On the Complementarity of Money and Credit

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Abstract

I construct an economy with microfoundations for the use of both money and credit as means of exchange. The model features spatial separation, absence of double coincidence of wants and competitive markets. Credit is a claim to future money: it is paid off with money in the future. This gives rise to a Cash-in-Arrears constraint. Credit bears interest, improves output and welfare. Money and credit are complementary. I analyse the effects of anticipated inflation on the interest rate, credit and output. The nominal interest rate increases with inflation, making it costly to hold a claim to future money: credit is negatively affected by inflation. The real interest rate increases with the inflation rate. The credit to money and credit to output ratios, output and welfare all decrease with inflation. A reverse Mundell-Tobin effect is generated. Complementarity implies that debt should increase the demand for cash by households. With microeconomic data I estimate a demand for cash with debt as an explanatory variable and find a positive coefficient for debt.

Keywords: Coexistence of Money and Credit; Mundell-Tobin effect.

JEL Classification: E40, E41, E51.

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1 Introduction

Money and credit are both used as means of exchange. Only money however acts as a means of payment[1]. Credit is often a promise to pay money in the future. The aspect usually studied in the literature is that credit in a monetary economy is a substitute for money as a means of exchange: credit as a claim to future commodities. Here I explore the idea that the two might be complementary: credit as a claim to future money.

"Real life monetary policy is primarily about interest rates -that is the relative price of money and claims to future money-. The basic literature generally abstracts from other assets besides money, and offers no compelling reason why societies need risk-free claims to future money as well as money itself." (Kocherlakota (2004)).

I construct an economy with microfoundations for the use of both money and claims to future money and ask what is the effect of anticipated inflation on the interest rate, credit, output and welfare. Complementarity generates new features: a Cash-in-Arrears constraint and a reverse Mundell-Tobin effect.

I also test the complementarity approach using microeconomic data. I estimate a demand for cash with debt as an explanatory variable and find a positive and significant coefficient for debt.

The model features lack of double coincidence of wants and spatial separation. When purchasing goods, agents can use fiat money to overcome the absence of double coincidence of wants and they can buy on credit by issuing promises. Agents use collateral to commit to repay promises. The commitment power of agents is otherwise limited and there is no public memory. Repayment is decentralized and it requires time. Market participation is intermittent[2]. Markets are walrasian and money is durable and perfectly divisible.

In equilibrium, money and credit coexist and credit is repaid with money: promises

[1] Goodhart (1989): "A medium of exchange includes those assets, or claims, whose transfer to the seller will commonly allow a sale to proceed. Payment is in some sense final. The most important general function of money is to serve as a means of payment."

[2] I capture intermittent market participation assuming that, after producing, agents need to rest for one period during which they will not be able to consume or produce.

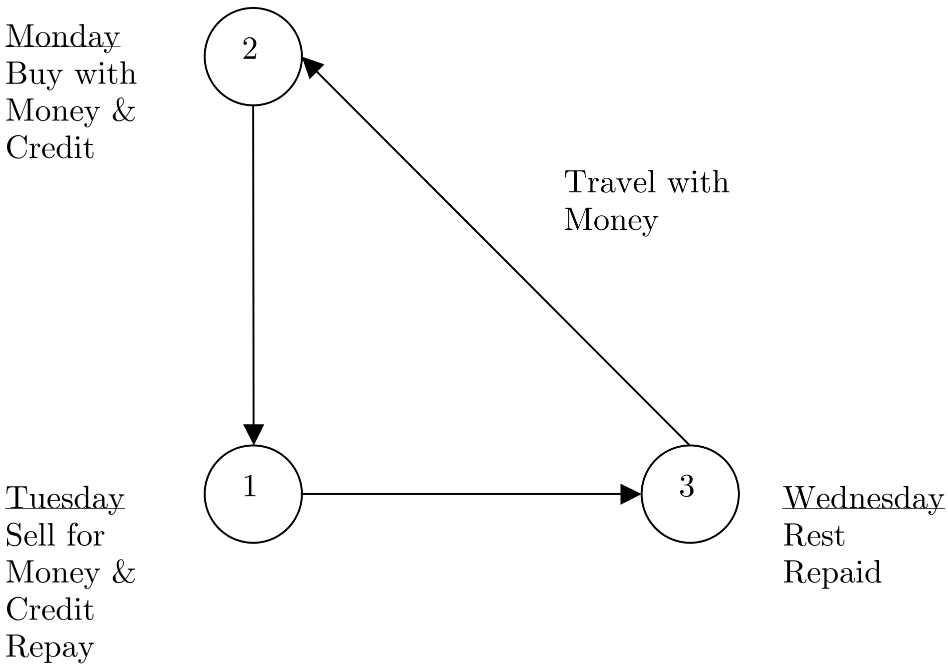

Figure 1: Agents Born on Island 1

are claims to future money. Each agent uses both money and credit to exchange commodities. The typical life of an agent in the economy is summarized in Figure 1. On Monday morning, an agent from island 1 is on island 2 in order to purchase commodities with money and promises. Overnight he travels back home together with his creditor. On Tuesday he produces for money, repays his debt and produces for promises becoming a creditor himself. Overnight he travels with his debtor to island 3 and on Wednesday -his period of rest- he waits for his debtor to repay. Overnight he travels to island 2 with money and on Thursday the cycle restarts.

Credit commands a higher rate of return than money and it increases the amount of transactions: output and welfare are higher than in an economy without credit. In my model money performs two classic functions: it is a means of exchange and a means of payment. The role of money as means of exchange originates from the absence of double coincidence of wants and spatial separation, the absence of a record-keeping technology and limited enforcement as in Kiyotaki and Wright (1989), Townsend (1980) and Kocherlakota (1998). The role as means of payment comes from the fact that in equilibrium the velocity of circulation of promises is limited and money will be accepted in the future as a means of exchange. The model generates a Cash-in-Advance constraint for purchases of goods with money and a Cash-in-Arrears constraint for the repayment of promises with money. Complementarity between money and credit is embedded in the Cash-in-Arrears constraint.

