

# Credit Shocks in a Monetary Business Cycle\*

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## Abstract

The paper sets out a monetary business cycle model extended to include the production of credit that serves as an alternative to money in transactions and is subject to productivity shocks. The model provides some improvement on certain puzzles, in particular by capturing the procyclic movements of monetary aggregates, inflation and interest rates. And its application to analyse banking episodes indicates that the credit shock helps explain cycle behavior during the US financial deregulation period of the 1980s and 1990s.

**Keywords:** business cycle, credit shocks, financial deregulation

**JEL:** E32, G20

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# 1 Introduction

The ability to explain nominal and real elements of the business cycle has been studied using the cash-in-advance approach in Cooley and Hansen (1989, 1995, 1998). They identify puzzles left in the ability of the MBC model to fit the data, and show how nominal wage rigidities can help explain puzzles related to the liquidity effect. Ohanian et al (1995) argue that nominal price rigidities improve the performance here. Other puzzles are well explained with the "inflation tax", approach of the cash-in-advance economy. For example the goods to leisure substitution feature of these exchange models is consistent with their ability to explain the negative correlation between hours worked and the money supply growth rate. Gavin and Kydland (1999) extend the exchange approach by using a shopping time technology and introducing a money supply process with output feedback. This helps explain relative volatilities of nominal variables, although Ireland (2003) finds the sticky prices overall better performance than the endogenous money supply. Yet some puzzles are not well explained by either nominal rigidities, the standard exchange technologies, or feedback rules. These include the procyclic movement of the income velocity of money, of monetary aggregates, and of inflation and the nominal interest rate. And a model that is more encompassing of the various answers to the puzzles still is not evident.

Another approach exists in the finance/credit literature on business fluctuations. These range from Kiyotaki and Moore's (1997) illustration of how financial shocks can be amplified in a non-monetary framework to Einarrson and Marquis's (2001) examination of credit aggregates in a monetary model with banking. Li (2000) even presents a credit model that exhibits some of the classic liquidity effects. He specifies a production function for credit as an alternative to money and shows how liquidity effects result when open market operations must pass through financial intermediaries. With a credit production approach that is related to Li, velocity trends have also been explained in Gillman and Kejak (2003). That paper argues that credit productivity can explain departures of M1 velocity trends from what the nominal interest rate movements alone would predict, in particular its leveling in the

1980s and its rise in the 1990s, as well as the related trends in the ratio of M2 to M1. Because the changes in credit productivity during this period chronologically are associated with a series of discrete changes in the US laws on financial regulation, this suggests that shocks to credit technology from financial deregulation may play a role in explaining the MBC facts and certain historical experience.

Berger (2003) documents how technological progress has occurred in banking. And further a literature investigates exactly whether there have been real effects on the economy from US bank deregulation, which Strahan (2003) summarizes well. He estimates how asset structures in the banking industry changed significantly after branching and interstate banking deregulations. And he also shows that the bank profit rate became sharply more correlated with its subsequent asset growth following the deregulation that began in the 1980s. Further he estimates with US state panel data that the states's growth rate of personal income accelerated by 0.56 percentage points following branching deregulation; this updates a previous study by Jayaratne and Strahan (1996) that finds that the states's growth rate accelerated by 0.5 to 1 percentage points following deregulation during the 1972 to 1992 period. Thus bank law deregulations have been specifically linked to structural change in the banking industry, higher profit with asset growth, and output growth rate increases.

This paper extends the MBC analysis by including shocks to the productivity of a credit sector. When positive the credit shock increases profit in that sector and this leads to an increase in aggregate output. Here the credit serves as an alternative payment mechanism for buying goods, in a stochastic extension of the Gillman and Kejak (2002) economy set in an exogenous growth framework. The paper first provides simulations of the model's cross correlations at different lags for comparison to US data. It also presents results for comparison two alternative exchange technologies, a standard cash-in-advance economy and a shopping time economy. And this comparison is done for different combinations of the main shocks in the model: money supply, goods productivity, and the additional shock in the credit model to credit productivity.

The simulation results are used to examine the main puzzles in the monetary business cycle literature, with a comparison of the credit model to the other models. Some striking differences result with the credit model, such as an ability to model the procyclic nature of monetary aggregates, the phase shift in the correlation between output and money, and the positive correlation between inflation, nominal interest rates and output. Altogether these show two aspects: that the credit model even without the credit productivity shock outperforms other models in certain dimensions, and that the additional credit shock itself enables improvement along certain dimensions.

The paper then proceeds to separately identify the credit shocks using a technique in Chari, Kehoe, and McGrattan (2003). Here we match up the random idiosyncratic shocks in the credit sector approximately to the changes in banking laws during the US finance sector deregulation. And these shocks in turn are related to changes in aggregate output changes in a way that shows that the business cycles were "improved" by banking deregulation, using Harding and Pagan (2002) measures of the recovery of the cycles..

Finally we identify several properties of the credit shock that are consistent with Uhlig's (2003) decomposition of the US total factor productivity. He finds a shorter term shock, which along with a medium shock similar to the goods sector productivity shock, together comprise the main shocks theoretically identified as explaining US data. The credit productivity shock has several dimensions in common with his shorter term shock.

## **2 The Credit Model**

### **2.1 The model economy**

The representative agent self produces credit with labor only and buys the aggregate consumption good with a combination of money and credit, whereby the marginal cost of money (the nominal interest rate) equals the marginal cost of credit (the real wage divided by the marginal product of labor in credit production). The credit production exhibits a rising marginal cost as the share of credit used in exchange goes up. The particular form of the

credit production function is equivalent to the assumption that the value-added from the credit service is proportional to the cost of production.

With an explicit price for the credit service as in Gillman and Kejak (2003), it can be shown that this assumption implies that the total revenue from selling the credit service (the value-added) is proportional to the wage cost, leaving a constant rate of profit. This proportionality of the value added with the total cost implies that as total consumption rises, so must the labor input into credit services in order to keep constant the share of credit in exchange. Then the implied production function can be written simply in terms of the share of credit being equal to a diminishing function of the ratio of labor in credit production relative to the total good consumption<sup>1</sup>.

The credit production specification allows for an additional productivity shock. Instead of just good productivity and money shocks, there are three shocks also including one to the productivity of credit.

Consider a representative consumer that maximizes over an infinite horizon its expected lifetime utility over consumption  $c_t$  and leisure  $x_t$ . Utility is given by:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t (\log c_t + \Psi \log x_t) \quad 0 < \beta < 1. \quad (1)$$

The consumer can purchase the goods by using either money or credit services. Let  $a_t \in (0, 1]$  denote the fraction of consumption goods that are purchased with money. Then the consumer's cash-in-advance constraint will have the form:

$$M_{t-1} + T_t \geq a_t P_t c_t, \quad (2)$$

where  $M_{t-1}$  is the money stock carried from the previous period,  $T_t$  is the nominal lump-sum money transfer received from the government and  $P_t$  denotes the current price level. It is assumed that the government policy includes

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<sup>1</sup>This payments technology has been used to reproduce the negative effect of inflation on growth over the range of levels of the inflation rate, with calibration in Gillman and Kejak (2002). This is a nonlinear relation whereby the marginal inflation-growth effect gets significantly weaker as inflation rises, which is found in evidence in Ghosh and Phillips (1998), Khan and Senhadji (2000) and Gillman, Harris and Matyas (2003).

sequences of nominal transfers which satisfy:

$$T_t = \Theta_t M_{t-1} = (\Theta^* + e^{u_t} - 1)M_{t-1}, \quad (3)$$

where  $\Theta_t$  is the growth rate of money and  $\Theta^*$  is the stationary growth rate of money. Transfer is subject to random shocks  $u_t$  which follow the autoregressive process:

$$u_t = \varphi_u u_{t-1} + \epsilon_{ut}, \quad \epsilon_{ut} \sim N(0, \sigma_u^2), \quad 0 < \varphi_u < 1. \quad (4)$$

The amount of credit used is equal to  $c_t(1 - a_t)$ . The production function for this amount of credit is given by

$$c_t(1 - a_t) = A_F e^{v_t} \left( \frac{l_{Ft}}{c_t} \right)^\gamma c_t, \quad A_F > 0, \quad \gamma \in (0, 1).$$

This can be written as

$$1 - a_t = A_F e^{v_t} \left( \frac{l_{Ft}}{c_t} \right)^\gamma, \quad (5)$$

where  $1 - a_t$  is the share of goods bought with credit,  $A_F e^{v_t}$  is the productivity shift parameter and  $l_{Ft}$  is the labor time spent in producing credit services. Assume a total time endowment of 1, which is divided among time spent working, leisure and time spent in credit service production:

$$n_t + x_t + l_{Ft} = 1. \quad (6)$$

There exists productivity shocks that follow an autocorrelated process:

$$v_t = \varphi_v v_{t-1} + \epsilon_{vt}, \quad \epsilon_{vt} \sim N(0, \sigma_v^2), \quad 0 < \varphi_v < 1. \quad (7)$$

Output  $y_t$  is produced by the agent, acting in part as the representative firm, from capital accumulated in the previous period  $k_{t-1}$  and current labor  $n_t$  using a Cobb-Douglas CRS production function which is subject to technology shocks  $z_t$ :

$$y_t = e^{z_t} k_{t-1}^\alpha n_t^{1-\alpha}, \quad (8)$$

$$z_t = \varphi_z z_{t-1} + \epsilon_{zt}, \quad \epsilon_{zt} \sim N(0, \sigma_z^2), \quad 0 < \varphi_z < 1. \quad (9)$$

The part of output that is not consumed is invested in physical capital. Current investment  $i_t$  together with depreciated capital form the capital stock used for production in the next period:

$$k_t = (1 - \delta)k_{t-1} + i_t. \quad (10)$$

Firms maximize their profits  $y_t - r_t k_{t-1} - w_t n_t + (1 - \delta)k_{t-1}$ , which yield the following functions for  $w_t$ , the real wage rate and  $r_t$ , the gross real rate of return, net of depreciation  $\delta$ :

$$w_t = (1 - \alpha)e^{z_t} k_{t-1}^\alpha n_t^{-\alpha}, \quad (11)$$

$$r_t = \alpha e^{z_t} k_{t-1}^{\alpha-1} n_t^{1-\alpha} + 1 - \delta. \quad (12)$$

Current income from labor, capital, money balances and lump-sum transfers are spent on consumption, new capital formation and the accumulation of real balances. The period  $t$  budget constraint of the representative consumer is given by:

$$w_t P_t (1 - x_t - l_{Ft}) + P_t r_t k_{t-1} + T_t + M_{t-1} \geq P_t c_t + P_t k_t + M_t. \quad (13)$$

The consumer chooses consumption, leisure, time spent in credit service production, capital stock, credit service purchase and money balance path  $\{c_t, x_t, l_{Ft}, k_t, a_t, M_t\}_{t=0}^\infty$  to maximize lifetime utility (1) subject to the cash-in-advance constraint (2), budget constraint (13) and credit service technology (5).

