_t sharply declined *vis-à-vis* a stable i_t , and after the currency crisis in 1992 when it peaked and declined much faster than i_t (see figure 4).

Table 4: FM-OLS estimates, quarterly data 87:4-97:1

	p_t current price index	k_t overnight rate	$###_t$ credit risk	Constant	R^2
s_t nominal wage rate	1.214** (28.719)	-0.061 (1.419)	-2.467** (4.241)	-1.088	0.88
i_t lending rate	-0.352* (3.392)	0.397** (13.424)	0.749** (4.919)	3.292	0.06
$y(t)_{t+1}$ real GDP	0.253** (119.07)	-0.267** (4.775)	-0.281* (3.284)	6.083	0.89
p_{t+1} future price index	0.981** (2561.45)	### 0.012 0.024** (2.66)	###	0.12 (2.16)	
Critical values	### ² ### =3.841	=0.05)	### ² ### (=0.1) =	2.706	

Note: **###**² tests in parentheses under coefficient estimates; * coefficient significant at 10% level; ** coefficient significant at 5% level.

Let us now assess these results from the viewpoint of the two main empirical issues in this paper: the identification problem of credit supply shocks, and the permanent real effects of monetary policy through the BLC.

As regards the first issue, our results may be interpreted as evidence of the existence of a genuine BLC in the Italian economy in the sense explained in section 3.2 (see also table 1). Such an interpretation is supported by the analysis of the restrictions implied by our theoretical model. We may start noting that the signs of the estimated coefficients in table 4 do not reject the H_{00} hypothesis in table 1. In fact, 1) if the risk variable $###_t$ increases (decreases), it exerts a negative (positive) influence

on $y(t)_{t+1}$ while i_t rises (falls), which indicates a credit supply, instead of a credit demand, contraction (expansion); 2) the signs of the relevant coefficients of the policy variable k_t are the same as those of $###_t$. Alternative hypotheses, such as those purely based on aggregate demand effects are not supported by our data since our estimation shows that an increase in the policy variable exerts a permanent positive effect on the bank interest rate, whereas aggregate demand transmission would imply either negligible or negative effects.

Note also that thanks to the general equilibrium structure of our model we can extract further information on the production *supply side* effects of credit shocks from the estimated wage and price equations. The two nominal variables display a similar pattern, namely that 1) the p_t coefficient is highly significant, and statistically it is not possible to reject the hypothesis that its value is equal to 1; 2) the $###_t$ coefficient is also significant with a negative sign, showing a correct reaction of the nominal variables to credit-induced changes in labour and output market conditions; 3) the k_t coefficient once again has the same sign as $###_t$ but does not pass the significance test. The economic meaning of these findings is that the real effects of credit supply shocks in our data set cannot simply be attributed to wage-price rigidity: both nominal variables do respond correctly albeit moderately. Moreover, since our estimated equations embody the rational-expectations hypothesis concerning future price changes, the above result also proves indirectly that the "price puzzle" is indeed absent when the product supply side of the economy is correctly specified. However, the lack of significance of k_t on the nominal variables with respect to $###_t$ raises the possibility that the *policy induced* component of credit supply shocks may be amplified by some nominal stickiness. On the other hand, pure statistical factors that may interfere with economic interpretation should also be taken into account: 1) the quarterly price index is much less variable than the overnight rate, 2) the 4-quarters lead of p_{t+1} relative to k_t may be a rather long time span: prices may react faster than output, and in fact other estimations of the p_{t+1} equation that we have run over shorter time spans have shown that k_t is significant.

Given the multi-equation structure of our test and the nature of our identification procedure summarized in table 1, we are even more interested in the consistency of the pattern of estimated parameters with table 1 than in each of them taken separately. Thus our results are further supported by

a formal Wald test, shown in table 5, which indicates that it is not possible to reject the strong H_{00} hypothesis *and* that the coefficients of k_t and $###_t$ in the equations of i_t and $y(t)_{t+1}$ are *equal* as implied by the theoretical model. At the same time it is not possible to accept the weak H_{01} alternative hypothesis that the credit channel is not activated by k_t . As to the strong H_1 alternative hypothesis that the credit channel does not operate at all, our data do not allow us to accept it at a high significance level. Finally, a joint Wald test of H_{01} and H_1 leads to rejection at a 1% significance level.

Table 5: Wald test on parameter restrictions

	Wald test	5% Critical value	1% Critical value
H_{00}	$###^2_{(3)} = 4.574$	7.815	11.341
H_1	$###^2_{(3)} = 12.445^{**}$		
H_{01}	$###^2_{(2)} = 6.195^*$	5.991	9.21
H_{01} and H_1	$###^2_{(5)} = 15.682^{**}$	11.170	15.086

Note: * and ** indicate rejection at a 5% and 1% significance level

This brings us to the second issue. Overall, our estimates show evidence of a real impact of the policy variable k_t that is consistent with our model prediction: a restrictive policy which increases the level of the overnight rate reduces bank credit supply, raises the real interest rate for firms and therefore has a permanent negative impact on production and the with a 4-quarters lag⁴⁴. Our preliminary cointegration analysis made on system (3.5), combined with the considerations put forward above, suggest that this result can be interpreted as a long-run equilibrium relationship consistent with non-neutrality proposition (P1) of section 3.

Caveats. We already recalled in the Introduction the traditional strong priors in favour of the credit channel in Italy. Our analysis lends further support to this view. Yet we also wish to recall some caveats.

Our model has not been conceived as a realistic portray of the Italian economy but as an "ideal type" of a credit economy in order to *isolate* quantitatively the presence of the BLC in the monetary transmission mechanism. In so doing we have deliberately ignored some structural features and other potential channels of monetary transmission in the Italian economy.

First, we are aware that a competitive model may be inappropriate to the Italian economy, where the labour, credit, and output markets present substantial monopoly powers. However, as shown by Tamborini (1997), the

⁴⁴This result is line with others in the empirical research on the credit channel in Italy; for instance Bagliano-Favero (1995), who use the bond-loan spread to identify the credit channel in a pure aggregate-demand model, found that a monetary restriction leading to an increase of 17 basis points in the spread would generate a 0.6% fall in industrial production after 1 year. Our estimated model assures that this is a permanent effect consistent with the rational expectations hypothesis.

existing incomes policy agreement ruling industrial wage contracts in Italy turns out to mimic the reduced equation of the nominal wage rate in our system with theoretical results comparable with those obtained in the present model.

Second, Italy is an open economy and hence the exchange rate has certainly been another important element in the monetary transmission mechanism which has not been explicated in our model. However, in the first part of our data period (1987:4-1992:9), and in the last part (1996:12-1997:1), the Italian lira was in the European exchange-rate system with no major realignments, which may have limited the effectiveness of the exchange-rate channel. Indeed, there was a major realignment in 1992-93 while the Italian currency was "out". As is clear from our figures, devaluation took place after the unprecedented upsurge of interest rates in 1992 to defend the exchange-rate parity, and concomitantly with progressive relaxation of monetary policy. At any rate, the exchange-rate channel of monetary policy typically works through aggregate demand, but, as explained above, the data do not reject the hypothesis of a significant credit supply-aggregate supply effect.