With anticipated inflation a reverse Mundell-Tobin effect is generated. Anticipated inflation drives up the nominal interest rate, which makes costly to hold promises of future money. The elasticity of the nominal interest rate to inflation is greater than one and thus the real interest rate increases with inflation. The credit to money ratio and the credit to output ratio decrease with inflation. An agent holding a promise will get final payment with money in the future. He will then have to hold money overnight before spending it to purchase goods. With inflation the opportunity cost of holding money is higher: the agent will reduce his holdings of claims to future money. In a recent paper, Green (2003) argues that inflation may destroy the acceptability of money in a model where debt is not settled with money, but not in a model where money serves as the means of payment. Here I go one step further, arguing that inflation may harm credit. The economy suffers in terms of output and welfare from inflation. Inflation, harming credit, reduces the amount of transactions performed and thus reduces output. Interestingly, the negative effect of inflation on output emerges for high enough inflation rates.

Recent empirical analyses highlight four facts consistent with the model:

1. there is positive correlation between private credit and output (Levine and Zervos (1998))

2. there is negative correlation between inflation and private credit (Boyd, Levine and Smith (2001))

3. there is negative correlation between inflation and output for high enough inflation (Bullard and Keating (1995))

4. the nominal interest rate is not unit elastic in the inflation rate (Koustas and Serletis (1999))

Boyd, Levine and Smith (2001), in particular, find evidence of a negative relationship between financial activity and inflation, using both cross-country and panel data. Their measure of financial activity is private credit to GDP. As for the third fact: "There is now a substantial body of evidence indicating that sustained -and, therefore, likely predictable- high rates of inflation can have adverse consequences either for an economy's long-run rate of real growth or for its long-run level of real activity." (Boyd, Levine and Smith (2001)). Bullard and Keating (1995) show that output is decreasing in the inflation rate when inflation is high enough.

Baumol-Tobin cash management theory is the basis for recent estimates of the demand for cash with microeconomic data (Attanasio, Guiso and Jappelli (2002)). Households choose their money holdings for transaction purposes taking into account the cost of transaction time and forgone interest. My model suggests that alongside interest rate, time and consumption, debt might have a role in determining agents' demand for cash. To test the impact of debt on the demand for cash I use data on the amount of cash withdrawn in a year, the interest rates on deposits, the amount of cash spent on non-durable consumption in a year and the amount of debt in a year for roughly 8000 households per year for the years 1989 and 1991[3]. Data are from the Survey of Household Income and Wealth run by the Bank of Italy every two years. Regressing the total amount withdrawn against a time trend, interest rate, consumption and debt I find a positive significant coefficient for debt.

1.1 Related Literature

The focus of the literature has been on the substitution between money and credit as means of exchange. Kocherlakota and Wallace (1998) have a model featuring random matching with the added twist of a central record keeping technology to monitor all trades. When records are updated with a lag, an equilibrium with a mix of money and credit can be sustained using coordinated punishments. Money is not the means of

[3]Some of the relevant variables are not available before 1989. After 1991 the Survey doesn't contain data on debt at the beginning of the year, but only at the end of the year. Since I'm interested in testing the Cash-in-Arrears framework I focus on debt at the beginning of the year.

payment. An example in Green (2003) shows that inflation may spoil the acceptability of money. In the present paper there isn't any record keeping technology: the repayment of credit is secured by the existence of collateral. Inflation doesn't spoil the acceptability of money while it harms credit.

A related paper is Shi (1996), where credit is also issued against collateral and it can be paid with money or goods. My contribution is however quite different in the focus and the modelling strategy. I focus on the complementarity between money and credit, stressing the fact that promises are paid off with money which is the sole means of payment, whereas in Shi's words "Money must compete against credit". As for the modelling strategy, Shi (1996) features random matching, prices are given by a bargaining procedure and individuals can hold either one unit or none of indivisible fiat money. For some parameter values, Shi (1996) finds coexistence of money and credit and rate of return dominance. My model features competitive markets, walrasian prices and divisible fiat money. This allows me to analyse monetary policy questions.

A paper similar in spirit to my own is Freeman (1996), where purchases are made with debt, debt is settled with a final payment of fiat money and there is a market for the resale of debt. The model is in the overlapping generation tradition and the clearing system is centralized: agents need to move to the central island to clear debts. In my paper the repayment process is completely decentralized.

Substitution between assets leads to different empirical predictions. In Tobin (1965) anticipated inflation induces agents to substitute in their portfolios capital for money thus increasing the capital stock and output and decreasing the real interest rate. Stockman (1981) however reversed the Mundell-Tobin effect imposing a Cash-in-Advance constraint on consumption and capital. His findings are similar to mine.

The recent literature in the Lucas tradition associates anticipated inflation with lower output and unchanged real interest rate. In Cooley and Hansen (1989) anticipated inflation induces agents "to substitute away from activities that require cash, such as consumption, for activities that do not require cash, such as leisure". Gillman (1993) introduces in a model à la Lucas and Stokey (1987) the possibility to choose between money and credit transactions. Money and credit are purely substitutes. Inflation drives up the nominal interest rate making more costly to hold money and inducing agents to switch increasingly to credit transactions. This literature finds evidence of a positive effect of inflation on alternative transaction services and identifies the welfare costs of inflation with the misallocation of resources to a costly transaction technology which provides the alternative means of exchange and is used to avoid the inflation tax. In my model credit enhances production and welfare. The source of the welfare cost is that inflation harms a valuable means of exchange.

Attanasio, Guiso and Jappelli (2002) have estimated a demand for money with microeconomic data based on the idea that agents cash management decisions are affected by the forgone interest cost of holding money when there is an interest bearing asset, like demand deposits. They were the first to find an accurate estimate of the interest rate elasticity of the demand for cash. My focus is on the debt elasticity of the demand for money.