Dividing equations (2) and (13) by the price level and substituting  $l_{Ft}$  expressed from (5), the Lagrangian of the maximization problem of the household is

$$\begin{aligned} L = E \sum_{t=0}^{\infty} \beta^t \{ & (\log c_t + \Psi \log x_t) \\ & + \lambda_t \left[ \frac{M_{t-1} + T_t}{P_t} - a_t c_t \right] \\ & + \mu_t \left[ w_t \left( 1 - x_t - \left( \frac{1 - a_t}{A_F e^{v_t}} \right)^{\frac{1}{\gamma}} c_t \right) + r_t k_{t-1} + \frac{M_{t-1} + T_t}{P_t} - c_t - k_t - \frac{M_t}{P_t} \right] \}. \end{aligned} \quad (14)$$

The first-order conditions with respect to  $c_t, x_t, k_t, a_t, M_t$  are

$$\frac{1}{c_t} - \lambda_t a_t - \mu_t w_t \left( \frac{1 - a_t}{A_F e^{v_t}} \right)^{\frac{1}{\gamma}} - \mu_t = 0, \quad (15)$$

$$\frac{\Psi}{x_t} - \mu_t w_t = 0, \quad (16)$$

$$-\mu_t + \beta E_t \{ \mu_{t+1} r_{t+1} \} = 0, \quad (17)$$

$$-\lambda_t c_t + \mu_t w_t c_t \frac{1}{\gamma A_F e^{v_t}} \left( \frac{1 - a_t}{A_F e^{v_t}} \right)^{\frac{1}{\gamma} - 1} = 0, \quad (18)$$

$$\frac{-\mu_t}{P_t} + \beta E_t \left\{ \frac{\lambda_{t+1} + \mu_{t+1}}{P_{t+1}} \right\} = 0. \quad (19)$$

A competitive equilibrium for this economy consists of a set of allocations  $\{c_t, x_t, l_t, n_t, k_t, a_t, M_t\}_{t=0}^{\infty}$ , a set of prices  $\{w_t, r_t\}_{t=0}^{\infty}$ , exogenous shock processes  $\{z_t, v_t, u_t\}_{t=0}^{\infty}$ , money supply process and initial conditions  $k_{-1}$  and  $M_{-1}$  such that given the prices, shocks and government transfers, the allocations solve the consumer's utility maximization problem, solve the firm's profit maximization problem and the goods and labor and money markets clear.

In a stationary deterministic steady state we use the transformation  $p_t = \frac{P_t}{M_t}$  (and also denote real money balances by  $m_t = \frac{M_t}{P_t}$ ). There is no uncertainty and time indices can be dropped, denoting by  $(*)$  the steady state values and by  $R^* = r^*(\Theta^* + 1)$  the steady state interest factor. In the equilibrium, inflation equals the growth rate of the money supply. The first order conditions (15)-(13) can be simplified to:

$$R^* - 1 = \frac{w^*}{\gamma^* A_F^*} \left( \frac{1 - a^*}{A_F^*} \right)^{\frac{1}{\gamma} - 1}, \quad (20)$$

$$\frac{x_t}{\Psi c_t} = \frac{1 + a^*(R^* - 1) + w^* \left( \frac{1 - a^*}{A_F^*} \right)^{\frac{1}{\gamma}}}{w^*}, \quad (21)$$

$$r^* = \frac{1}{\beta}. \quad (22)$$

Equations (20)-(22) together with the steady-state versions of equations (2)-(6) and (11)-(3) define the steady state of the system.

## 2.2 Log-linearization, Calibration, and Numerical Dynamics Solution

The model is solved by using the log-linearization technique proposed by King, Plosser and Rebello (1987), Campbell (1994) and Uhlig (1995) for solving business cycles. It uses the first-order Taylor approximation of the log variables around the steady state and replaces all equations by approximations which are linear functions in the log-deviations of the variables. We replace variables  $x_t$  with  $x_t = x^*(1 + \hat{x}_t)$ , where  $\hat{x}_t$  is the percentage deviation (log-deviation) from the steady state, or,  $\tilde{x}_t \approx d \log x_t$  and  $x^*$  is the steady state value of the variable  $x_t$ .

After log-linearizing, the first order conditions (15)-(19) become:

$$(\lambda^* a^* c^* + \mu^* c^*) \hat{c}_t + \lambda^* a^* c^* \hat{a}_t + \mu^* w^* l_F^* \hat{w}_t + \mu^* w^* l_F^* \hat{l}_{Ft} + \lambda^* a^* c^* \hat{\lambda}_t + (\mu^* w^* l_F^* + \mu^* c^*) \hat{\mu}_t = 0, \quad (23)$$

$$\hat{x}_t + \hat{\mu}_t + \hat{w}_t = 0, \quad (24)$$

$$-\hat{\mu}_t + E_t \hat{\mu}_{t+1} + E_t \hat{r}_{t+1} = 0, \quad (25)$$

$$-\hat{\lambda}_t + \hat{\mu}_t + \hat{w}_t + (1 - \gamma) \hat{l}_{Ft} - (1 - \gamma) \hat{c}_t - v_t = 0, \quad (26)$$

$$-\hat{\mu}_t + \hat{p}_t + E_t \left\{ \frac{\lambda^*}{\lambda^* + \mu^*} \hat{\lambda}_{t+1} + \frac{\mu^*}{\lambda^* + \mu^*} \hat{\mu}_{t+1} - \hat{p}_{t+1} - u_{t+1} \right\} = 0. \quad (27)$$

Equations (11)-(12) and (8) from the firm's conditions become:

$$-\hat{w}_t + z_t + \alpha \hat{k}_{t-1} - \alpha \hat{n}_t = 0, \quad (28)$$

$$-\hat{r}_t + [1 - \beta(1 - \delta)] z_t + (\alpha - 1) [1 - \beta(1 - \delta)] \hat{k}_{t-1} + (1 - \alpha) [1 - \beta(1 - \delta)] \hat{n}_t = 0, \quad (29)$$

$$-\hat{y}_t + z_t + \alpha \hat{k}_{t-1} + (1 - \alpha) \hat{n}_t = 0. \quad (30)$$

The equations (5), (6) and the equations (2), (13), (3) expressed in real terms become:

$$-\hat{l}_{Ft} + \frac{a^*}{\gamma(a^* - 1)} \hat{a}_t + \hat{c}_t - \frac{1}{\gamma} v_t = 0, \quad (31)$$

$$l_F^* \hat{l}_{Ft} + x^* \hat{x}_t + n^* \hat{n}_t = 0, \quad (32)$$

$$\hat{p}_t + \hat{a}_t + \hat{c}_t = 0, \quad (33)$$

$$-w^* n^* \hat{w}_t - w^* n^* \hat{n}_t - r^* k^* \hat{r}_t - r^* k^* \hat{k}_{t-1} + c^* \hat{c}_t + k^* \hat{k}_t = 0, \quad (34)$$

$$\hat{p}_t - \hat{p}_{t-1} - \hat{\pi}_t + u_t = 0. \quad (35)$$

The 12 equations above, together with the productivity and money supply shocks processes (9), (7) and (4) form a system of linear stochastic difference equations in the endogenous state variable  $\hat{k}_t$ , exogenous state variables  $z_t$ ,  $v_t$ ,  $u_t$ , endogenous control variables:  $\hat{c}_t$ ,  $\hat{x}_t$ ,  $\hat{n}_t$ ,  $\hat{l}_{Ft}$ ,  $\hat{a}_t$ ,  $\hat{w}_t$ ,  $\hat{r}_t$ ,  $\hat{y}_t$ ,  $\hat{p}_t$  and shadow prices  $\hat{\lambda}_t$ ,  $\hat{\mu}_t$ .

Solving the stochastic difference equations system above means determining a recursive equilibrium law of motion of the endogenous variable  $\mathbf{X}'_t = [\hat{k}_t]$  and  $\mathbf{Y}'_t = [\hat{c}_t \ \hat{x}_t \ \hat{n}_t \ \hat{l}_{Ft} \ \hat{a}_t \ \hat{w}_t \ \hat{r}_t \ \hat{y}_t \ \hat{p}_t]$  on the lagged values of the endogenous state variable  $\mathbf{X}'_{t-1} = [\hat{k}_{t-1}]$  and on the current values of the exogenous state variables  $\mathbf{Z}'_t = [z_t \ v_t \ u_t]$ . Thus, we are interested in a solution of the following form:

$$\mathbf{X}_t = PP \mathbf{X}_{t-1} + QQ \mathbf{Z}_t, \quad (36)$$

$$\mathbf{Y}_t = RR \mathbf{X}_{t-1} + SS \mathbf{Z}_t, \quad (37)$$

where  $PP$ ,  $QQ$ ,  $RR$ ,  $SS$  are coefficient matrices.

We use the US economy as a benchmark during the process of calibration, and at the same time we try to keep the parameters as close as possible to the parameters of other related studies from the literature (Cooley and Hansen, 1989, 1995; Gillman and Kejak 2002) in order to allow for an easier comparison of the results with those works.

Parameter values are chosen under the assumption that the length of a period is one quarter. This results in a quarterly discount factor of  $\beta = 0.99$  that implies through equation (22) a quarterly net real return of 1%. The depreciation rate is set to  $\delta = 0.025$ . The share of capital input is set to  $\alpha = 0.36$  as in the majority of the business cycle literature.