Should unusual events be included in statistical analysis of economic theories? This is a long-standing unsettled question. We have decided to include the 1992 episode in our analysis because we believe that "crucial experiments", which are so rare in social sciences, provide valuable test benches. Even if most of the real effects of monetary policy in the sample were due to the 1992-93 episode, our identification procedure of the BLC would still be discriminant. Yet we have also tried to gauge the quantitative effect of 1992 by re-estimating our equations, first with a dummy variable, and second after eliminating "outliers". We have observed that the 1992 dummy variable has a significant negative impact on nominal variables (s_t , p_{t+1}) but not on output. Accordingly, estimation with exclusion of 1992 yields essentially the same results as those presented above except a loss of significance of the effect of the credit variables on the nominal wage. This finding may reintroduce wage stickiness in the picture as an *additional* factor behind the BLC "in normal times", whereas we are in a position to exclude it in times of unusual credit shocks to the economy.

5. Summary and conclusions

We believe that money supply and monetary policy work through the economy in several different ways. This investigation into the macroeconomics of the "credit view" confirms that the "special role of credit" when capital markets are imperfect or less developed contributes significantly to the connection between money and economic activity, and indeed deserves greater attention from macroeconomists. The thrust of our version of the BLC is that credit conditions, and monetary policy to the extent that it leads banks to alter credit conditions, affect the supply-side of the economy. In summary, our empirical analysis of a typical "credit economy" applied to Italy, from 1987:4 up to 1997:1, lends itself to the following conclusions:

- ### the equations in the reduced form system (3.5) can be interpreted as long-run equilibrium relations which link wages, lending rates and output to bank credit and monetary policy variables
- ### there is evidence that monetary policy affects the credit market and real variables through the BLC
- ### monetary policy is not neutral in the long run; a restrictive policy which increases the level of the overnight rate has a permanent negative impact on production within twelve months.

If one is concerned with the policy side of this result, one may conclude that restrictive monetary policy played a role in curbing price dynamics in Italy in the convergence process towards EMU but that the associated credit supply effects brought about a cost in terms of reduced output. To the extent that the structural conditions underlying the presence of a BLC in the monetary transmission mechanism in Italy are bound to persist, the potential non-neutrality of the BLC should also be taken into account when assessing the local effects of centralized monetary policy in the EMU.

Presenting our empirical analysis we acknowledged the objections that our model and our data set may raise. A richer specification of financial determinants of aggregate demand and supply, and better measurement of monetary policy stance and bankruptcy risk may be matter of further investigation. Nonetheless we think that the results mentioned above show that specifying the production supply-side effects of the BLC is a research strategy that improves our understanding of how money affects economic activity.

Further considerations that can be drawn from our analysis can be summarized as follows. Firstly, the shift in theoretical focus implied by the credit view is important, yet whether the credit transmission mechanism has stronger effect than the money transmission mechanism largely remains an empirical matter. Secondly, the time structure of transactions, the contractual arrangements in the labour and credit markets, and the formation and effect of price expectations are all critical elements in modelling a credit economy that do not always find a place in current research. Thirdly, it is also important, especially for empirical analysis, to discriminate the source and nature of the shocks driving the adjustment of real and nominal variables in the economy: credit, real or inflationary shocks trigger different patterns of adjustment though all involve the credit transmission mechanism.

References

- Angeloni I. 1994, "Strumenti e obiettivi operativi della Banca d'Italia: verso un modello europeo", *Note Economiche*, 14, 128-161.
- Angeloni I., Conti V., Passacantando F. 1997, *Le banche e il finanziamento delle imprese*, Bologna, Il Mulino.
- Badocchi M.G. 1998, *Finanziamento delle imprese, domanda di credito e tassi d'interesse*, unpublished dissertation, University of Trento.
- Bagliano F.C., Favero C.A. 1995, "The Credit Channel of Monetary Transmission. The Case of Italy", paper presented at the conference: "I meccanismi di trasmissione della politica monetaria", Catholic University, Milan.
- Bagliano F.C., Favero C.A. 1998, "Measuring Monetary Policy with VAR Models: An Evaluation", *European Economic Review*, 42, 1069-1112.
- Banca d'Italia 1997a, "I canali di trasmissione della politica monetaria nel modello econometrico trimestrale della Banca d'Italia", *Temi di Discussione*, Rome, n.316.
- Banca d'Italia 1997b, *Relazione annuale 1996*, Rome.
- Bernanke B., 1993, "Credit in the Macroeconomy", *Federal Reserve Bank of New York Quarterly Review*, 18, pp. 50-70.
- Bernanke B., Blinder A. 1988, "Credit, Money, and Aggregate Demand", *Papers and Proceedings of the American Economic Association*, *American Economic Review*, 78, 435-439.
- Bernanke B., Blinder A. 1992, "The Federal Funds Rate and the Channels of Monetary Transmission", *American Economic Review*, 82, 901-21.
- Bernanke B.S., Gertler M. 1989, "Agency Costs, Net Worth and Business Fluctuations", *American Economic Review*, 79, 14-31.
- Bernanke B., Gertler M. 1995, "Inside the Black Box: the Credit Channel of Monetary Policy Transmission", *Journal of Economic Perspectives*, 9, 27-48.
- Bernanke B., Mihov I. 1995, "Measuring Monetary Policy", *Quarterly Journal of Economics*, 113, 869-898.
- Bertocco G. 1997, "Il governo della moneta e del credito in Italia. Un'analisi del meccanismo di trasmissione della politica monetaria nel periodo 1960-95", *Politica Economica*, n.4, 375-215.
- Blinder A., Stiglitz J.E. 1983, "Money, Credit Constraints and Economic Activity", *American Economic Review*, 73, 297-302.
- Buttiglione L., Ferri G. 1994, "Monetary Policy Transmission via Lending Rates in Italy: Any Lessons from Recent Experience?", *Temi di Discussione*, Bank of Italy, Rome, n.224.
- Cappuccio N., Lubian D. 1993, "The Relationships Among Some Estimators of the Cointegrating Coefficient. Theory and Montecarlo Evidence", *Dipartimento di Scienze Economiche, Università di Padova*, Quaderno n. 21.
- Cappuccio N., Lubian D. 1994a, "Fully Modified Estimation of Cointegrating Vectors via VAR Prewhitening: A Simulation Study",