The paper is structured as follows. Section 2 describes the model. Section 3 analyses the impact of anticipated inflation on the interest rate, output and the credit to money ratio. Section 4 discusses the results and compares them with the existing literature. Section 5 shows the empirical findings. Finally, section 6 concludes.

2 The Model

Time is discrete and continues for ever. Agents are infinitely lived. They can produce, consume and rest. There are $N > 4$[4] islands arranged on a circle, indexed by $j = 1, ..., N$. Each island is inhabited by a continuum of mass one of agents. On each island j one and only one type of perishable commodity (j) can be produced: agents j are the producers of commodity j. Market participation is intermittent. After producing individuals need to rest for one period: they will not be able to consume or produce for one period[5]. To induce absence of double coincidence of wants, I assume that agents j enjoys consuming

[4] $N > 4$ guarantees that promises cannot be simply swapped instead of being repayed.

[5] The cost of consuming or producing without resting is infinite. This assumption can be relaxed by having a finite disutility $\gamma < 0$ of not resting. Intermittent market participation is necessary since credit is a slower means of exchange: one period is needed to repay.

commodity $j+1$ (modulo N) only. Since commodity $j+1$ is produced on island $j+1$, in order to purchase it consumers have to move there. Every ordered pair of islands is connected by ships, leaving the island in the evening. Agents are free to choose their itineraries. On each island competitive markets for the exchange of the local commodity open each morning, closing at noon. Due to the complete absence of double coincidence of wants, the absence of a record keeping technology and limited commitment, agents need to use media of exchange in order to trade. At time 0 on each island there is an amount M of fiat money, in the form of durable and worthless pieces of paper. Individuals have also the option of issuing their own promises. There is no central record-keeping technology to monitor and enforce promises. Each individual has an amount of durable collateral specific to him without which he is unable to consume[6]. When issuing a promise, each individual surrenders his collateral to their trading partners on the market in exchange for the commodity they purchase. Repayment takes time: the issuer of a promise needs to go back to his island, produce and sell in order to gain the money needed to make final payment. There is no central island or clearing-house to clear all promises simultaneously. The economy has limited commitment: the commitment power of agents is confined to the use of collateral. At all times they can simply decide not to participate in the exchange process. On each island there are competitive markets for the exchange of goods for money (the money market) and for the exchange of goods for promises (the credit market).

Individuals are characterized by a utility function which I assume to be linear in consumption

$$u(x_{t,j}) = x_{t,j}$$

where $x_{t,j}$ is the quantity bought at time t on island j and by a cost function which I assume to be quadratic in the productive effort

$$c(y_{t,j}) = \frac{1}{2}\left(y_{t,j}\right)^2$$

where $y_{t,j}$ is the quantity produced by producer j. The objective of an individual of

[6] The utility of consuming without the collateral is zero. Shi (1996) uses a similar assumption.

type j is to maximize

$$\sum_{t\in T}\beta^t \left[x^M_{t,j+1} + x^C_{t,j+1} - \beta\frac{1}{2}\left(y^M_{t+1,j} + y^C_{t+1,j}\right)^2\right]$$

where $T = \{1, 4, 7, ...\}$ in order to take into account the resting period and travel to the island for repayment and $0 < \beta < 1$ is the time discount rate. $x^M_{t,j+1}$ and $x^C_{t,j+1}$ are the quantities of good $j+1$ bought at time t by individual j on the money market and on the credit market respectively, while $y^M_{t+1,j}$ and $y^C_{t+1,j}$ the quantities sold for money and for credit. Define the price on the money market for good j at time t as $p_{t,j}$ and the price on the credit market as $q_{t,j}$.

Here is the sequence of events. Individual j at time t uses part or possibly all of the money he accumulated in the past (m^j_{t-1}) to buy goods on the money market

$$p_{t,j+1}x^M_{t,j+1} \leq m^j_{t-1}$$

then proceeds to the credit market where he sells a promise d^j_t to be repaid in the future:

$$q_{t,j+1}x^C_{t,j+1} = d^j_t$$

In the following period he produces for money in order to pay off his debt:

$$p_{t+1,j}y^M_{t+1,j} = m^j_{t+1} \geq d^j_t$$

He is then free to produce for a promise that will be repaid the next day when he will follow his debtor on island $j-1$ in order to get his money back:

$$q_{t+1,j}y^C_{t+1,j} = b^j_{t+1} = m^j_{t+2}$$

At time $t+2$ each individual receives a lump-sum money transfer from the government. The previous sequence of exchanges gives rise to the following budget constraint

$$m^j_{t+2} = p_{t+1,j}y^M_{t+1,j} + q_{t+1,j}y^C_{t+1,j} + m^j_{t-1} - p_{t,j+1}x^M_{t,j+1} - q_{t,j+1}x^C_{t,j+1} + \tau_{t+2,j}$$

the Cash-in-Advance constraint

$$p_{t,j+1}x^M_{t,j+1} \leq m^j_{t-1}$$

and the Cash-in-Arrears constraint

$$p_{t+1,j}y^M_{t+1,j} \geq q_{t,j+1}x^C_{t,j+1}$$

which states that the amount of money obtained producing has to be at least enough to repay the debt. The Cash-in-Arrears constraint embeds the relationship of complementarity between money and credit in an otherwise fairly standard cash-in-advance framework and is going to play a major role in the analysis.

The economy features limited commitment. Agents -as in Kocherlakota (1998)- always have the option to stay home and do nothing. The relevant Participation Constraint states that producing tomorrow for promises and consuming in three periods must give non-negative utility:

$$\beta^{t+3}\left(x^M_{t+3,j+1} + x^C_{t+3,j+1}\right) - \beta^{t+1}\frac{1}{2}\left(y^M_{t+1,j} + y^C_{t+1,j}\right)^2 \geq 0$$

2.1 Key Assumptions

In my model there are five key assumptions:

1. Absence of double coincidence of wants and spatial separation are necessary to give a role for money as a means of exchange.