The standard deviation of disturbances to the goods production technology are calibrated so that the standard deviation of the simulated output series is as close as possible to the standard deviation of the US output, resulting in  $\sigma_{eu} = 0.0075$  (close to the 0.00721 from Cooley and Hansen, 1989). Persistence is set to  $\varphi_z = 0.95$ , as is common in the business cycle literature (e.g. Cooley and Hansen, 1989, 1995).

The money supply process is calibrated so that the money supply varies in a way that is consistent with the US experience between 1959-2000. As in Cooley and Hansen (1989, 1995) the persistence and the variance of the money supply is estimated from the following regression for the money supply growth (standard errors in parentheses):

$$\Delta \log M_t = \underset{(0.0011)}{0.005139} + \underset{(0.065)}{0.576748} \Delta \log M_{t-1}, \quad \sigma_\epsilon = 0.010022. \quad (38)$$

This implies  $\varphi_u = 0.57$ ,  $\sigma_{\epsilon u} = 0.01$ , which is close to Cooley and Hansen's (1995) estimates of 0.49 and 0.0089 for the period 1954-1991. The regression above also implies an average growth rate of money ( $E \Delta \log M_t$ ) of 1.23% per quarter, which is around 5% per year.

Regarding the parameters of the exchange technology, the share of cash purchases is fixed at  $a = 0.7$ . The degree of diminishing return in the credit sector is set to  $\gamma = 0.21$  which is Gillman and Otto's (2002) estimate for the US. Through equation (20), at a 2.25% quarterly interest rate (1% real return + 1.23% quarterly inflation) this results in a productivity parameter of  $A_F = 1.422$ .

The proportions of time allocated to leisure is set at the baseline at the value of  $x_t = 0.7055$ , similar to the 0.7 in Gillman and Kejak (2002) or 0.69 in Jones et al. (1993). Then, the steady-state first order conditions result in the hours spent in credit services production of  $l_F = 0.00049$ , which is close to the value of 0.0014 in Gillman and Kejak (2002), though lower, due to the fact that in our calibration the cash-in-advance constraint and credit production apply only to one quarter instead of one year.

Finally, credit sector productivity disturbances were calibrated similarly to the disturbances in the consumption goods producing sector:  $\sigma_{\epsilon v} = 0.0075$  and  $\varphi_v = 0.95$ .

Having the values for the parameters and the steady state variables, we can proceed with solving the system of linear stochastic difference equations set up in the previous section. For this purpose we employ the method described in detail in Uhlig (1995) and we also use the MATLAB program provided by Uhlig, which we have adapted for our model.

The recursive equilibrium laws of motion described by the equations (36)-(37) are as follows:

$$\hat{k}_t = 0.953\hat{k}_{t-1} + 0.117z_t - 0.0003v_t + 0.007u_t, \quad (39)$$

$$\begin{bmatrix} \hat{c}_t \\ \hat{x}_t \\ \hat{n}_t \\ \hat{l}_{Ft} \\ \hat{a}_t \\ \hat{w}_t \\ \hat{r}_t \\ \hat{p}_t \\ \hat{y}_t \end{bmatrix} = \begin{bmatrix} 0.564 \\ 0.110 \\ -0.265 \\ 0.100 \\ 0.042 \\ 0.456 \\ -0.028 \\ -0.606 \\ 0.190 \end{bmatrix} \begin{bmatrix} \hat{k}_{t-1} \end{bmatrix} + \begin{bmatrix} 0.399 & 0.014 & -0.120 \\ -0.321 & -0.005 & 0.002 \\ 0.772 & 0.011 & -0.023 \\ -0.551 & 0.056 & 10.430 \\ 0.085 & -0.432 & -0.949 \\ 0.722 & -0.004 & 0.008 \\ 0.052 & 0.0002 & -0.001 \\ -0.485 & 0.4184 & 1.068 \\ 1.494 & 0.007 & -0.015 \end{bmatrix} \begin{bmatrix} z_t \\ v_t \\ u_t \end{bmatrix}. \quad (40)$$

### 2.3 Alternative Exchange Technologies

Two alternative exchange technologies are also studied for comparison purposes, the cash-only cash-in-advance and shopping time models. The cash-only model is a special case of the credit model in the restriction  $a = 1$  is imposed, so that all purchases are made by cash and there is no credit production. Apart from this, the model is calibrated with the same baseline parameters as in the credit model.

The shopping time model typically has general specification as in for example Walsh (2003) and Ljungqvist and Sargent (2000). The credit model is actually mathematically equivalent to a special case of the general shopping time transaction cost function, as detailed in Gillman and Yerokhin (2003). This is because the cash-in-advance constraint in the credit model can have the credit services production substituted into it through the share variable  $a_t$ , and then can be solved for the credit labor time as a function of the real money balances and consumption. Instead of shopping time, here the time is that used in the production of the credit, or what can be called the *banking time*. In the replication of the shopping time economy, in which in general the time spent shopping depends positively on the amount of goods

purchased and negatively on the real money balances ( $s = f(c, m)$ ,  $f_c > 0$ ,  $f_m < 0$ ), the specification follows Gavin and Kydland (1999) and Lucas (2000) by specifying the form  $f(c, m) = \omega \frac{c}{m}$ , so that the banking/shopping time is proportional to the consumption velocity of money. Apart from this, the same parameters as in the credit model are used in the calibration.

The main differences amongst the three alternative models in the steady state can be summarized in terms of the interest elasticity of money demand. The cash-only model has a very sluggish interest elasticity of money that rises slightly in magnitude as the inflation rate goes up, unlike the Cagan model which has a steadily rising interest elasticity with inflation. The shopping time model has a constant interest elasticity similar to Baumol's model. And the credit, or banking time, model produces an interest elasticity that rises in magnitude with the inflation rate in a way very similar to the Cagan model<sup>2</sup>.

## 3 Results

### 3.1 Impulse Responses

The recursive equilibrium laws of motion determined in the previous section permit us to analyze the impulse responses and the implications of the model. We illustrate the impulse responses of the credit economy when faced with a 1% shock to the productivity of the good producing sector, to the banking sector productivity and to the money supply.

#### 3.1.1 The productivity shock

When faced with a 1% one period shock to the productivity of the consumption goods producing sector, the adjustment mechanism for the real variables in the credit model tends to be similar to what is generally observed in standard RBC models: Output, capital stock and consumption respond positively; the response of consumption is smaller(0.39%) than that of output (1.49%) but its convergence is also slower (consumption smoothing effect). The increased productivity increases real wages by 0.72%, which

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<sup>2</sup>Gillman and Kejak (2002) explain this correspondence in more detail.

causes a 0.77% rise in labor supply. Leisure falls accordingly, and so does labor in the banking sector (by 0.55%) to equate the marginal product in the banking sector with the increased marginal product in the goods production sector. Real return rises by 0.05% and the relative price of inputs (real wage/real return) rises by 0.67%. Due to the positive supply shock prices fall and reduce temporarily the inflation (by 0.48%) and accordingly the interest rates (by 0.43%). A lower interest rate diminishes the supply of credit services and raises the share of cash purchases (by 0.08%), which results in an increasing real money demand (by 0.48%) since equilibrium money demand is determined by the amount of consumption goods which is not financed by credit services.

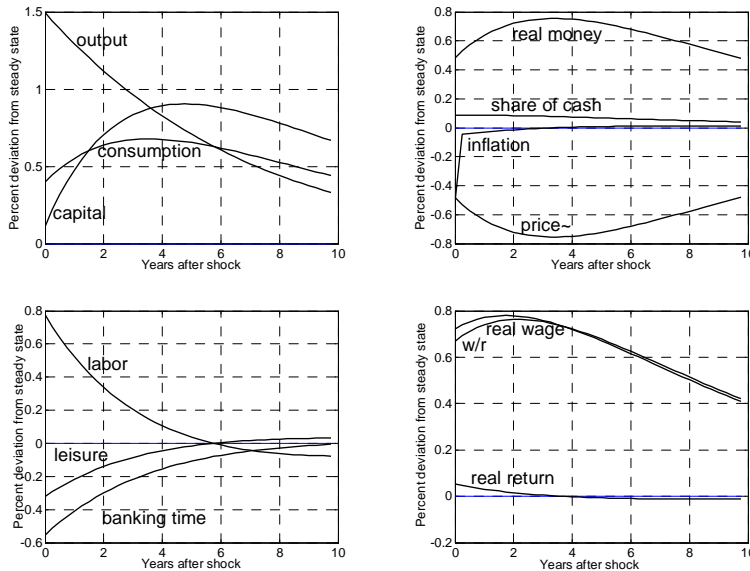


Figure 1. Impulse responses to 1 % productivity shock

### 3.1.2 The monetary shock

Money has real influences on the economy through the inflation tax effect: A positive monetary shock (an increase in the growth rate of the money supply) generates an increase in inflation and reduces the purchasing power of the monetary balances held, therefore consumption also decreases via the cash-in-advance constraint. The household's reaction to this is to adopt a

behavior that allows them to avoid this tax. This behavior is different in the cash-only and the credit model in several aspects: In the former case the household turns its consumption willingness to leisure which does not bear the inflation tax. In the credit model, there is credit available to finance consumption expenditures, credit which is not subject to the inflation tax. As it is also emphasized by Gillman and Otto (2002), the substitution from goods to leisure is only a secondary channel in avoiding the inflation tax. The primary effect is substitution from cash purchases to credit purchases.