- Dipartimento di Scienze Economiche, Università di Padova, Quaderno n. 35.
- Cappuccio N., Lubian D. (1994b), "Representations of a Cointegrated System and Implied Estimation Procedures", *Giornale-degli-Economisti-e-Annali-di-Economia*, 53, 547-565
- Cappuccio N., Lubian D. (1996), "Triangular Representation and Error Correction Mechanism in Cointegrated Systems", *Oxford Bulletin of Economics and Statistics*; 58, 409-415
- Christiano L.J, Eichenbaum M., Evans C.L. 1996, "The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds", *Review of Economics and Statistics*, 78. 16-34.
- Conigliani C., Ferri G., Generale A. 1997, "La relazione banca-impresa e la trasmissione degli impulsi di politica monetaria", *Moneta e Credito*, n.198, 139-165.
- Dale S., Haldane S. 1993, "Bank Behaviour and the Monetary Transmission Mechanism", *Bank of England Quarterly Bulletin*, pp.478-490.
- De Arcangelis G, Di Giorgio G. 1998, "In Search of Monetary Policy Measures: The Case of Italy in the 1990s", *Giornale degli Economisti e Annali di Economia*, 57, 213-250.
- Diamond D.W. 1984, "Financial Intermediation and Delegated Monitoring", *Review of Economic Studies*, 51, 393-414.
- Dixon H.D., Rankin N. 1995, "Imperfect Competition and Macroeconomics: A Survey", in Dixon H.D., Rankin N. (ed.), *The New Macroeconomics. Imperfect Markets and Policy Effectiveness*, Cambridge, Cambridge University Press.
- Eichenbaum M. 1992, Comment to Sims C., "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy", *European Economic Review*, 36, pp. 1001-1111.
- Eichenbaum M. 1994, Comment to Kashyap A.K., Stein J.C., "Monetary Policy and Bank Lending", in Manikw N.G. (ed.), *Monetary Policy*, Chicago, Chicago University Press.
- Gale D., Hellwig M. 1985, "Incentive-compatible Debt Contracts: The One Period Problem", *Review of Economic Studies*, 52, 647-663.
- Gertler M. 1988, "Financial Structure and Aggregate Activity: An Overview", *Journal of Money, Credit and Banking*, 20, 559-588.
- 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 Manufacturing Firms", *Quarterly Journal of Economics*, 109, pp.309-340.
- Gertler M, Hubbard R.G. 1988, "Financial Factors in Business Fluctuations", in Federal Reserve Bank of Kansas City, *Financial Market Volatility*, Kansas City.

- Gordon D., Leeper E.M. 1994, "The Dynamic Impact of Monetary Policy: an Exercise in Tentative Identification", *Journal of Political Economy*, 102, 1228-1247.
- Greenwald B.C., Stiglitz J.E. 1987, "Keynesian, New Keynesian and New Classical Economics", *Oxford Economic Papers*, 39, 119-32.
- 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, Clarendon Press, 103-140.
- Greenwald B.C., Stiglitz J.E. 1990, "Macroeconomic Models with Equity and Credit Rationing", in Hubbard, R.G.(ed.), *Information, Capital Markets and Investment*, Chicago, Chicago University Press, 15-42.
- 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, pp.23-44.
- Hawtrey R.G. 1927, *Currency and Credit*, London, McMillan, 3rd ed.
- Hahn F., Solow R. 1995, *A Critical Essay on Modern Macroeconomic Theory*, Cambridge Mass., The MIT Press.
- Hansen B.E. and Phillips P. C. B., 1990, "Statistical Inference in Instrumental Variable Regressions with $I(1)$ processes", *Review of Economic Studies*, 57, pp. 99-125.
- Hargreaves C.H., 1993, "A Review of Methods of Estimating Cointegrating Relationships", in Hargreaves (ed.) *Nonstationary Time Series Analysis and Cointegration*, Oxford University Press, 87-132.
- Hubbard R. G. 1998, "Capital Market Imperfections and Investment", *Journal of Economic Literature*, 36, 193-225.
- Johansen S.J. 1988, "Statistical Analysis of Cointegrated Vectors", *Journal of Economics Dynamics and Control*, 12, pp. 231-254.
- Kaldor N. 1982, *The Scourge of Monetarism*, Oxford, Blackwell.
- 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., Stein J.C. 1994, "Monetary Policy and Bank Lending", in Manikw N.G. (ed.), *Monetary Policy*, Chicago, Chicago University Press.
- Keynes J.M. 1930, *A Treatise on Money*, in *The Collected Writings of John Maynard Keynes*, ed. by E. Moggridge, London, MacMillan, 1973, vol.IX.
- Keynes J.M. 1936, *The General Theory of Employment, Interest and Money*, in *The Collected Writings of John Maynard Keynes*, ed. by E. Moggridge, London, MacMillan, 1973, vol.VII.
- 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.

- King S. R., 1986, "Monetary Transmission: Through Bank Loans or Through Bank Liabilities?", *Journal of Money Credit and Banking*, 18, pp.290-303.
- Kitamura Y. And Phillips P. C. B., 1993, "Fully Modified IV, GIVE and GMM Estimation with Possibly Non-stationary Regressors and Instruments", *Cowles Foundation Discussion Paper*, 1043, Yale University
- Kiyotaki N., Moore J. 1997, "Credit Cycles", *Journal of Political Economy*, 105, pp. 211-248.
- Lucas R.E., Rapping L. 1969, "Real Wages, Employment and Inflation", *Journal of Political Economy*, 77, n.5, 721-754.
- Miron J.A., Romer C., Weil D.N. 1994, "Historical Perspectives on the Monetary Transmission Mechanism", in Mankiw G. (ed.), *Monetary Policy*, Chicago, Chicago University Press.
- Morelli P., Pittaluga G.B. 1997, "Le sofferenze bancarie: tendenze e previsione", mimeo, Centro di Economia Monetaria e Finanziaria "Paolo Baffi", Milan.
- Pagan A., 1984, "Econometric issues in the analysis of regressions with generated regressors", *International Economic Review*, 25, pp. 221-247.
- Phillips P.C.B 1995, "Fully Modified Least Squares and Vector Autoregression", *Econometrica*, 63, 1023-1078.
- Phillips P.C.B., Ouliaris S. 1990, "Asymptotic Properties of Residual Based Tests for Cointegration", *Econometrica*, 58, 165-193.
- Radcliffe Committee 1959, *Report on the Working of the Monetary System*, London, HMSO.
- Romer C.D., Romer D. 1990, "New Evidence on the Monetary Transmission Mechanism", *Brookings Papers on Economic Activity*, n.1, pp. 149-213.
- Rondi L., Sack B., Schiantarelli F., Sembenelli A., 1998 "Firms' Financial and Real Responses to Monetary Tightening: Evidence for Small and Large Italian Companies", *Giornale degli Economisti e Annali di Economia*, 57, 35-64
- Sargent T. 1986, *Macroeconomic Theory*, New York.
- Sims C. 1992, "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy", *European Economic Review*, 36, pp. 975-1000.
- Tamborini R. 1997, "Il costo del denaro è uno strumento anti-inflazionistico?", *Rivista di Politica Economica*, 87, 57-83.
- Townsend R. 1979, "Optimal contracts and competitive markets with costly state verification", *Journal of Economic Theory*, 20, 265-93.
- Vicarelli F. (cur.) 1974, *Capitale industriale e capitale finanziario: Il caso italiano*, Bologna.
- Visco I. 1995, "Inflation, Inflation Targeting and Monetary Policy: Notes for Discussion on the Italian Experience" in Leiderman, L. and L.E.O. Svensson, eds., *Inflation Targets*, London, CEPR.