2. Absence of a record keeping technology rules out a centralized credit contract.

3. Limited commitment rules out bilateral credit contracts.

4. Collateral makes the exchange of promises possible, giving agents a limited form of bilateral commitment power.

5. Intermittent market participation is crucial to generate an essential role for credit as a means of exchange.

The first three assumptions are widely used in the literature to create a role for money: the absence of double coincidence and spatial separation are necessary while absence of memory and limited commitment are sufficient to make money essential as a means of exchange.

Assumptions 4 and 5 deserve some comments. Collateral in my model has no public value being individual specific. The reader can think of a consumption tool as in Shi (1996) or alternatively of a blueprint for future production.

One way to introduce intermittent market participation is by assuming that agents need to rest for one period after producing. This assumption captures the fact that human beings, unlike machines, are not constantly performing tasks, they produce and consume at a slower pace. Intermittent market participation slows down the economy and allows agents to use credit together with money as means of exchange.

2.2 Individuals

In a symmetric equilibrium individuals choose $\left(x_t^M, x_t^C, y_{t+1}^M, y_{t+1}^C, m_{t+2}\right)$ to solve

$$\max \quad \sum_{t=1,4,\ldots} \beta^t \left[x_t^M + x_t^C - \beta\frac{1}{2}\left(y_{t+1}^M + y_{t+1}^C\right)^2\right]$$

$$s.t. \quad p_t x_t^M \leq m_{t-1} \qquad [\lambda_t]$$

$$p_{t+1} y_{t+1}^M \geq q_t x_t^C \qquad [\mu_t]$$

$$m_{t+2} = p_{t+1} y_{t+1}^M + q_{t+1} y_{t+1}^C + m_{t-1} - p_t x_t^M - q_t x_t^C + \tau_{t+2} \qquad [\gamma_t]$$

$$\beta^{t+3}\left(x_{t+3}^M + x_{t+3}^C\right) \geq \beta^{t+1}\frac{1}{2}\left(y_{t+1}^M + y_{t+1}^C\right)^2 \qquad [\phi_t]$$

together with the transversality condition on money holdings.

In the interior solution the Euler equations are

$$\frac{1}{q_t} = \frac{(1+\phi_t)\,\beta\left(y_{t+1}^M + y_{t+1}^C\right)}{p_{t+1}} \tag{1}$$

which equates the marginal benefit of consuming on credit to the marginal cost of producing tomorrow for money in order to repay and

$$\frac{\beta^3}{p_{t+3}} = \frac{(1+\phi_t)\,\beta\left(y_{t+1}^M + y_{t+1}^C\right)}{q_{t+1}} \tag{2}$$

which equates the marginal benefit of consuming with money in three periods time to the marginal cost of producing for a promise tomorrow. Define the interest factor

$(1+i_t) = \frac{q_t}{p_t}$ for all t. Observe that $\lambda_t > 0$ and $\mu_t > 0$ when $(1+i_t) > 1$ for all t. The binding Cash-in-Arrears constraint is

$$y_{t+1}^M = (1+i_t)\frac{p_t}{p_{t+1}} x_t^C \tag{3}$$

and the complementary slackness condition for the Participation Constraint is

$$\phi_t \left[\beta^3 \left(x_{t+3}^M + x_{t+3}^C \right) - \beta \frac{1}{2} \left(y_{t+1}^M + y_{t+1}^C \right)^2 \right] = 0 \tag{4}$$

with $\phi_t \geq 0$.

(1) and (2) can be solved together to give the two period interest factor

$$(1+i_t)(1+i_{t+1}) = \frac{1}{\beta^3} \frac{p_{t+3}}{p_t}$$

Below, I solve system (1)-(4) in a stationary equilibrium for the one period interest factor, the credit to money ratio, total output and the multiplier ϕ.

Finally as a benchmark consider an economy where credit cannot be used (for instance because there is no collateral). In this case the model turns into a cash-in-advance model where the Cash-in-Arrears constraint and the participation constraint are not binding and the solution is

$$\widehat{y}_{t+1}^M = \beta^2 \frac{p_{t+1}}{p_{t+3}}$$

2.3 The Government

On each island, the government issues money every period and gives lump-sum transfers to agents in their rest period. The government budget constraint equates the increase in the money supply on each island to the total transfers to agents:

$$M_t - M_{t-1} = T_t$$

where I dropped the index for the islands since I solve for a symmetric equilibrium. The money supply grows at a rate z_t :

$$M_t = (1+z_t) M_{t-1}$$

3 Equilibrium without Inflation

I solve first for a stationary symmetric competitive equilibrium without inflation. In such an equilibrium

1. agents maximize utility subject to the budget constraint, the cash-in-advance constraint, the repayment constraint, the participation constraint and the transversality condition;

2. all markets clear at all times: the goods-for-money market $x_t^M = y_t^M$, the goods-for-credit market $x_t^C = y_t^C$, the market for money $m_t = M_t$;

3. the Government fulfills its budget constraint and sets $z_t = 0$ ($T_t = 0$) at all times;

The system (1), (2), (3) and (4) can be solved in a stationary equilibrium for the one period nominal interest factor, for the credit to money ratio, for total output and for the multiplier ϕ. The interest factor is

$$(1+i) = \beta^{-\frac{3}{2}}$$

the credit to money ratio is

$$\frac{y^C}{y^M} = \beta^{\frac{3}{2}}$$

and the multiplier

$$\phi = \beta^{\frac{1}{2}} - \left(y^C + y^M\right)$$

is positive if $\beta < \left(\frac{1}{2}\right)^{\frac{2}{3}}$.