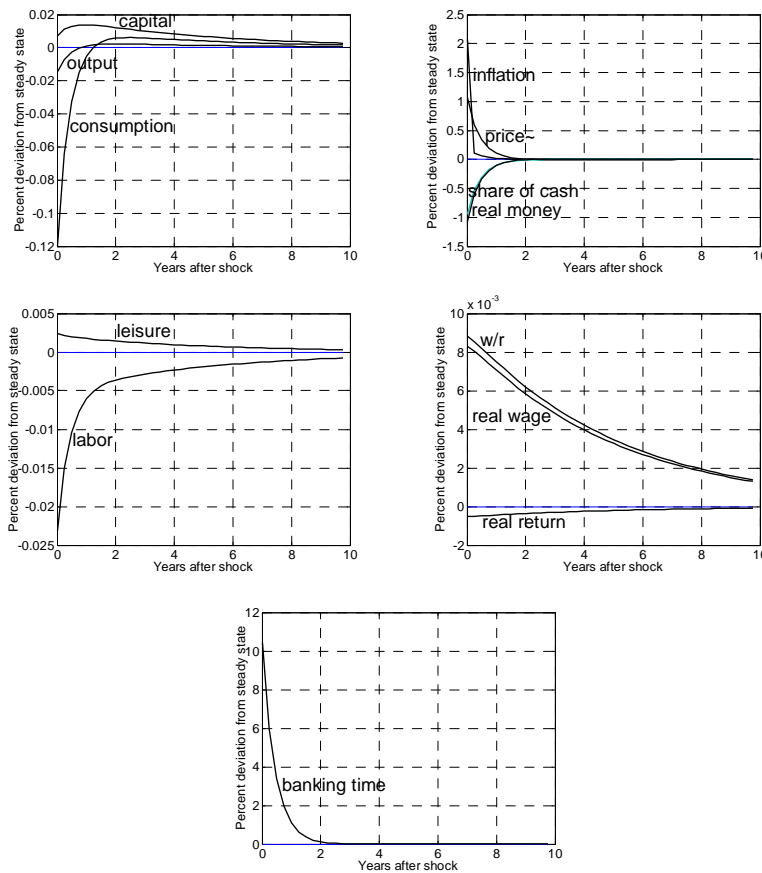


Figure 2. Impulse responses to 1 % money supply shock

In our credit economy, a 1% shock to the money supply growth rate causes a 2.06% increase in inflation. As a result, the purchasing power of the money stock held is reduced and real money balances fall by 1.06%. To avoid the inflation tax, consumers substitute cash purchases for credit

purchases, and at the same time reduce consumption and substitute it for leisure. Cash purchases decrease by 0.95%, consumption falls by 0.12% and leisure increases by 0.002%. The increased demand for credit drives up the relative price of credit (which is the interest rate); this causes an increase in the marginal product and the relative wage in the finance sector and creates an incentive for labor to move from the goods producing sector to the credit sector, causing a considerable increase in banking time of 10.43%. These labor movements, together with the increase in leisure, cause a 0.02% fall in labor in the consumption goods producing sector and a rise of the marginal product and real wage by 0.008%.

As compared to the cash-credit economy, in the cash-only model money supply shocks have larger negative effects on the real economy. The fall in consumption is more accentuated (0.52% vs. 0.11%). This is due to the fact that there is no other way to avoid the inflation tax but to reduce consumption and substitute for leisure. The increase of leisure is higher accordingly (0.026% vs. 0.002%). The stronger decrease in hours worked causes a stronger fall in output (0.040% vs. 0.015%) and a stronger increase in the marginal product, real wage (0.023% vs. 0.008) and the input price ratio (0.024% vs. 0.008%).

### **3.1.3 The credit sector productivity shock**

The cash-in-advance model with costly credit production allows for potentially importance changes in the productivity of the banking sector on money demand and other variables. Financial innovation and productivity growth in the banking sector (Fig. 1) lower the supply price of credit resulting in a lower cost of using credit relative to the cost of using cash. This causes an increase in demand for credit, and a reduction of demand for cash as a means of payment. The share of cash purchases falls by 0.43% while the real money demand drops by 0.42%, this drop being equivalent with an immediate upward jump in the nominal price level. However, the price level will adjust back to its long-run growth path, that is why inflation, after the shock, converges from below to its long-run level.

A secondary effect of the fall in transaction cost is the substitution from

leisure to consumption, which means an increase in consumption of 0.014% and a decrease in leisure of 0.005%. The time saved in this way causes an increase in labor by 0.01% and in the time spent in the banking sector by 0.056%. The increased labor supply lowers slightly the real wage and the input price ratio ( $w/r$ ) by about 0.004%.

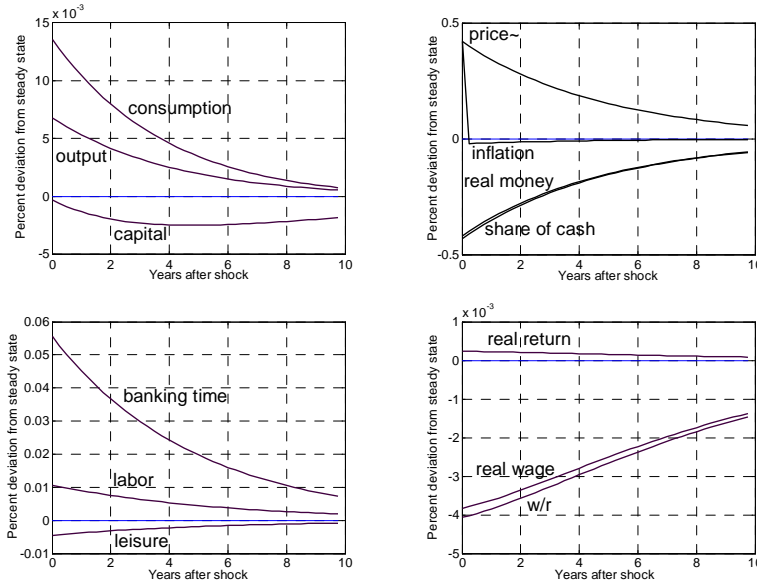


Figure 3. Impulse responses to 1 % credit productivity shock

If the credit productivity parameter is calibrated to be larger, then the positive response of the time spent in banking is lessened, or becomes even negative. This is due to the fact that for an extremely large productivity parameter a positive shock would cause such a large positive credit services supply shift that this would cover the increased demand and there is no need to increase this supply more by employing more labor in the credit sector.

### 3.2 Cross Correlations

Table 1 presents the results of simulating the credit model economy using the parameter values and the dynamic response functions determined in section 2.1. The model is simulated 50 times, each simulation being 168 periods long, to match the number of observations (between 1959:I and 2000:IV) underlying the US statistics reported in Table 2. Each simulated time series

is filtered using the H-P filter. The standard deviations of the key variables are reported as well as their cross-correlation with output.

Table 2 illustrates the cyclical behavior of the postwar US economy by updating the business cycle facts presented in Kydland and Prescott (1995) or in Cooley and Hansen (1995). It shows the standard deviations and the cross-correlations with real GDP and with M1 growth of the most important real and nominal variables.

### **3.3 Confronting the Puzzles**

#### **3.3.1 Standard solution: productivity and money shocks**

The typical way of modeling and reproducing business cycle facts found in data is to expose the model economy to productivity and/or money supply shocks, as in Cooley and Hansen (1989, 1995, 1998) and in Gavin and Kydland (1999). Table 3 and 4, columns 1-10 summarize the extent to which the cash-only, the shopping time and the credit economies are able to explain monetary puzzles when faced with productivity shocks (columns 2-4), money supply shocks (columns 5-7) and joint productivity and money shocks (columns 8-10).

Productivity shocks alone in the credit model are able to generate procyclic monetary aggregates as well as a strongly procyclic income velocity, although we can not obtain the desired weak correlation; it remained just as strong as in the two alternative models. Still, we can also replicate the negative correlation between output and prices.

Money shocks alone, besides generating the countercyclical price level, also catch the phase shift between output and money as well as the negative correlation between money growth on the one hand, and output, hours and consumption on the other hand. At this point the credit model perform just as well as the other two models.

Although the credit model does not perform better than its alternatives when faced with productivity or money shocks alone, when subject to joint productivity and money shocks its performance increases notably: it generates the procyclic monetary aggregates and the money-output phase shift,

Variable	SD %	Corr w/ M grw	Cross correlation of output with:												
			x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)		
Capital	0.40%	0.02	-0.45	-0.39	-0.29	-0.14	0.07	0.36	0.54	0.63	0.66	0.64	0.59		
Real money	1.31%	-0.87	-0.10	-0.04	0.01	0.10	0.22	0.37	0.31	0.25	0.21	0.16	0.11		
Price	2.79%	0.59	0.05	0.03	0.01	-0.03	-0.08	-0.16	-0.13	-0.11	-0.09	-0.08	-0.07		
Consumption	0.47%	-0.25	-0.23	-0.12	0.03	0.24	0.51	0.86	0.73	0.60	0.48	0.37	0.26		
Leisure	0.31%	0.04	-0.06	-0.18	-0.32	-0.50	-0.72	-0.98	-0.62	-0.34	-0.13	0.04	0.15		
Labor	0.75%	-0.06	0.06	0.18	0.32	0.50	0.72	0.98	0.62	0.34	0.13	-0.04	-0.15		
Banking time	11.02%	1.00	0.02	0.01	0.00	-0.01	-0.04	-0.06	-0.05	-0.03	-0.03	-0.02	-0.01		
Share of cash	1.09%	-0.92	-0.02	0.00	0.00	0.02	0.05	0.08	0.06	0.04	0.04	0.03	0.02		
Real wage	0.72%	-0.01	-0.12	0.00	0.16	0.38	0.65	0.98	0.74	0.54	0.37	0.22	0.10		
Real return	0.05%	-0.04	0.10	0.21	0.35	0.52	0.72	0.96	0.59	0.29	0.07	-0.09	-0.20		
Inflation	2.00%	0.84	0.00	-0.03	-0.03	-0.05	-0.08	-0.09	0.03	0.03	0.02	0.02	0.02		
Output	1.44%	-0.01	-0.03	0.09	0.25	0.45	0.70	1.00	0.70	0.45	0.25	0.09	-0.03		
Interest rate	2.00%	0.84	0.00	-0.02	-0.02	-0.03	-0.06	-0.07	0.05	0.04	0.02	0.02	0.02		
w/r	0.68%	-0.01	-0.14	-0.02	0.15	0.36	0.63	0.97	0.75	0.55	0.39	0.24	0.12		
Income velocity	1.54%	0.73	0.06	0.13	0.22	0.34	0.46	0.60	0.38	0.21	0.06	-0.05	-0.12		
Cons. velocity	1.09%	0.92	0.02	0.00	0.00	-0.02	-0.05	-0.08	-0.06	-0.04	-0.04	-0.03	-0.02		
Investment	4.51%	0.09	0.04	0.15	0.30	0.49	0.71	0.99	0.65	0.38	0.17	0.00	-0.11		
Money	2.33%	0.23	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.00	-0.01	-0.02		
Money growth	1.06%	1.00	0.02	0.01	0.02	0.01	0.00	-0.01	-0.02	-0.01	-0.02	-0.02	-0.02		