Williamson S.D. 1987, "Costly Monitoring, Loan Contracts, and Equilibrium Credit Rationing", *Quarterly Journal of Economics*, 102, 135-45.

Figure 1. Work, production and consumption in the sequence economy

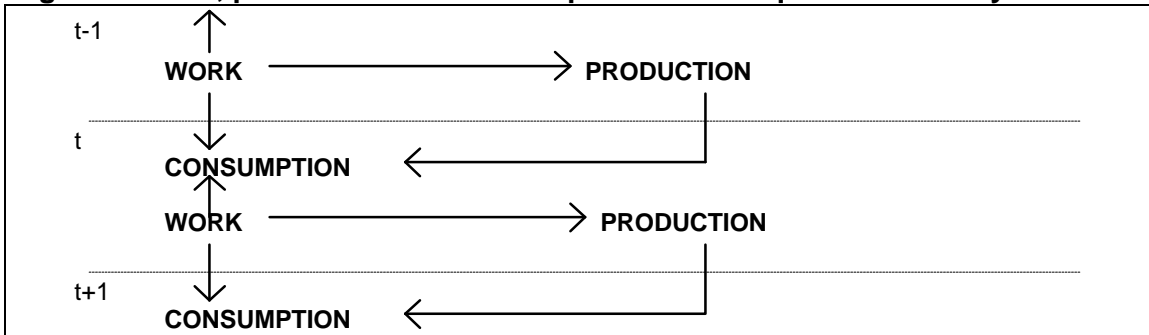


Figure 2. An increase in systemic bankruptcy risk

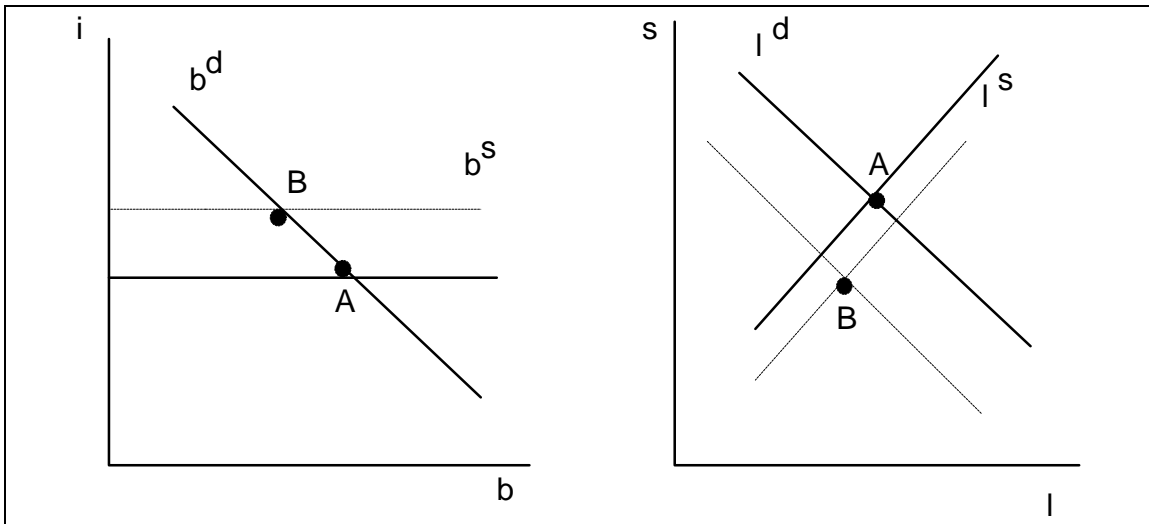


Figure 3. Quarterly real GDP

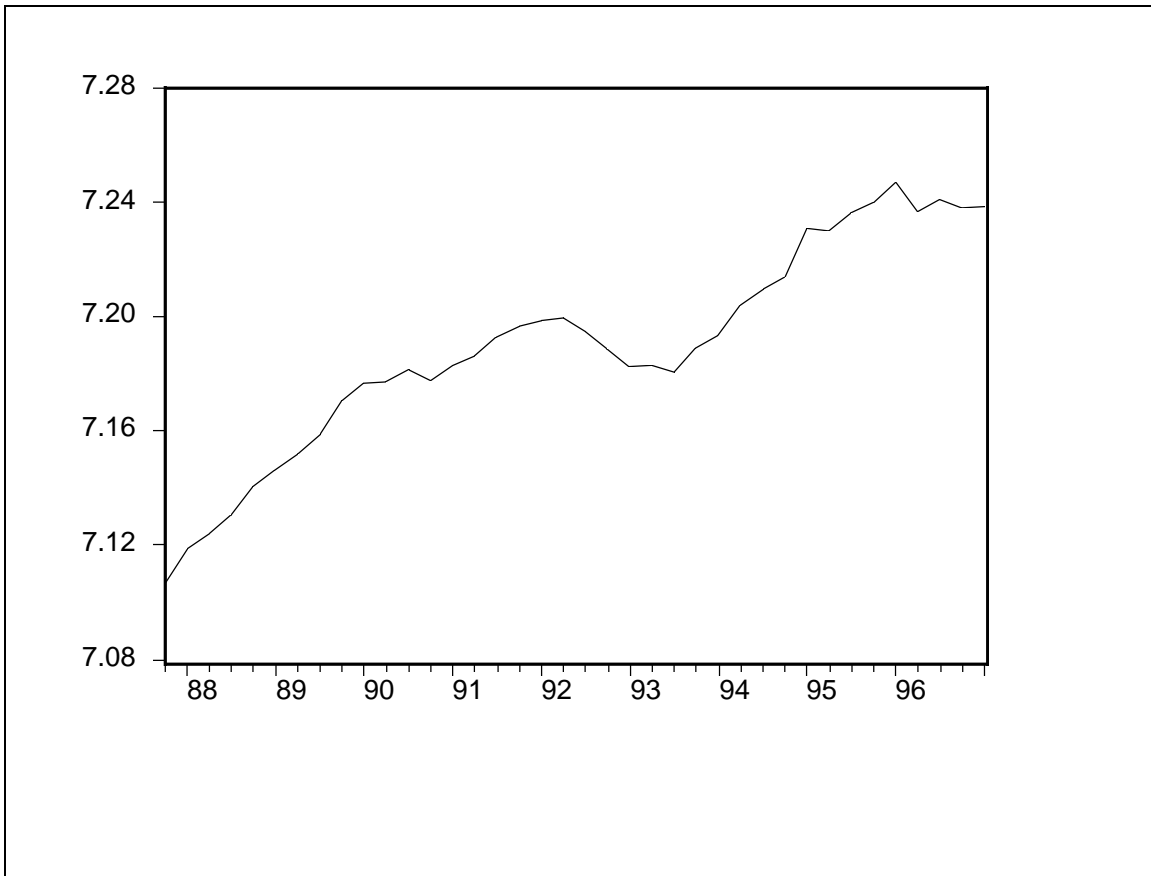


Figure 4. Main short-term interest rates and bank lending rate

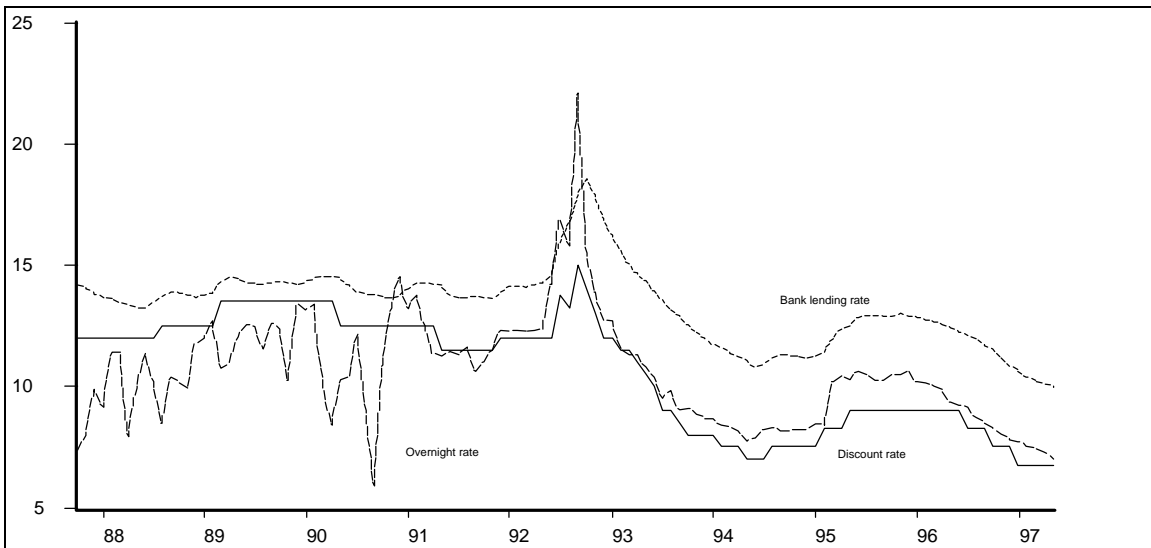


Figure 5. Quarterly estimated bankruptcy risk



**MONETARY POLICY, CREDIT AND AGGREGATE SUPPLY:
THE EVIDENCE FROM ITALY**

Riccardo Fiorentini, Roberto Tamborini

Mathematical Appendix

M.1. Let a generic one-period debt contract between a bank b and a borrower j be identified by the set $\{B_{jt}, I_t, B_{jt}I_t(S), X_{jt+1}(D)\}$ where the first element is the amount borrowed, the second is the gross interest rate, the third is the amount due in case of solvency, the fourth is the amount due in case of default. Both the banker and the entrepreneur are risk-neutral. In our specific setup, the borrower is an entrepreneur who produces $Y(t)_{jt+1}$ units of output in t , and obtains a revenue $R_{jt+1} = P_{jt+1}Y(t)_{jt+1}$ in $t+1$. Hence the two possible states, S, D in $t+1$, he may face are:

$$S = R_{jt+1} : R_{jt+1} \geq B_{jt}I_t$$

$$D = R_{jt+1} : R_{jt+1} < B_{jt}I_t$$

The true borrower's state can only be established by the bank after direct monitoring at a nominal cost proportional to the borrower's market value (total revenue), $M_{jt+1} = mR_{jt+1}$.

The standard debt contract under assumption (A4) in the paper is a specific form of the debt contract such that:

- 1) whenever default is declared, the bank monitors the true state of the borrower incurring the cost M_{jt+1}
- 2) the amount due in case of default is the borrower's total revenue, $X_{jt+1}(D) = R_{jt+1}$

We prove that the standard debt contract is optimal in two steps. First, we identify the conditions on which the borrower is incentivated to declare his/her true state. Second, we show that, under such conditions, the standard debt contract maximizes the borrower's expected profit under the bank's participation constraint (Williamson, 1987).

The first problem is the borrower's incentive to declare his/her true state. This condition is satisfied by the deterministic monitoring clause 1). In fact, if S occurs and D is declared, the bank monitors the borrower's true state and recovers the amount due, $B_{jt}I_t$. The borrower cannot seize extra-profits by declaring a false state. Yet the bank earns $B_{jt}I_t - M_{jt+1}$ if a

false state is declared. Therefore, necessary and sufficient condition for deterministic monitoring to be binding on the borrower's declarations is

$$(1^*) \quad M_{jt+1} \leq B_{jt}I_t$$

The second problem is that the debt contract should be devised in such a way that the borrower is incentivated to maximize profit, i.e. his/her ability to pay, under the bank's participation constraint. The latter is given by the zero-expected profit condition (see section 2.3). Moreover, $X_{jt+1}(D)$ cannot exceed R_{jt+1} . Hence the optimal contract solves the following problem:

$$\begin{aligned} \max Z_{jt+1}^e &= E_t(R_{jt+1} - B_{jt}I_t) \\ \text{s.t. } Z_{bt+1}^e &= 0 \\ X_{jt+1}(D) &\leq R_{jt+1} \end{aligned}$$

The solution to this problem depends on the amount $X_{jt+1}(D)$, and the optimal contract implies clause 2) of the standard debt contract, i.e. $X_{jt+1}(D) = R_{jt+1}$.