When the Participation Constraint is binding, total output and consumption in the economy are given by

$$y^C + y^M = 2\beta^2 = x^C + x^M$$

When $\beta \geq \left(\frac{1}{2}\right)^{\frac{2}{3}}$ the Participation Constraint is not binding and total output and consumption are

$$y^C + y^M = \beta^{\frac{1}{2}} = x^C + x^M$$

In the monetary equilibrium without credit, total output and consumption would be

$$\widehat{y}^M = \beta^2 = \widehat{x}^M$$

In the equilibrium in each period one third of the population is consuming using both money and credit, one third is producing for money and credit and one third is resting while repayment takes place. Agents j in the morning of day t are on island $j+1$ and trade money for goods. They also issue promises secured by the collateral to increase their consumption of good $j+1$. In the evening they catch the ship back to island j. At $t+1$ they produce for money and for promises. They repay their promise in the afternoon, by handing fiat money to their creditors (agents $j+1$) who have travelled with them and are waiting on island j. The collateral is returned and promises destroyed. In the evening they leave to island $j-1$ where the next day they wait for repayment to take place. In the evening they travel to island $j+1$ to restart the cycle. Money and credit are both media of exchange and money is the means of payment.

Observe that in equilibrium the price on the credit market is higher than the one on the money market: $(1+i) \equiv \frac{q}{p} = \beta^{-\frac{3}{2}} > 1$, i.e. there is rate of return dominance. This is necessary for a promise of money-later to be accepted instead of money-now. Total production in the economy with credit is higher than total production in the economy with only money: $\beta^{\frac{1}{2}} > \beta^2$and $2\beta^2 > \beta^2$. Credit is a valuable means of exchange that increases the number of transactions. More transactions induce agents to consume and produce more compared to an economy with only money. The two means of exchange coexist in a fundamental sense: each agent uses both at every stage to exchange.

To summarise, credit is repaid with money, there is an endogenous interest rate and output is higher than in the corresponding economy without credit.

3.1 Welfare

To show that money and credit together can achieve an outcome that is socially preferred to the outcome that can be achieved with money alone, I will compare welfare in the equilibrium with credit and in the equilibrium without it, taking as a measure of welfare the sum of the value functions of the three groups of individuals -i.e. consumers, producers and resting agents-.

$$W = V_c + V_p + V_r = \frac{x^M + x^C - \frac{1}{2}\left(y^M + y^C\right)^2}{(1-\beta)}$$

is the sum of the value functions of the three groups of individuals in the money and credit equilibrium and

$$\widehat{W} = \widehat{V}_c + \widehat{V}_p + \widehat{V}_r = \frac{\widehat{x}^M - \frac{1}{2}\left(\widehat{y}^M\right)^2}{(1-\beta)}$$

is the sum of the value functions of the three groups of individuals in the money only equilibrium.

The difference $W - \widehat{W}$ -when $\beta > \left(\frac{1}{2}\right)^{\frac{2}{3}}$- is

$$W - \widehat{W} = \frac{2\beta^{\frac{1}{2}} - \beta}{2(1-\beta)} - \frac{2\beta^2 - \beta^4}{2(1-\beta)}$$

which is positive for all $0 < \beta < 1$.

The difference $W - \widehat{W}$ -when $\beta < \left(\frac{1}{2}\right)^{\frac{2}{3}}$- is

$$W - \widehat{W} = \frac{4\beta^2 - 4\beta^4}{2(1-\beta)} - \frac{2\beta^2 - \beta^4}{2(1-\beta)}$$

which is positive for $\beta < \left(\frac{2}{3}\right)^{\frac{1}{2}}$. Notice that $\left(\frac{2}{3}\right)^{\frac{1}{2}} > \left(\frac{1}{2}\right)^{\frac{2}{3}}$.

Money and credit thus achieve a socially preferred outcome. Money helps credit to work providing the means of payment and the use of credit improves output and welfare compared to an economy without credit since it allows agents to perform more transactions.

4 Equilibrium with Anticipated Inflation

Next, I solve for a stationary symmetric competitive equilibrium with steady inflation. In such an equilibrium

1. agents maximize utility subject to the budget constraint, the cash-in-advance constraint, the repayment constraint, the participation constraint and the transversality condition;

2. all markets clear at all times: the goods-for-money market $x_t^M = y_t^M$, the goods-for-credit market $x_t^C = y_t^C$, the market for money $m_t = M_t$;

3. the Government fulfills its budget constraint and sets $z_t = z > 0$ at all times;

By money market clearing, the inflation rate $\pi = z$. In the symmetric stationary equilibrium the nominal interest factor is

$$(1+i) = \left(\frac{1+z}{\beta}\right)^{\frac{3}{2}} \tag{5}$$

The participation constraint is binding when ϕ is positive:

$$\phi = \frac{\beta^{\frac{1}{2}}}{(1+z)^{\frac{1}{2}}} - \left(y^C + y^M\right)$$

and it is non binding when

$$1+z \geq \frac{1}{4\beta^3}$$

Observe that the real interest factor increases with the inflation rate

$$(1+r) = \frac{1+i}{1+z} = \frac{(1+z)^{\frac{1}{2}}}{\beta^{\frac{3}{2}}} \tag{6}$$

The nominal interest factor is more than unit elastic in the inflation factor and the real interest factor increases with inflation. The real interest factor (6), using the repayment constraint and the equilibrium condition on the credit market

$$y^M = (1+r)\, y^C$$

gives the ratio of the real demand for promises to the real demand for money. The credit to money ratio in the economy goes down with inflation since lenders have to hold money overnight after repayment takes place

$$\frac{y^C}{y^M} = \frac{\beta^{\frac{3}{2}}}{(1+z)^{\frac{1}{2}}} \tag{7}$$

The amount of goods sold for credit as a share of output in the credit unconstrained case is decreasing in the inflation rate

$$\frac{y^C}{y^C + y^M} = \frac{\beta^{\frac{3}{2}}}{\beta^{\frac{3}{2}} + (1+z)^{\frac{1}{2}}} \tag{8}$$

Notice that when the inflation rate tends to infinity the credit to output ratio vanishes.