Table 1: Standard deviations in percent and correlations with output of the simulated economy (HP filtered series)

Variable	SD %	Corr w/ M grw	Cross correlation of output with:										
			x(-5)	x(-4)	x(-3)	x(-2)	x(-1)	x	x(+1)	x(+2)	x(+3)	x(+4)	x(+5)
Real Output	1.43%	-0.13	0.06	0.26	0.46	0.67	0.86	1.00	0.86	0.67	0.46	0.26	0.06
Consumption	1.47%	0.01	0.42	0.57	0.69	0.80	0.84	0.79	0.62	0.43	0.23	0.04	-0.13
Investment	4.77%	-0.11	0.20	0.37	0.52	0.70	0.83	0.89	0.80	0.63	0.43	0.20	-0.01
Wages	1.16%	0.18	0.43	0.53	0.57	0.60	0.58	0.45	0.29	0.14	-0.02	-0.18	-0.30
Prices (CPI)	1.22%	-0.15	-0.61	-0.68	-0.71	-0.70	-0.64	-0.51	-0.37	-0.22	-0.09	0.04	0.16
Inflation	0.42%	-0.32	-0.33	-0.25	-0.10	0.02	0.20	0.38	0.47	0.47	0.49	0.49	0.41
Money (M1)	3.98%	0.11	0.14	0.15	0.14	0.14	0.11	0.07	0.00	-0.06	-0.09	-0.12	-0.15
Real Money	3.32%	0.20	0.35	0.40	0.43	0.44	0.39	0.30	0.17	0.06	-0.04	-0.13	-0.21
Interest rate (TBill)	1.15%	-0.51	-0.61	-0.50	-0.33	-0.14	0.13	0.36	0.48	0.51	0.50	0.47	0.43
Cons. velocity	2.68%	-0.25	-0.24	-0.21	-0.17	-0.11	-0.02	0.07	0.14	0.18	0.18	0.18	0.17
Income velocity	3.27%	-0.28	-0.38	-0.34	-0.26	-0.16	-0.01	0.15	0.23	0.27	0.27	0.26	0.23

Table 2: Cyclical behavior of the US economy: 1959:I - 2000:IV

Facts and Puzzles	Productivity shocks			Money shocks			Prod. & money shocks			Credit model with credit shocks			
	Credit CIA model (2)	SHT model (3)	CIA model (4)	Credit CIA model (5)	SHT model (6)	CIA model (7)	Credit CIA model (8)	SHT model (9)	CIA model (10)	CR shock (11)	PR+CR+M shocks (12)	CR+PR+M shocks (13)	CR+PR+M shocks (14)
<b>A. Credit</b>													
1. Monetary aggregates are procyclical (+0.07; +0.33 in CH 1995)	Yes	Yes	NO	NO	Yes	NO	Yes	NO	NO	<b>YES</b>	<b>YES</b>	NO	Yes
2. Phase shift in the corr. b/w output and money = lagged money is correlated with present output	NO	Yes	Yes	Yes	Yes	Yes	Yes	NO	NO	<b>YES</b>	NO	Yes	Yes
3. Positive correlation between output and inflation (+0.38)	NO	NO	NO	NO	NO	NO	NO	NO	NO	<b>YES</b>	NO	NO	NO
4. Positive corr. b/w output and nominal interest rate (+0.35)	NO	NO	NO	NO	NO	NO	NO	NO	NO	<b>YES</b>	NO	NO	NO
<b>B. Inflation Tax</b>													
1. Income velocity is procyclical (+0.15)	Yes	Yes	Yes	NO	NO	NO	Yes	Yes	Yes	Yes	Yes	NO	<b>YES</b>
2. Negative correlation between money growth and output (-0.13)	N/A	N/A	N/A	Yes	Yes	Yes	<b>YES</b>	<b>YES</b>	Yes	N/A	N/A	Yes	Yes
3. Negative corr. b/w money growth and hours (-0.15 in CH 1995)	N/A	N/A	N/A	Yes	Yes	Yes	<b>YES</b>	<b>YES</b>	Yes	N/A	N/A	Yes	Yes
4. Negative corr. b/w money growth and cons. (-0.1 in CH 1998 but 0.02 in CH 1995, 0.01 here)	N/A	N/A	N/A	Yes	Yes	Yes	Yes	Yes	<b>YES</b>	N/A	N/A	Yes	<b>YES</b>
5. Negative correlation between output and prices (-0.51)	Yes	Yes	Yes	<b>YES</b>	Yes	Yes	Yes	Yes	Yes	NO	Yes	Yes	Yes
	-0.91	-0.89	-0.92	-0.44	-0.16	-0.62	-0.15	-0.20	-0.15	1	-0.72	-0.35	-0.16

Table 3: The extent to which productivity, money or credit shocks can explain the monetary puzzles

Facts and Puzzles	Productivity shocks		Money shocks		Prod. & money shocks		Credit model with credit shocks						
	Credit CIA model	SHT model	Credit CIA model	SHT model	Credit CIA model	SHT model	CR shocks	PR+CRCR+M shocks	CR+PR+M shocks				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
<b>C. Liquidity</b>													
1. Weak phase shift in the correlation of money growth with real variables	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2. Negative correlation between money growth and price level (-0.15)	N/A	N/A	N/A	NO	NO	NO	NO	NO	NO	N/A	N/A	NO	NO
3. Negative correlation between money growth and inflation (-0.32)	N/A	N/A	N/A	NO	NO	NO	NO	NO	NO	N/A	N/A	NO	NO
4. Negative correlation between money growth and nominal interest rate (liquidity effect) (-0.50)	N/A	N/A	N/A	NO	NO	NO	NO	NO	NO	N/A	N/A	NO	NO
5. Negative corr. b/w money growth and investment (-0.10)	N/A	N/A	N/A	NO	NO	NO	NO	NO	NO	N/A	N/A	NO	NO
6. Negative corr. b/w money growth and income velocity (-0.35 in CH 1998, -0.27 here)	N/A	N/A	N/A	NO	NO	NO	NO	NO	NO	N/A	N/A	NO	NO
<b>D. Feedback</b>													
1. Much higher variance than price variance, 3.98% vs. 1.22	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				2.27%	2.24%	2.22%	2.27%	2.27%	2.28%			0.32%	2.23%
				vs.	vs.	vs.	vs.	vs.	vs.			vs.	vs.
				2.76	2.39%	2.80%	2.79%	2.47%	2.88%			0.30%	2.79%

Table 4: The extent to which productivity, money or credit shocks can explain the monetary puzzles (cont'd)

facts that cannot be replicated by the two alternative models under similar conditions.

### 3.3.2 Credit shocks

Although productivity and money shocks together produce better performance in the credit economy than in the cash only or the shopping time model, several puzzles remained unexplained. For this reason, we proceed further with shocking the productivity parameter of the credit sector. Results are included in Table 3 and 4, columns 11-14.

Credit shocks alone (Table 3 and 4, column 11) are able to explain more puzzles than either productivity or money shocks are in any of the models. Moreover, in many cases they produce the closest correlation coefficients to the empirical values. Namely, they generate procyclic monetary aggregates and income velocity and the phase shift between money and output. And what is more important, they replicate the procyclic inflation and nominal interest rate (and do this with correlation coefficients which are nearly identical to what is found in data), facts that can not be explained by any of the models and shocks studied by us.

With productivity shocks added to credit shocks (Table 3 and 4, column 12), the performance of the credit model is deteriorated somehow (we “lose” the phase shift and the procyclic inflation and the interest rate); however, we capture the negative correlation between output and prices and obtain a correlation coefficient which is rather close to the observed value.

Credit and money shocks together (Table 3 and 4, column 13) capture the phase shift between money and output and the countercyclical price level, as well as the negative correlation between money growth on the one hand, and output, hours and consumption on the other. Moreover, they generate a slightly higher money variance than price variance, a fact that could not be reproduced by the alternative models or alternative shock combinations.

When subject to all three shocks (Table 3 and 4, column 14), the credit model performs better than the cash only or the shopping time model: it never fails when the other two are successful; moreover, it does well in explaining the weak procyclicality of the monetary aggregates, it displays a

weak phase shift between money and output and in many cases it produces closer correlation coefficients to the observed values than the two alternative models.

### **3.3.3 Categorization of the Puzzles**

Table 3.3 categorizes the puzzles into four categories: Credit, Inflation Tax, Liquidity Effects, and Money Feedback Rule. The main contribution of the credit model is in terms of the puzzles under the Credit category. As an exchange economy with an active "inflation tax", as opposed to an economy with nominal rigidities, the second category on Inflation tax includes the puzzles where all three of the exchange economies that are examined perform comparatively well. The puzzles in the Liquidity Effects category all are not well-addressed by the three exchange models. The final category concerns nominal variances which Gavin and Kydland show can be explained with a monetary supply rule with output feedback, as can be implicit in Taylor rule operating procedures. The credit model under a credit shock also makes a contribution here in explaining the evidence.

### **3.3.4 Puzzle Contribution of the Credit Model**

Summarizing the first category on Credit, the A1 and A2 puzzles show that the credit model with standard money and productivity shocks can explain procyclic monetary aggregates and the money-output phase shift. Consider a focus on the A1 puzzle on monetary aggregates, of which the A2 puzzle is a corollary, in light of the impulse responses of Figures 1 and 2 for the credit model, and of Appendix A3 and A4 for the CIA and ST (shopping time) models. These responses are from the standard money and productivity shocks. The credit model captures the procyclic monetary aggregate from these shocks while the other models do not because of differences with the response to each shock.

The interest elasticity of money demand in the CIA model is relatively inelastic at all ranges of the inflation rate. Thus a money shock causes little substitution away from money, and instead causes relatively high substitution

from goods to leisure with the result of a more than double the decrease in output than in either of the other two models. At the other extreme, the ST model is so interest elastic that there is no net substitution from goods to leisure. This substitution channel is so small relative to the substitution from money towards more shopping time that both goods and leisure actually go down, as the income effect of using up more shopping time dominates the small substitution effect from goods to leisure. In the credit model there is an active goods to leisure substitution channel and an active one from money to credit. The interest elasticity rises with the inflation rate in the credit model rather than being nearly fixed at an inelastic point (CIA) or completely fixed at an elastic point (ST). Consumption goes down more than six times output in the credit model as compared to twelve times output in the CIA model and two times output in the ST model.