First, recall that, given assumption (A1) on individual sale prices in $t+1$, $R_{jt+1} = P_{t+1}U_{jt+1}Y(t)_{jt+1}$. Hence the borrower's two states can be rewritten:

$$\begin{aligned} S: \quad & U_{jt+1} \geq U_{jt+1}^* \\ D: \quad & U_{jt+1} < U_{jt+1}^* \end{aligned}$$

with probability of default given by:

$$\begin{aligned} j_t &= \text{Prob}(U_{jt+1} < U_{jt+1}^*) \\ &= \int_0^{U_{jt+1}^*} g(\bullet) dU_{jt+1} = G(U_{jt+1}^*) \end{aligned}$$

Therefore, the borrower's expected profit as of t , given that he/she always declares the true state *sub* clause 1), is:

$$\begin{aligned} Z_{jt+1}^e &= \int_{U_{jt+1}^*}^{\infty} (Y(t)_{jt+1} P^e(t)_{jt+1} U_{jt+1} - B_{jt}I_t) g(\bullet) dU_{jt+1} \\ &+ \int_0^{U_{jt+1}^*} (Y(t)_{jt+1} P^e(t)_{jt+1} U_{jt+1} - X_{jt+1}(D)) g(\bullet) dU_{jt+1} \end{aligned}$$

Parallely, the bank's expected profit is ⁴⁵:

⁴⁵For simplicity we ignore direct or opportunity costs of the bank. Their inclusion is immaterial to the problem's solution.

$$Z^e_{bt+1} = B_{jt} I_t \int_{U^*_{jt+1}}^{\infty} g(\bullet) dU_{jt+1} + \int_0^{U^*_{jt+1}} (X_{jt+1}(D) - M_{jt+1}) g(\bullet) dU_{jt+1}$$

In force of the rational expectations hypothesis (A2), we can set $P^e(t)_{jt+1} = P_{t+1}$. In addition, in this demonstration we are allowed to take P_{t+1} as exogenous, and to set it equal to unity for convenience. Also, we can divide both expressions by $Y(t)_{t+1}$. Denoting with small case letters all variables in terms of units of output, Z^e_{jt+1} can be rewritten as follows:

$$z^e_{jt+1} = 1 - z^e_{bt+1} - m \int_0^{U^*_{jt+1}} g(\bullet) dU_{jt+1}$$

$$(2^*) \quad z^e_{jt+1} + z^e_{bt+1} = 1 - mG(U^*_{jt+1})$$

The nature and the solution of the optimal debt contract problem can be understood observing expression (2*): the borrower's output is split between the borrower and the bank after subtracting the monitoring cost. After imposing the constraint $z^e_{bt+1} = 0$, maximizing (2*) requires minimizing the monitoring cost. This in turn requires minimizing the set of states in which default and monitoring occur, i.e. the value of U^*_{jt+1} .

Recalling that $U^*_{jt+1} \equiv B_{jt} I_t / Y(t)_{jt+1} = S_t L_{jt} I_t / Y(L_{jt})$, for any concave production function $Y(L_{jt})$ we can say that U^*_{jt+1} is an increasing function of the level of employment L_{jt} , $U^*_L > 0$. Since $X_{jt+1}(D)$ is a cost to the borrower in all default states, the optimal level of employment must be a decreasing function of $X_{jt+1}(D)$, $U^*_X < 0$. Therefore, it must also be that $U^*_X < 0$. In other words, the higher the amount due by the borrower in default states, the lower the borrower's debt/output ratio, the lower his/her probability of default and monitoring. Consequently, the first order condition for an optimal debt contract consists of the amount $X_{jt+1}(D)$ such that:

$$(3^*) \quad \begin{aligned} & G_U U^*_X \geq 0 \\ & X_{jt+1}(D) \leq R_{jt+1} \end{aligned}$$

Since $G_U > 0$ and $U^*_X < 0$, the first inequality is always met. But since G and U^* are generally monotonic functions, the constraint must be binding, i.e. $X_{jt+1}(D) = R_{jt+1}$.

###

As an exemplification, consider the case of the production function we have adopted in the paper, $Y(t)_{jt+1} = L_{jt}$. As is shown in the paper, setting $X_{jt+1}(D) = R_{jt+1}$ implies that, at the optimal production plan chosen

by the borrower, $U^*_{jt+1} = ###$. Consequently, $U^*_X = 0$, so that the conditions in (3*) are both met as equalities.

M.2. Given assumption (A1) and the definition of bankruptcy state, the entrepreneur's expected total payoff as of t is

$$\begin{aligned} Y(t)_{jt+1} P^e(t)_{t+1} \int_{U^*_{jt+1}}^{\infty} U_{jt+1} g(\bullet) dU_{jt+1} - S_t L_{jt} I_t \\ = Y(t)_{jt+1} P^e(t)_{t+1} \left[\int_0^{\infty} U_{jt+1} g(\bullet) dU_{jt+1} + \right. \\ \left. - \int_0^{U^*_{jt+1}} U_{jt+1} g(\bullet) dU_{jt+1} \right] - S_t L_{jt} I_t \end{aligned}$$

In this latter equation, in any bankruptcy state the entrepreneur's expected payoff is zero (the second integral); hence total expected payoff maximization coincides with the maximization of the first integral, i.e.:

$$E_{jt}(Z_{jt+1}) = P^e_{t+1} Y(t)_{t+1} - S_t L_{jt} I_t$$

This is in fact the G-S expected profit function (equation 15) with zero bankruptcy costs.

M.3. Let us first derive the temporary equilibrium solution for the economy at time t , i.e. the solution of equations (3.1)-(3.3) for the endogenous variables $(s_t, b_t, i_t, y(t)_{t+1})$ given $(k_t, ###, p_t, p^e(t)_{t+1})$:

$$\begin{aligned} (1 * a) \quad & \begin{bmatrix} s_t \\ b_t \\ i_t \\ y(t)_{t+1} \end{bmatrix} = \begin{bmatrix} s_o \\ b_o \\ 0 \\ y_o \end{bmatrix} + \frac{1}{\Delta} \begin{bmatrix} 1-b & 1-b & \Delta & \Delta - (1-\eta)a \\ -b & -b & \Delta & \Delta + \eta a \\ \Delta & \Delta & 0 & 0 \\ -\eta & -\eta & 0 & \eta a \end{bmatrix} \begin{bmatrix} k_t \\ \theta_t \\ p_t \\ q^e(t)_{t+1} \end{bmatrix} \\ \Delta = b - \eta \end{aligned}$$

Now let us consider the aggregate demand equation in $t+1$ given by the *average* real savings and real profits of the active population in period t , and the *average* current consumption of the workers in period $t+1$. Their sum must equate output:

$$D_t/P_{t+1} + Z_{t+1}/P_{t+1} + C(t+1)_{t+1} = Y(t)_{t+1}$$

The average depositors D_t given by the workers' utility-maximizing programme (2.6)-(2.7) are:

$$(2^*) \quad D_t = (1-a)S_tL_t$$

Given the Cobb-Douglas production function (2.4), and the entrepreneur's profit-maximizing programme (2.2)-(2.3), any individual entrepreneur j 's realized profit in $t+1$ is:

$$(3^*) \quad Z_{jt+1} = (P_{jt+1} - \beta P^e(t)_{t+1}) Y(t)_{jt+1}$$

Under assumption (A1) on the distribution of the individual selling prices of firms, the average profit is:

$$(4^*) \quad Z_{t+1} = (P_{t+1} - \beta P^e(t)_{t+1}) Y(t)_{t+1}$$

Given constant preferences and population, $C(t+1)_{t+1}$ can also be deduced from the workers' utility-maximizing programme (2.6)-(2.7) one period ahead, i.e.:

$$(5^*) \quad C(t+1)_{t+1} = aS_{t+1}L_{t+1}/P_{t+1}$$

Therefore, recalling that in each period $S_tL_t = B_t$, output market equilibrium in $t+1$ requires:

$$(6^*) \quad (1-a)B_t/P_{t+1} + aB_{t+1}/P_{t+1} = (\beta P^e(t)_{t+1}/P_{t+1}) Y(t)_{t+1}$$