At time t a producer in equilibrium holds a claim to future money which will be paid off at $t+1$. At t He doesn't hold any money overnight since he uses the money he acquires to repay his debt immediately after trading. He will however have to hold money for one day, from $t+1$ until $t+2$ when he will spend it to buy consumption goods. Inflation drives up the nominal interest rate and makes it costly to hold claims to future money: agents reduce their credit holdings. This accounts for formulas (7) and (8) above, where Credit to Money and Credit to GDP decrease with inflation. To summarise, the real interest rate increases with the inflation rate and the credit to money ratio decreases with inflation.

4.1 The Welfare Cost of Inflation

Output is decreasing in the inflation rate. Credit increases the amount of transactions which increases output. This can be seen from the Euler equation

$$\left(y^M + y^C\right) = \frac{1}{\beta\left(1+r\right)} = \frac{1}{\beta}\frac{y^C}{y^M}$$

where the second equality is obtained using the binding repayment constraint and market clearing. Higher inflation reduces the credit to money ratio and this reduces transactions and the incentive to exert productive effort. Output and consumption when the participation constraint is not binding are decreasing in the inflation rate

$$y^M + y^C = \frac{\beta^{\frac{1}{2}}}{\left(1+z\right)^{\frac{1}{2}}} = x^M + x^C$$

while, when the participation constraint is binding, output is insensitive to the inflation rate

$$y^M + y^C = 2\beta^2 = x^M + x^C$$

Total output increases with the credit to money ratio: more credit allows agents to trade more driving up production. Inflation in turn decrease the credit to money mix, by reducing the incentive to hold future money. Thus inflation reduces output in the

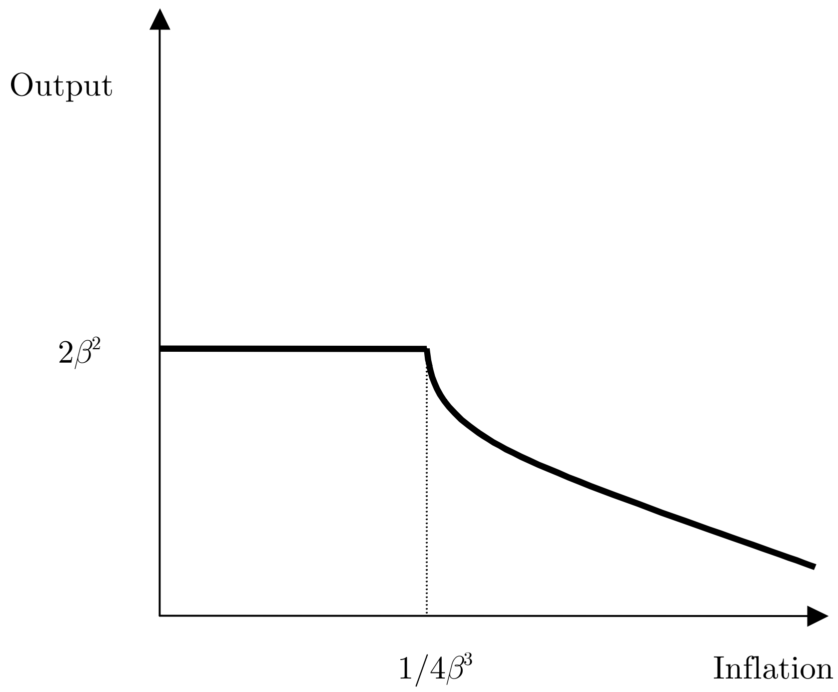

Figure 2: High Inflation harms Output

economy. This however happens only when the inflation rate is sufficiently high -i.e. for $1+z \geq \frac{1}{4\beta^3}$. For lower inflation factors output is constant (see Figure 2).

A steady inflation generates a welfare loss, since agents transact, produce and consume less. Welfare, when the Participation Constraint is not binding, is given by

$$W(z) = \frac{2\beta^{\frac{1}{2}}(1+z)^{\frac{1}{2}} - \beta}{2(1-\beta)(1+z)} \tag{9}$$

and when the Participation Constraint is binding, by

$$W(z) = \frac{4\beta^2 - 4\beta^4}{2(1-\beta)} \tag{10}$$

As a measure of the welfare cost of inflation consider the difference between welfare in an economy with inflation and in an economy without inflation: $W(z) - W(0)$. Observe that (9) is decreasing in the inflation rate for any $z \geq 0$

$$W'(z) = \frac{\beta^{\frac{1}{2}}\left[\beta^{\frac{1}{2}} - (1+z)^{\frac{1}{2}}\right]}{2(1-\beta)(1+z)^2}$$

Therefore, welfare with inflation is lower than welfare without inflation. (10) is constant and equal to welfare without inflation.

First Best is given by $y^* = x^* = 1$. The optimal monetary policy would be the Friedman Rule. The government should tax money balances, deflating at a rate $\beta - 1$, until the rate of return on money and credit are equalised, allowing the distortion due to market incompleteness to be overcome and the first best allocation to be reached. However, the Friedman Rule cannot be implemented through taxes since enforcement is limited in the economy and agents cannot be forced to surrender money to the government.

Output and consumption in the monetary equilibrium without credit would be

$$\widehat{y}^M = \frac{\beta^2}{(1+z)^2} = \widehat{x}^M$$

Welfare in the money economy without credit would then be

$$\widehat{W}(z) = \frac{\beta^2 \left[2(1+z)^2 - \beta^2\right]}{2(1-\beta)(1+z)^4}$$

The economy with credit always performs better than the corresponding economy without credit. Taking the difference between welfare with credit -when the participation constraint is slack- and welfare without credit, I obtain

$$W(z) - \widehat{W}(z) = \frac{2\beta^{\frac{1}{2}}(1+z)^{\frac{7}{2}} - \beta(1+z)^3 - 2\beta^2(1+z)^2 + \beta^4}{2(1-\beta)(1+z)^4}$$

which is strictly positive for any $z \geq 0$. When the participation constraint is binding, the difference in welfare is

$$W(z) - \widehat{W}(z) = \frac{4\beta^2(1+z)^4 - 4\beta^4(1+z)^4 - 2\beta^2(1+z)^2 + \beta^4}{2(1-\beta)(1+z)^4}$$

which is positive for any $z \geq 0$ when $\beta < \left(\frac{2}{3}\right)^{\frac{1}{2}}$.