A positive goods productivity shock causes similar behavior across the three models with output going up. Whether output is up after the combination of both money and productivity shocks depends on the severity of the output decrease from the money shock, and on the fine details of the output increase from the productivity shock. With such a strong decrease in output from the money shock, the CIA monetary aggregate is countercyclic. The ST and credit models differ somewhat on the strength of the output increase from the productivity shock. Banking time responses sensitively to the increase in the real wage cost of the labor supply and falls more than sixfold more than does shopping time, making for a somewhat bigger percentage increase in output. Thus despite a bigger decrease in output from the money shock, this ends up making the monetary aggregate procyclic in the credit model and not so in either the CIA or ST models.

The A3 and A4 puzzles show that the credit shock itself in the credit model induces procyclic inflation and nominal interest rates. The Figure 3 impulse responses explain why these results occur. It is simply that substitution occurs from money to credit causing inflation to rise, and so also the nominal interest rate. During a period of banking deregulation, such credit shocks potentially can be prominent. The puzzle analysis suggests that such positive shocks can make high levels of the inflation and nominal interest

rates even higher, as the consumer switches to credit from money holdings, while at the same time boosting output.

## 4 Sensitivity and Robustness

To test the robustness of our results, the model is simulated under different parameter values for the degree of diminishing return to labor in credit production, the credit productivity shift parameter, and the level of the inflation rate.

### 4.1 Degree of diminishing return in credit production

For the  $\gamma$  values of 0.21 (the baseline calibration), 0.3, 0.5, 0.6, and 0.8, two of the most important cases are examined: the credit shock only case and the case when the economy is faced with all three shocks. When faced with credit shocks only, the procyclicality of monetary aggregates remains unchanged under all  $\gamma$  values except for the largest value 0.8. The procyclic nature of income velocity, inflation and nominal interest rate are extremely robust; the correlation coefficients remain approximately constant under all values of  $\gamma$ . The same robustness is found in the phase shift between output and money.

When subject to all three shocks, the economy demonstrates the same robustness. Moreover, when  $\gamma$  increases, the correlation coefficients of the money growth with output and hours worked approach more their observed values. The only exception is the correlation of output with monetary aggregates, which, at higher  $\gamma$ -s, becomes acyclical or slightly countercyclical.

### 4.2 Productivity shift parameter

For the productivity parameters ( $A_F$ ) of 0.6, 1.0, 1.422, 1.7 and 2.0, when only credit shocks operate in the economy, the model remains robust under various productivity parameters with one exception: at low productivity the nominal money supply becomes slightly countercyclical. Under joint productivity, money and credit shocks the system proves to be robust; however, just

as with varying  $\gamma$ -s, monetary aggregates display a rather acyclical pattern, although the shift in the correlation coefficient is almost negligible (from +0.01 to -0.01 ... -0.04).

### **4.3 Inflation**

Under various inflation rates (-4%, -2%, 0%, 2%, 5%, 10%, 20%, 100%), the results are robust with all of the shock processes. The exception is the behavior of nominal money supply under credit shocks, which turns to be procyclic only at moderate inflation rates, but countercyclical at deflationary or hyperinflation rates.

## **5 The US Banking Deregulation Episode**

Using the framework of the credit model, here it is determined how the deregulatory banking acts of the 80s were associated with shocks to the banking sector that contributed to a rapid recovery from the recessions of 1980 and 1982. On the other hand, it is seen that negative shocks of the savings and loan crises contributed to the recession of 1990-91. Then, it is shown how the sense in which deregulatory actions of the 1990s coincided with shocks that added to the boom of the mid and late 90s<sup>3</sup>.

### **5.1 Legislative Background**

The US banking crises of the 1930s in the US induced regulations designed to increase the safety and the soundness of the banking system through restrictions on banking scope geographically and vertically within the finance sector (The Banking Acts of 1933 and 1935). Legislation also prohibited the banks from paying interest on demand deposits and set maximum limits on the interest rate paid on time deposits (Regulation Q). However, in the 1960s and 1970s rapid inflation caused interest rates to rise. Banks and other financial institutions found it difficult to compete for depositors's funds when rate ceilings on the deposits fell below the market level. At the same time,

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<sup>3</sup>See also Owens and Schreft (1995) for an analysis of "credit crunch".

money market funds, which were exempt from the regulations, expanded rapidly and grew at the expense of those constrained by the regulations. Pressure developed to deregulate the banking institutions.

The Depository Institutions Deregulation and Monetary Control Act (DIDMCA) of 1980 removed or weakened many of the barriers and enhanced the competitiveness of traditional financial institutions. It phased out the deposit interest rate ceilings and allowed checkable deposits that paid interest. A second major step in the deregulatory process was the Garn-St Germain Act of 1982, which helped to enable financial intermediaries to evolve into more complete financial service firms. Among its most important provisions, it authorized banks and other depository institutions to offer money market deposit accounts that could compete with money market mutual funds<sup>4</sup>.

The end of the 1980s found the US in a savings and loan crisis, a fall-out of the innovation in the other parts of the banking sector. What could be considered as re-regulation came through the Financial Institutions Reform, Recovery and Enforcement Act of 1989 (FIRREA) and the Federal Deposit Insurance Corporation Improvement Act of 1991 (FDICIA). These acts allowed for a restructuring of the savings and loan sector as regulators were allowed stronger tools while at the same time their discretion was restricted<sup>5</sup>.

The 1990s saw further financial deregulation, eliminating most of the remaining restrictions from the 1930s regulatory acts. The Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994 repealed the McFadden Act and allowed interstate bank branching and consolidation. The Gramm-Leach-Bliley Act of 1999 repealed the Glass-Steagall Act and allowed mergers between commercial banks, insurance companies and investment banks. These Acts evidently increased competition, generated greater efficiencies and increased the productivity in the banking sector<sup>6</sup>.

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<sup>4</sup>For more detailed explanations regarding banking legislation see Mishkin (1997).

<sup>5</sup>See Hanc(1998) for a detailed analysis.

<sup>6</sup>See Guzman (2003) for details on financial deregulations in the 90s.

## 5.2 Labor hour trends

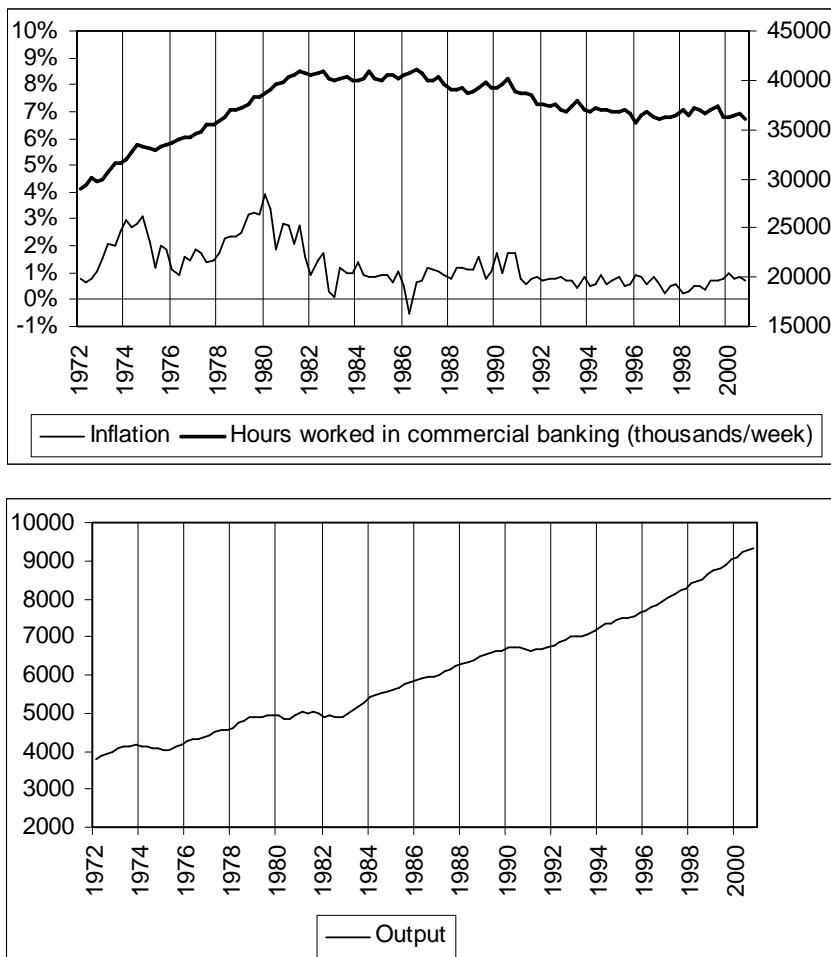


Figure 4. Evolution of US banking hours, inflation and real GDP

As a first part of the analysis of the deregulatory period consider how labor hours and inflation evolved, and how the model explains this. Figure 4 illustrates the evolution of the labor hours in commercial banking, the inflation rate and the GDP, during the regulatory and deregulatory periods. The period before 1980 is characterized by relatively high and rising inflation accompanied by rising interest rates, which, due to the interest rate ceilings that could be paid, imposed difficulties for commercial banks in attracting deposits. As a result, since Regulation Q ceilings eliminated price competition among banks, they were competing for deposits by offering higher quality

services for which more and more labor resources would plausibly have been needed. The model's calibration shows as in Aiyagari, Braun and Eckstein (1998) that banking hours and the inflation rate move together.<sup>7</sup> This can explain the continuously rising labor hours in the banking sector in the 1970s.

After 1980 inflation continuously fell which, according to the model, is consistent with a falling demand for credit services and declining labor hours in the finance sector. On the other hand, the positive productivity shocks generated by the bank deregulation of the 1980s would in the model generate a shift out in the demand for credit labor hours. These two impacts have opposite effects on the labor hours, which could explain the relatively constant number of hours from 1980 to 1986. The slight downward trend in labor hours after 1986 would be explained from the model as the result of the continued sharp decline in inflation in combination with the mainly positive productivity shocks from interstate banking and branching deregulations.

### **5.3 The Role of Credit shocks**

The aggregate cycles during the period of changes in the banking laws can be related to the direction and the magnitude of the credit shocks and their chronological association with the banking acts.