Hence aggregate demand depends on the evolution of real credit from t to $t+1$. We can use the temporary equilibrium results in system (1*) to study the evolution of this variable. First, note that from (1*b) we can also write:

$$(7^*) \quad B_t/P_t = B_0 K_t^{-B1} \beta_t^{-B2} Q^e(t)_{t+1}^{B3}$$

$$B_{t+1}/P_{t+1} = B_0 K_{t+1}^{-B1} \beta_{t+1}^{-B2} Q^e(t+1)_{t+2}^{B3}$$

Second, let β_{it} ($i = 1, 2$), all t , be i.i.d. random shocks such that K_t and β_{it} evolve stochastically according to the following laws:

$$(8^*) \quad K_{t+1} = K_t \beta_{1t+1}$$

$$(9^*) \quad \beta_{it+1} = \beta_{it} \beta_{2t+1}$$

Third, provisionally define any possible change in the economy's expected price as given by:

$$(10^*) \quad P^e(t+1)_{t+2} = P^e(t)_{t+1} \beta_{3t+1}$$

Therefore, recalling that $P_{t+1} = P_t Q_{t+1}$, real credit in $t+1$ results to be:

$$(11^*) \quad B_{t+1}/P_{t+1} = B_0 (K_t \beta_{1t+1})^{B1} (\beta_{it} \beta_{2t+1})^{B2} (Q^e(t)_{t+1} \beta_{3t+1}/Q_{t+1})^{B3}$$

$$= (B_t/P_t) Q_{t+1}^{-B3} [\beta_{1t+1}^{B1} \beta_{2t+1}^{B2} \beta_{3t+1}^{B3}]$$

That is to say, real credit changes from t to $t+1$ by a fraction of inflation up to random shocks to the exogenous variables.

Substituting (11*) into (6*) and solving for Q_{t+1} yields:

$$(12^*) \quad Q_{t+1} = [(1-a)/a] (1 + I_t)^{1/(1-B3)} [\beta_{1t+1}^{B1} \beta_{2t+1}^{B2} \beta_{3t+1}^{B3}]^{-1/(1-B3)}$$

Now we can take the log-linear form of equation (12*) which is reproduced in the text as equation (3.4):

$$(13^*) \quad q_{t+1} = q_o - \frac{b-\eta}{\eta a} (\theta_t + k_t) + \alpha' \omega_{t+1}$$

Under the rational expectations hypothesis made in assumption (A1), we should set in any t , $p^e(t)_{t+1} = E_t(p_{t+1})$ or, given p_t , $q^e(t)_{t+1} = E_t(q_{t+1})$, given all available information in equation (13*). Let ϵ_{it} ϵ_{it} ϵ_{it} ($i = 1, 2$) have zero mean. This implies that $E_t(\epsilon_{3t+1}) = E_t[p_{t+1} - E_{t+1}(p_{t+2})] = 0$ and hence:

$$(14^*) \quad E_t(q_{t+1}) = q_o - \frac{b-\eta}{\eta a} (\theta_t + k_t)$$

Substituting for $q^e(t)_{t+1}$ into system (1*) yields system (3.5) in the text, where b_t is not explicited being the linear combination of s_t and $y(t)_{t+1}$.

**MONETARY POLICY, CREDIT AND AGGREGATE SUPPLY:
THE EVIDENCE FROM ITALY**

Riccardo Fiorentini, Roberto Tamborini

Statistical Appendix

S.1. Among our estimation regressors we need a proxy of the credit risk variable u_t . We have chosen the unlagged residuals from an auxiliary regression of credit on a set of regressors consistent with our theoretical model. Consider the following standard linear model

(1*) **Error! Bookmark not defined..**

The OLS estimate of B is

(2*) **Error! Bookmark not defined.**

After estimation, u can be computed as

(3*) $\hat{u} = Y - \hat{B}X$

The preferred interpretation of time series u_t when y_t is a policy variable is that u_t represents the "innovation" or "unexpected shock" in the policy variable. However, disturbances are by definition "explanatory variables" (they co-determine Y like all other variables on the RHS of the regression equation) that are not observed ex-ante. Hence we used an empirical specification of our equation of credit in this same format.

According to our model, the amount of credit is demand-determined; hence the observed time series of bank loans may contain both supply and demand shocks. Therefore, as is common practice in empirical analyses of credit, we have chosen the credit/GDP ratio as dependent variable, which removes the endogenous cyclical component of bank loans. As to the regressors, our model indicates the policy variable, to which further trend components may be added to correct for demand effects. The set of explanatory variables giving the most efficient results contains a linear trend, a non-linear trend and the overnight rate:

(4*) $X = (t, t^2, k_t)$

Hence we interpret the deviations of the actual credit/GDP ratio from its estimated path as credit supply innovations reflecting, *inter alia*, risk. Qualitative inspection of this proxy reported in the text is consistent with the overall macroeconomic picture and other independent information sources. At any rate, it should be recalled that the ultimate test of the goodness of our proxy is given by the identification criteria explained in

section 3 and in table 1. The pattern of correlation signs of ϵ_t under the null hypothesis H_{00} can only result if the corresponding variable captures credit supply shocks and not demand shocks.

Our use of the proxy of ϵ_t thus obtained may present a problem of possible correlation with k_t as they are then used together as explanatory variables in the overall model's estimation. Theoretically, our model excludes that the risk variable depends on the policy variable; however other models do not, and it is in practice reasonable to think that credit risk is correlated with other macroeconomic variables and in particular with monetary policy variables. If we then look at the statistical properties of our proxy, by construction the OLS residual **Error! Bookmark not defined.** given by (3*) are orthogonal to the explanatory variables, since **Error! Bookmark not defined.**; therefore we expect that also in the case of our regression this property holds. We have formally checked that our proxied time series of ϵ_t is indeed orthogonal to k_t .