The model highlights a neglected component of the welfare costs of inflation: inflation drives down the credit to money mix in the economy. Production suffers from the decrease in credit: welfare is lower.

5 Discussion

The relationship between money and credit in the model revolves around the Cash-in-Arrears constraint, embedding complementarity. The new constraint is responsible for the effects of inflation on the interest rate, on output and on credit. Anticipated inflation gives rise to a reverse Mundell-Tobin effect. The nominal interest rate is more than unit elastic in the inflation rate and thus the real interest rate increases with inflation, the credit to money and credit to GDP ratios decrease with inflation and finally output decreases with inflation, when the inflation rate is sufficiently high.

Boyd, Levine and Smith (2001) use macroeconomic data to show that anticipated inflation has a negative impact on private credit to GDP and interestingly, Bullard and Keating (1995) provide evidence of the fact that output is relatively insensitive to inflation when inflation is low and decreasing for higher inflation rates. There is also recent evidence that the nominal interest rate is not unit elastic in the inflation rate.

In the model by Tobin (1965) a permanent increase in inflation induces agents to substitute capital for money balances, increasing the capital stock and output and lowering the return on capital which equates the real interest rate. Capital and money are substitute in the portfolios of agents.

The predictions differ also from those derived in more recent models where in the presence of inflation agents switch to credit in order to avoid the inflation tax, as in the paper by Gillman (1993) and in similar models by Aiyagari, Braun and Eckstein (1998) and English (1999). These models modify a cash in advance economy à la Lucas and Stokey to allow the representative agent to decide which goods to buy with cash and which goods with a costly transaction technology that produces credit services. Gillman (1993) shows that "the consumer chooses between a foregone-interest cost of cash and a time cost of credit when purchasing any one good. Avoiding the inflation tax means switching from fiat that uses no resources to exchange credit that uses up societal resources.[...]the consumer substitutes away from cash until the marginal cost of avoiding inflation, through credit use, equal the marginal inflation tax on cash use". The increase in the nominal interest rate makes more costly to hold money. Agents thus switch to an alternative -inflation free- means of exchange. The credit to money ratio and credit to output ratio increase with inflation. Moreover the nominal interest rate elasticity to inflation is equal to one.

The literature typically identifies the welfare costs of inflation with the resource cost of producing transaction services alternative to cash. Resources are diverted from production to credit services and welfare is lower. The point is neatly summarized in a recent paper by Lucas (2000): "In a monetary economy, it is in everyone's private interest to try to get someone else to hold non-interest-bearing cash and reserves. [...] All of us spend several hours per year in this effort and we employ thousands of talented and highly-trained people to help us. These person-hours are simply thrown away, wasted on a task that should not have to be performed at all."

Complementarity between money and credit highlights an aspect of the welfare cost of inflation which has been neglected in the previous literature: inflation, driving up the nominal interest rate, makes costly to hold a promise of money, thus reducing the credit to money ratio which in turn reduces transactions, output, consumption and welfare.

6 Empirical Findings

The Cash-in-Arrears constraint is the driving force of the model. Broadly speaking it says that agents with debt will have to hold cash in the future in order to repay. Money demand functions have been estimated on the basis of theoretical models of cash management of the Baumol-Tobin type in which consumers when deciding their money holdings for transaction purposes, they take into account the cost of transaction time and the forgone interest of other assets. To test the Baumol-Tobin model Attanasio, Guiso and Jappelli (2002) estimate a money demand function with time, interest on checking accounts and consumption as explanatory variables.

In my model, debt influences cash management decisions by households, since debt is paid off with money. Specifically higher debt would induce agents to hold more cash. I thus look at the impact of debt on the amount of money withdrawn controlling for consumption and interest rates, using micro-data on Italian households. I use the same dataset as Attanasio, Guiso and Jappelli (2002)[7]-namely the Survey of Household Income and Wealth- to estimate a demand for money including debt as an explanatory variable.

[7] Attanasio, Guiso and Jappelli (2002) provide a very careful description of the data. The reader is referred to their paper for further details.

The Survey is run by the Bank of Italy every two years. It is a collection of roughly 8000 households per year with information on consumption, financial wealth and cash management variables. The Survey contains information about the province of residence of each household. The Monetary Statistics Survey of the Bank of Italy provides average interest rates on checking accounts per province. I thus have interest rates on checking accounts varying by year and province for each household. The variables of interest are: total amount withdrawn in a year, total consumption in a year, after tax interest rate on checking accounts, total amount of debt at the beginning of the year. The years are 1989 and 1991, since after 1991 the Bank of Italy collected data only on debt at the end of the year. The total number of household is 16392. All monetary variables are deflated -base year 1995- and converted to euros. I computed the total amount withdrawn in a year multiplying the number of withdrawals and the average amount withdrawn from ATM and checking accounts. First I want to check whether households with debt take different cash management decisions compared to households with no debt. I thus estimate a money demand function including a dummy for households with debt and controlling for the interest rate on checking accounts and consumption:

$$\log m = \alpha + \beta t + \gamma \log i + \delta \log c + \zeta dd$$

where on the LHS there is the log of the total amount of money withdrawn from ATM and checking accounts in a year by households with a bank account, on the RHS there is a time trend, the log of the after tax interest rate for checking accounts per province, the log of total consumption in a year and a dummy for agents with debt: $dd = 1$ being a household with debt. Parameters estimates are reported in Table 1 column 1 in the Appendix. The coefficient for the debt dummy is positive and significant.

Next I estimate a money demand equation where I include the volume of debt divided by the net wealth of households:

$$\log m = \alpha + \beta t + \gamma \log i + \delta \log c + \zeta \log dw$$

where on the LHS there is the log of the total amount of money withdrawn from ATM and checking accounts in a year by households with a bank account, on the RHS there is a time trend, the log of the after tax interest rate for checking accounts per province, the log of total consumption in a year and $dw = 1 + \frac{\text{Debt}}{\text{Net Wealth}}$ in order to include households without debt. Parameters estimates are reported in Table 1 column 2 in the Appendix. The elasticity for debt is positive and significant.