#### **5.3.1 Excess Movements of Cycles and Dating**

For defining, measuring and studying business cycles, consider the measures in Harding and Pagan (2002) for the cycle duration (in number of periods), amplitude (in % of GDP), cumulative movements (total gain/loss during the cycle) and excess movements (the deviation of the cumulative movements from its approximation by a triangle)<sup>8</sup>. The averages of these measures for the postwar US data, as well as the particular values for the post-1973 cycles, are presented in Table 5. The dating of the business cycles here follows the Bry and Boschan (1971) technique also used in Harding and Pagan.

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<sup>7</sup>We do the analysis given the assumption that banking hours respond positively to credit shocks. This is the case for calibrations with reasonable parameter values, as we discussed it in section 3.1.3.

<sup>8</sup>Details on the triangle analysis are provided in the Appendix A5.

	US avg.	1973:IV ↘ 1975:I ↗	1980:I ↘ 1980:III ↗	1981:III ↘ 1982:III ↗	1990:II ↘ 1991:I ↗	2000:IV
Duration						
Peak ↘ Trough	3.17	5	2	4		3
Trough ↗ Peak	24	20	4	31		39
Amplitude (%)						
Peak ↘ Trough	-2.02	-3.40	-2.19	-2.86		-1.49
Trough ↗ Peak	28.87	23.66	4.26	37.04		39.39
Cumulation (%)						
Peak ↘ Trough	-2.65	-5.06	-2.04	-6.40		-1.19
Trough ↗ Peak	423.79	252.43	8.57	603.20		668.06
Excess (%)						
Peak ↘ Trough	-0.58	-1.04	-0.62	-0.19		-0.60
Trough ↗ Peak	1.02	-0.20	0.51	-0.34		3.07

Table 5: Cycle characteristics: post-war averages, and individual values for the cycles of interest

### 5.3.2 Decomposition of shocks

The effects of the changes in banking laws on the business cycle can be quantified by determining the magnitude of the credit shocks, their effects on output, and then comparing these effects with the chronology of the deregulation. First the magnitude of shocks in each period are determined from the theoretical laws of motion of output, consumption, investment, banking hours and real money (laws which were computed in section 2.1). US data on these variables are used to determine  $\hat{y}_t$ ,  $\hat{c}_t$ ,  $\hat{i}_t$ ,  $\hat{l}_{Ft}$  and  $\hat{m}_t$ , the percentage deviations of the variables in each period relative to their H-P filtered trend. Then, with data on investment  $i_t$  and an initial choice of capital stock  $k_{-1}$ , a series for the capital stock is constructed using the capital accumulation equation (10) as in Chari, Kehoe, and McGrattan (2003). This results in a series for  $\hat{k}_t$ . Using equations (39) and (40) we can finally recover  $z_t$ ,  $v_t$  and  $u_t$ , that is, the magnitude of the productivity, credit and money shocks.

The magnitudes of the shocks are plotted in Figure 5. Two important observations are to be made here: First, these shocks are serially correlated, with an estimated autocorrelation coefficient which is very close to the one

we have assumed<sup>9</sup>. This can be regarded as an argument toward the appropriateness of our shock estimation procedure. Second, the variance of credit shocks seems to be larger than the variance of the productivity shocks<sup>10</sup>. This can be attributed to the fact that the consumption good producing sector represents an aggregation of various sectors of the economy, which are hit by adverse shocks. These shocks, when aggregated, partly compensate each other resulting in a cumulated shock  $z_t$  which finally has a smaller variance than the credit shocks  $v_t$  which affects only one sector.

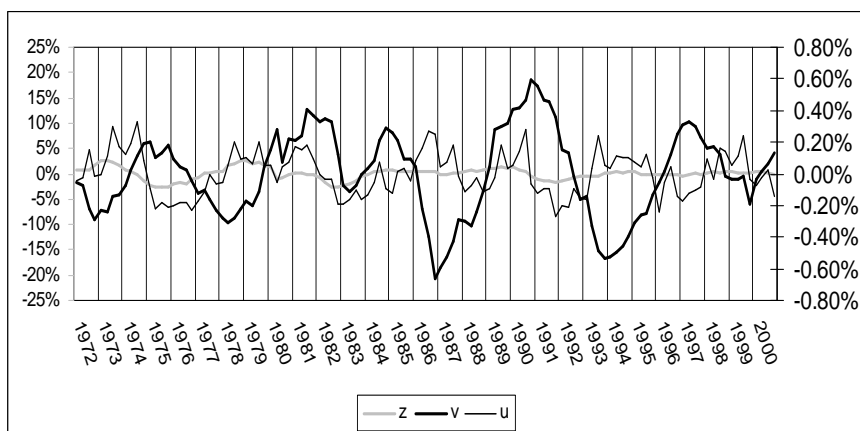


Figure 5. Evolution of productivity ( $z$ ), credit ( $v$ ) and money ( $u$ ) shocks ( $u$  on the right axis)

We would like to determine the instantaneous credit shocks which hit the economy in each period  $t$ , on one hand, and the effect of the credit shocks on the GDP, on the other hand. While  $v_t$  is an autocorrelated process which incorporates the shocks propagated from previous periods, the period-by-period innovations can be estimated with the residuals from fitting an AR(1) model on  $v_t$  (which assumes the estimation of equation 7). As such,  $\hat{\epsilon}_{vt}$  from equation (7) identifies the instantaneous credit shocks. The effect

<sup>9</sup>The estimated coefficients are:  $\hat{\rho}_z = 0.9203$ ,  $\hat{\rho}_v = 0.9362$ ,  $\hat{\rho}_u = 0.6564$ , vs. the assumed values  $\rho_z = 0.95$ ,  $\rho_v = 0.95$ ,  $\rho_u = 0.57$ .

<sup>10</sup>We repeated the simulations of section 3.2 by using this larger, estimated credit shock variance. We found that the variance of the share of cash, real money and inflation increased, and their correlation with output and money growth weakened. However, our conclusions drawn in section 3.2 remained unchanged, as the larger credit shock variance did not affect the extent to which our model was able to explain the puzzles.

of credit shocks on GDP are found through a simulated GDP series where all the credit shocks  $v_t$  are set to zero. The percentage deviation of the true GDP from the simulated one is plotted on the Figure 6 right axis while the period-by-period credit innovation is on the left axis. The results show that the individual credit shocks tend to bunch up in positive and negative directions and thereby add up to create cyclical changes in output with some lag. Further these bunches of shocks appear to be associated chronologically with the banking reform legislation of the period as described below.

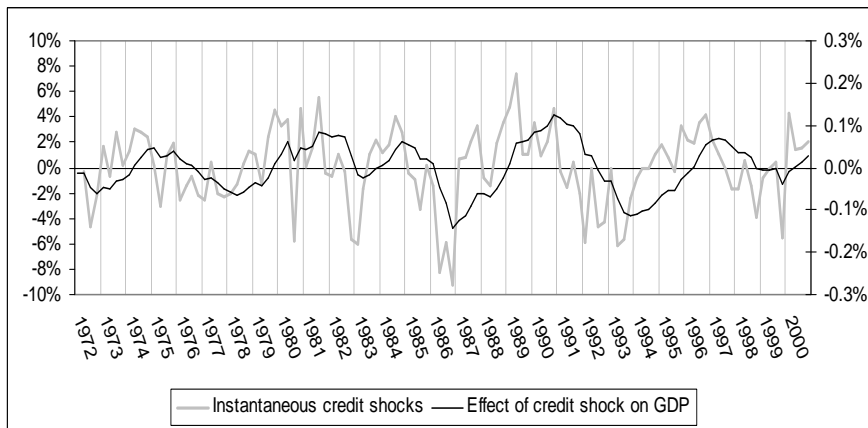


Figure 6. Credit innovations ( $=\hat{\epsilon}_{vt}$ ) and the effect of credit shocks on GDP  
 $(=\frac{GDP_{true}}{GDP|_{v=0}}-1)$

### 5.3.3 Effects on the Business Cycle

Table 6 gives a summary of the banking acts and their relations to the business cycle. The Regulation Q, which prohibited the banks from paying interest on demand deposits and set maximum limits on the interest rate paid on time deposits, became effective after 1974 when interest rates hit the ceiling. According to Figure 6, the estimated credit shocks are indeed negative after 1975, thereby having a negative effect on output, even though the economy was in an upturn at that time. Regulation Q was phased out by the DIDMCA of 1980; this Act occurred when indeed there appear positive shocks to the banking sector. Evidence indicates that these shocks acted so as to speed up the recovery of 1980. In particular a faster recovery is suggested by the

below-average excess business cycle movement of Harding and Pagan (0.51% vs. the average of 1.02%)

The next deregulatory act, the Garn-St Germain Act was issued at the end of the next recession (the 1981-82). This also appears to be associated chronologically with positive shocks that acted as contributing influence towards the recovery after 1982. And again evidence indicates that these shocks may have acted to speed up the recovery in that it was faster than the average ( $-0.34\%$ ).

The banking activity of the mid and late 1980s involved state by state permission of interstate banking (Strahan, 2003, Figure 1) that saw a large bunching of such deregulations from 1985 to 1988. As this increased competition developed there ensued a nationwide savings and loan crisis. This resulted in the FIRREA of 1989 that was designed to clean up the insolvent savings and loans institutions. During this period our Figure 6 show a spike in negative credit shocks that appears to be associated with this crisis. The FIRREA, while possibly being considered part of the bank re-regulatory process, involved the restructuring of the debt of the savings and loans and appears from our shock and GDP estimates to have contributed towards an increase in the GDP.

The FDICIA of 1991 is considered a further re-regulation that is followed chronologically by negative credit shocks that contributed to making the recovery after 1991 slower than the average (3.07% vs. the average 1.02%).

The mid and late 1990 is again a period of bank deregulations. The 1994 repeal of the McFadden Act was followed closely by new positive credit shocks in Figure 6 that contributed to GDP increases. Strahan considers that with this act "the deregulatory process was completed". Here interstate branching was allowed at a federal level, as opposed to interstate banking that was allowed at a state level in the 1980s, so that true national banks could begin to emerge. Finally came the 1999 repeal of the Glass-Steagall Act, which allowed mergers between commercial banks, insurance companies and investment banks. This is followed by a positive credit spike in Figure 6.