As a first step we have computed the covariance between k_t and ϵ_t and we obtained $E(k_t \epsilon_t) = 8.26E^{-16}$, a value very close to zero. As a second step we have run two formal orthogonality tests. In general, orthogonality test are based on an equation like

$$(5^*) \quad y_t = \epsilon_t + \epsilon_t$$

where ϵ_t is the information set available at period t . Orthogonality tests verify whether the information set ϵ_t is useful in predicting the variable **Error! Bookmark not defined.** by testing the significance of the coefficient vector ϵ . In our case, we have run the regressions

$$(6^*a) \quad \epsilon_t = \epsilon + \epsilon_1 k_t$$

$$(6^*b) \quad \epsilon_t = \epsilon + \epsilon_2 \epsilon k_t$$

and tested the significance of ϵ_1 and ϵ_2 . The rationale behind such tests is that if k_t and ϵ_t are orthogonal, knowledge of k_t should not be informative in predicting ϵ_t , and the ϵ coefficients should be statistically not significant. As it appears from the following table, the two coefficients are indeed not significantly different from zero, so that we may conclude that k_t and ϵ_t are orthogonal.

Table S1. Orthogonality test

	ϵ_1	ϵ_1
$F = 0 : 0 H$	2..52E-13	-1.779

Finally, it should also be added that our proxy of $###_t$ have passes the weak exogeneity test reported below

S.2. In this appendix we wish to summarize the Phillips' estimation procedure that we have adopted in our work.

Let us consider the following model:

$$(1^*) \quad \mathbf{Error! Bookmark not defined.}$$

$$(2^*) \quad \mathbf{Error! Bookmark not defined.}$$

where A is an $n \times m$ coefficient matrix and **Error! Bookmark not defined.** is a vector of cointegrated or stationary regressors of dimension m . The problem is to find an estimator of the coefficient matrix A under the condition that the explanatory variables **Error! Bookmark not defined.** are first difference stationary and do not cointegrate. Vector **Error! Bookmark not defined.** may contain $I(1)$ and $I(0)$ variables as well, so that equation (4.1) may be written in the following alternative form that separates out the $I(0)$ and $I(1)$ regressors

$$(3^*) \quad \mathbf{Error! Bookmark not defined.}$$

where **Error! Bookmark not defined.** are $I(0)$ and **Error! Bookmark not defined.** are $I(1)$. Now, let **Error! Bookmark not defined.** and assume it follows a linear process **Error! Bookmark not defined.** with **Error! Bookmark not defined.**. Finally, let **Error! Bookmark not defined.** be the long run variance matrix of **Error! Bookmark not defined.** and define the following one-sided long run covariance

$$\mathbf{Error! Bookmark not defined.}$$

Phillips derives his "Fully Modified OLS" (FM-OLS) estimator of A by making corrections for regressor endogeneity and for serial correlation to the OLS estimator **Error! Bookmark not defined.**. The first step is to define the transformed variable **Error! Bookmark not defined.**. This transformation is designed to take in account endogeneities in **Error! Bookmark not defined.** due to any cointegration links between **Error! Bookmark not defined.** and **Error! Bookmark not defined.**. On the other side, the correction **Error! Bookmark not defined.** is used to take in account both serial covariance in the shocks that drive the non stationary regressors **Error! Bookmark not defined.** and serial covariance between the error terms of equations (1*) and (2*). In the above correction formulae

Error! Bookmark not defined. and **Error! Bookmark not defined.** are kernel estimates of long-run covariances, while **Error! Bookmark not defined.** and **Error! Bookmark not defined.** are kernel estimates of one-sided long-run covariances.

Combining the two corrections Phillips derives the FM-OLS formula

(4*) **Error! Bookmark not defined.**

and shows that researchers may directly perform hypothesis testing on the coefficient matrix **Error! Bookmark not defined.** by means of standard chi-square tests using the estimated variance-covariance matrix. Furthermore, the Phillips methodology is flexible enough to accommodate IV, GMM and VAR estimation.

S.3. We are interested in the long-run properties of system (3.5). It contains 6 variables, so that in principle at most 5 cointegrating vectors may exist. Following the Johansen's approach, we may use the ML Trace statistics to test the number of possible cointegrating vector in a recursive way.

The starting point is the test of the null hypothesis of no cointegration. If the null is rejected, the hypothesis of one cointegrating vector is tested and so on until it is possible to accept the hypothesis of a given number of cointegrating relations.

Table S2. Johansen Trace Test

	5% critical value Likelihood ratio	1% critical value	N° of cointegrating equations
	94.15	103.18	None**
	158.52	76.07	At most 1**
	92.21	54.46	At most 2**
	52.48	35.65	At most 3
	26.71	20.04	At most 4
	13.76	6.65	At most 5
	1.08		

Note: ** indicate rejection at a 1% significance level; the number of lags in the level VAR is 2.

In our case, the trace tests reported in table S2 indicates the existence of three cointegrating relations since we can recursively reject at the 1% significance level the hypothesis that at most none, 1 and 2 cointegrating equations exist.

In system (3.5) there are exactly three equations, so that the above analysis may lead to the conclusion that the wages, interest rate and output

equations are long-run equilibrium conditions. However, it is still not possible to draw such a conclusion, since there are several ways to normalize three cointegrating vectors among six variables. In order to find the correct normalization it is necessary to determine the weakly exogenous variables in the system. In other words, according to the Johansen methodology, we may interpret the three equations in system (3.5) as long run equilibrium relations only if we are able to show that the RHS variables are weakly exogenous. For this reason, we have run a weak-exogeneity test and reported its results in table S3

Table S3. Weak-Exogeneity Test

	Error! Bookmark not defined.	Error! Bookmark not defined.	Error! Bookmark not defined.	Error! Bookmark not defined.	Error! Bookmark not defined.	### _t
	18.00**	22.90**	8.61*	5.71	3.44	4.91
	defined. Error! Critical values defined.	Bookmark not defined.	Error! Bookmark not defined.	Bookmark not defined.		

Note: * and ** indicate rejection at 5% and 1% significance level

From the table we can see that it is not possible to reject the hypothesis that the three regressors are weakly exogenous. Our conclusion therefore is that the equations in system (3.5) can be derived from the normalization of three cointegrating vectors and that statistical analysis of the data support the theoretical assumption that system (3.5) identities long run equilibrium relationships.

S.4. Data sources

Quarterly Gross Domestic Product at constant prices (seasonally adjusted) : OECD, "Main Economic Indicators" (1990=100);

Production Price Index: ISTAT, "Indice dei prezzi alla produzione dei prodotti industriali", (1990=100)

- ### Wage Index: ISTAT, "Indice delle retribuzioni contrattuali per dipendente. Industria. Operai" (1990=100);
- ### Overnight Rate: Banca d'Italia, "Tasso medio sugli scambi dei depositi overnight", table DTF00080, series S301764M;
- ### Discount Rate :Banca d'Italia, "Tasso ufficiale di sconto", table TDF00020, series S940722M;
- ### Average Bank Lending Rate: Banca d'Italia, "Tasso medio sugli impieghi a breve termine in lire", table TDF00082, series S939796M
- ### Credit: Banca d'Italia, "Finanziamenti interni al settore non statale", table TDG00180, series S149559M.