Finally I check whether the amount of debt has an impact on cash withdrawn. The third equation is

$$\log m = \alpha + \beta t + \gamma \log i + \delta \log c + \zeta \log d$$

where on the LHS there is the log of the total amount of money withdrawn from ATM and checking accounts in a year by households with a bank account, on the RHS there is a time trend, the log of the after tax interest rate for checking accounts per province, the log of total consumption in a year and the log of the volume of debt including households that have zero debt ($d = 1 + debt$). Parameters estimates are reported in Table 1 column 3 in the Appendix. The elasticity for debt is positive and significant, although smaller than before. All regressions include 11437 observations. Excluded observations are for households that don't have a bank account. White heteroskedasticity consistent t-statistics are in parenthesis. All regressions show a positive and significant sign for debt as predicted by the model.

7 Conclusion

The aim of the paper was to address the issue of the coexistence of credit and money as means of exchange in a model with microfoundations. In equilibrium credit and money coexist, credit is repaid with money and there is rate of return dominance. A Cash-in-Arrears constraint arises. Credit improves output and welfare. The complementarity approach generates some interesting predictions about the effects of anticipated inflation on macro variables: the real interest rate increases with inflation, the credit to money ratio and output both decrease with inflation. This changes some of the predictions of traditional models featuring substitution and generates a reverse Mundell-Tobin effect. The model has implications for empirical estimates of the demand for money. Using microeconomic data I estimated a money demand function and found a positive elasticity of the demand for cash to debt.

8 Appendix

Table 1

The Effect of Debt on the Demand for Cash

OLS Estimation

bDependent variable: log(Cash Withdrawn)	1	2	3
Constant	1.470*** (6.708)	1.391*** (6.301)	1.479*** (6.742)
Time	0.064*** (8.112)	0.067*** (8.417)	0.064*** (8.119)
log(Consumption)	0.768*** (49.13)	0.778*** (49.55)	0.768*** (49.04)
log(Int.Rate Dep.)	−0.02 (−0.23)	−0.03 (−0.36)	−0.02 (−0.25)
Dummy Debt	0.146*** (6.496)	–	–
log(1+Debt/wealth)	–	0.228*** (4.949)	–
log(1+Debt)	–	–	0.016*** (6.296)
Adjusted R^2	0.186	0.183	0.186
F statistic	656.04	636.50	655.25

Legend: The years are 1989 and 1991. The number of observations is 11437. Parameter estimates are reported with White heteroskedasticity consistent t-statistics in brackets. ***significant at the 1-percent level, **significant at the 5-percent level, *significant at the 10-percent level.

References

[1] Aiyagari, Braun and Eckstein (1998), Transaction services, Inflation and Welfare, *Journal of Political Economy*, 106, 6, 1274-1301.

[2] Attanasio, Guiso and Jappelli (2002), The demand for money, financial innovation, and the welfare cost of inflation: an analysis with household data, *Journal of Political Economy*, 110, 21, 317-351.

[3] Boyd, Levine and Smith (2001), The Impact of Inflation on Financial Sector Performance, *Journal of Monetary Economics*, 47, 2, 219-446

[4] Bullard and Keating (1995), The long-run relationship between inflation and output in post-war economies, *Journal of Monetary Economics*, 36, 477-496

[5] Cooley and Hansen (1989), The inflation tax in a real business cycle model, *The American Economic Review*, 79, 733-748.

[6] English (1999), Inflation and Financial Sector Size, *Journal of Monetary Economics*, 44, 379-400

[7] Freeman (1996), The Payments System, Liquidity, and Rediscounting, *The American Economic Review*, 86, 1126-1138.

[8] Gillman (1993), The Welfare Cost of Inflation in a Cash-in-advance Economy with Costly Credit, *Journal of Monetary Economics*, 31, 97-115.

[9] Goodhart (1989), *Money, Information and Uncertainty*, Macmillan, London.

[10] Green (2003), Payment Arrangements and Inflation, mimeo.

[11] International Monetary Fund, *International Financial Statistics*, 2004.

[12] Kiyotaki and Wright (1989), On Money as a medium of exchange, *Journal of Political Economy*, 97, 4, 927-954.

[13] Kocherlakota (1998), Money is Memory, *Journal of Economic Theory,* 82, 232-251.

[14] Kocherlakota (2004), Societal benefits of illiquid bonds, *Journal of Economic Theory*, 108, 179-193.

[15] Kocherlakota and Wallace (1998), Incomplete record-keeping and optimal payment arrangements, *Journal of Economic Theory, 81, 272-289.*

[16] Koustas and Serletis (1999), On the Fisher effect, *Journal of Monetary Economics*, 44, 105-130.

[17] Levine and Zervos (1998), Stock Markets, banks and economics growth, *The American Economic Review*, 88, 537-558.

[18] Lucas (2000), Inflation and Welfare, *Econometrica*, 68, 247-274.

[19] Lucas and Stokey (1987), Money and Interest in a Cash-in-Advance Economy, *Econometrica*, 55, 3, 491-513.

[20] Shi (1996), Credit and money in a search model with divisible commodities, *Review of Economic Studies*, 63, 627-652.

[21] Stockman (1981), Anticipated inflation and the capital stock in a cash-in-advance economy, *Journal of Monetary Economics*, 8, 387-393.

[22] Tobin (1965), Money and economic growth, *Econometrica*, 33, 671-810.

[23] Townsend (1980), Models of money with spatially separated agents, in Kareken J.H. and N. Wallace (eds.), *Models of Monetary Economies*, Federal Reserve Bank of Minneapolis, Minneapolis.

[24] Williamson (1999), Private Money, *Journal of Money, Credit and Banking*, 31, 469-491.