Recessions (↘) and recoveries (↗)	and Compared to average	Banking Act	Regulatory or deregulatory?	Estimated instantaneous credit shock	Estimated total shift in credit productivity	Effect of the credit shocks on GDP
↘ 1973:IV - 1975:I	slower	Regulation Q	reg.	pos.	neg. → pos.	increase
↗ 1975:I - 1980:I	faster	Regulation Q	reg.	mainly neg.	pos. → neg.	decrease
↘ 1980:I - 1980:III	slower			pos. → neg.	pos.	ambiguous
↗ 1980:III - 1981:III	faster	DIDMCA (end of 1980)	dereg.	pos.	pos.	increase
↘ 1981:III - 1982:III	faster			small	small	ambiguous
↗ 1982:III - 1990:II	faster	Garn-St Germain (1982-83) FIRREA (1989)	dereg. reg.	neg. → pos. pos.	pos. pos.	increase increase
↘ 1990:II - 1991:I	slower			pos.	pos.	increase
↗ 1991:I - 2000:IV	slower	FDICIA (1991) Riegle-Neal (1994) Gramm-Leach-Bliley (1999 nov)	reg. dereg. dereg.	neg. pos. pos.	still pos. neg. neg.	decrease increase increase

Table 6: Summary of the banking episodes

## 6 Discussion:

### 6.1 Other Models and the Puzzles

Cooley and Hansen (1995, 1998) use a Lucas and Stokey (1987) cash-good/credit-good exchange technology instead of the simpler cash-only one found in Cooley and Hansen (1989). These "inflation tax" models are then modified with nominal rigidities through wage contracts. The short run non-neutralities so introduced cause larger velocity and interest rate volatility as in the facts. The inflation tax model better fits the negative correlation between current output and the price level. And real variable movements are poorly explained by the nominal rigidity models. Also money growth and interest rate correlations are not captured by these models, nor are price level and inflation rate correlations. A weak phase shift between money supply and real variables also is not captured.

The shopping time economy in contrast involves the consumer in using real resources to avoid the inflation tax, as Lucas (2000) emphasizes in his welfare cost calibrations. Gavin and Kydland (1999) present a MBC economy that uses a shopping time exchange technology as in Lucas, with a constant interest elasticity of money. Gavin and Kydland emphasize the break in the money supply process in 1979 to motivate the study. The focus is on how money supply instability, as caused by feedback monetary policy rules, may affect the MBC model's ability to explain some puzzles. They find that different policy rules do not affect real variables. But the price level movement and other nominal effects depend on the nature of the feedback including its persistence. Price level countercyclic behavior can be made countercyclic as in the data, with or without feedback, or procyclic. But they find that they can generate a procyclic money supply correlation, which is a puzzle in Cooley and Hansen, with a feedback rule that maintains price level countercyclic behavior.

The results of the credit model show that it can generate a cyclic movement of the money supply with only a simple money supply rule without feedback, while getting robust price level countercyclic correlation. And the credit shocks add the ability to have procyclic inflation and nominal interest

rates, while being able to help explain the effects of banking deregulation.

## **6.2 Uhlig's shocks**

Consider Uhlig's (2003) contribution that identifies various sources of shocks in order to explain US business cycle evidence. He concludes that there are two main shocks which are able to explain the majority of the movements in GDP: one a medium-run one being interpreted as a productivity shock, and another shorter term one, which is hard to interpret. Our preliminary investigation shows that the credit shock of our model has some similar features of Uhlig's short term shock. Namely, the impulse response of output, consumption, labor hours and real wages show similar patterns to that of Uhlig's. However, our inflation does not match Uhlig's CPI inflation, although it does match fairly well the PPI inflation. This may possibly be associated with our not have a liquidity effect.

## **6.3 Government Money Supply or Private Banking Sector Shocks?**

The well-known 1989 Cooley and Hansen paper offers a rigorous way to study one aspect of the Friedman and Schwartz (1964) hypothesis that money supply shocks at times affect real output and welfare. Instead of relying on empirical VAR studies with Granger causality tests of how money affects output, Cooley and Hansen frame the issue in a dynamic general equilibrium cash-in-advance economy with goods sector productivity and money supply shocks. The remarkable result is that welfare is little affected by monetary shocks in the real business cycle framework. This seems to discredit the Friedman and Schwartz's monetary theories of the business cycle to some extent, in the sense of saying that monetary shocks are not important, but such an interpretation of the results may be too narrow.

Our results again confirm that money supply shocks may not be important in explaining business cycle movement, although related work confirms that long run changes in the inflation rate have significant effects on the real economy. And evidence suggests that a stable money demand may well ex-

ist and that the growth of monetary aggregates still underlies the worldwide phenomenon of inflation targeting. And just as the banking sector has proved a key facet in explaining money demand (Choi and Oh 2003), velocity (Gillman and Kejak 2003), and the liquidity effect (Li 2000), it has also offered an ability to explain long run inflation evidence in an endogenous growth context. With such related evidence along with the results of this paper, it is plausible that banking may play an important role in the business cycle. And this is the other aspect of the original Friedman and Schwartz work. They emphasize not only government induced money supply changes, but also the private bank sector shocks that result in "inconvertibility crises", a major focus of their work.

## 7 Conclusions

The paper analyzes a stochastic version of the Gillman and Kejak (2002) monetary economy with a payments technology for credit. Deterministically this credit technology has been useful in explaining long run international panel evidence on inflation and growth (Gillman, Harris, and Matyas, 2003), and in explaining a long run increase in the capital to effective labor ratio as a result of inflation (Gillman and Nakov, 2003). Applied to the business cycle, the credit sector allows for a new focus on shocks besides the goods productivity and money supply shocks. Compared to these, the credit shock is able to explain better the effect of the US financial deregulation of the 1970s to 1990s, including the re-regulation after the savings and loans crisis. In particular, we offer an interpretation that the binding of the Regulation Q interest ceilings in the early 1970s appear as a negative credit shock that lowered GDP; the deregulation in the early 1980s acted as a positive credit shock that increased GDP, and the national branching that was allowed in the mid 1990s acted likewise as a positive credit shock that increased GDP. On alternative approaches, such as the shopping time model of Gavin and Kydland (1999), there is no credit sector from which such shocks can emanate. The general idea that a credit shock can affect aggregate productivity and be linked to changes in government policy is not inconsistent with the con-

clusions of Kehoe and Prescott (2002) that depressions across the world have resulted from shocks to productivity related to government policy changes.

Uhlig (2003) identifies two shocks which explain the majority of the movements in GNP: one a medium-run one similar to the goods productivity shock, and another shorter term one. Preliminary investigation shows that the credit shock of this model has some similar features of Uhlig's short term shock; this is left for future research. Another source of new insight in the business cycle literature is that of Chari, Kehoe, and McGrattan (2003) who decompose the shocks into different kinds of marginal distortions. How the possible source of a credit shock may fit into productivity, labor tax, and capital tax wedges is worthy of further study. Since their labor tax distorts the leisure-labor margin in a way exactly like the inflation tax in a monetary model, it appears that the money and credit shocks of the credit model may be accounted for partly within their decomposition, again an area for further research. Perhaps the most promising extension is to include liquidity effects as in Li (2000), along with a Gavin and Kydland (1999) feedback rule, to see if the model can provide better answers to many of the monetary business cycle puzzles simultaneously. It may be that a better model with such extensions combines productivity shocks to aggregate output and to credit, without the money shock.

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# Appendix

## A1. Derivation of steady state conditions

To obtain the steady state relations, let's drop the time indices and set the shocks ( $z$ ,  $v$ , and  $u$ ) to zero. Then, equation (17) can be written as  $\mu^* = r^* \beta \mu^*$ , that is:

$$r^* = \frac{1}{\beta},$$

which is equation (22).

Now multiply equation (19) by  $\pi^*/\mu^*$ , this gives:

$$\pi^* = \beta \left( \frac{\lambda^*}{\mu^*} + 1 \right).$$

Substitute  $\beta = 1/r^*$  and express  $\lambda^*/\mu^*$ :

$$\frac{\lambda^*}{\mu^*} = \pi^* r^* - 1 = R^* - 1.$$

Then express  $\lambda^*/\mu^*$  from equation (18):

$$\frac{\lambda^*}{\mu^*} = \frac{w^*}{\gamma A_F} \left( \frac{1 - a^*}{A_F} \right)^{\frac{1}{\gamma} - 1},$$

which leads to equation (20).

Finally, express  $\frac{1}{c^*}$  from equation (15) and  $\frac{\Psi}{x^*}$  from equation (16) and divide them:

$$\frac{x^*}{\Psi c^*} = \frac{\mu + \lambda a^* + \mu^* w^* \left( \frac{1 - a^*}{A_F} \right)^{\frac{1}{\gamma}}}{\mu^* w^*} = \frac{1 + a^* (\lambda^*/\mu^*) + w^* \left( \frac{1 - a^*}{A_F} \right)^{\frac{1}{\gamma}}}{w^*},$$

which leads to equation (21).

## A2. Calibration results

	Credit	Cash Only	Shopping Time
$\alpha$	0.36	0.36	0.36
$\delta$	0.05	0.05	0.05
$\beta$	0.99	0.99	0.99
$A_F$	1.422	N/A	N/A
$\Psi$	2.03	2.03	1.876
$\Theta$	0.0125	0.0125	0.0125
$\gamma$	0.21	N/A	N/A
$\varphi_z$	0.95	0.95	0.95
$\sigma_z$	0.0075	0.0075	0.0075
$\varphi_v$	0.95	N/A	N/A
$\sigma_v$	0.0075	N/A	N/A
$\varphi_u$	0.57	0.57	0.57
$\sigma_u$	0.01	0.01	0.01
$c$	0.8098	0.8072	0.8463
$x$	0.7055	0.7069	0.6847
$n$	0.2940	0.2930	0.3072
$l_F$	0.00049	N/A	0.0080
$a$	0.7002	N/A	N/A
$w$	2.3706	2.3706	2.3706
$r$	1.0101	1.0101	1.0101
$\pi$	1.0125	1.0125	1.0125
$y$	1.0891	1.0855	1.1381
$k$	11.1695	11.1333	11.6725
$m$	0.5670	0.8072	0.3598

### A3. Impulse responses in the Cash-in-Advance Model

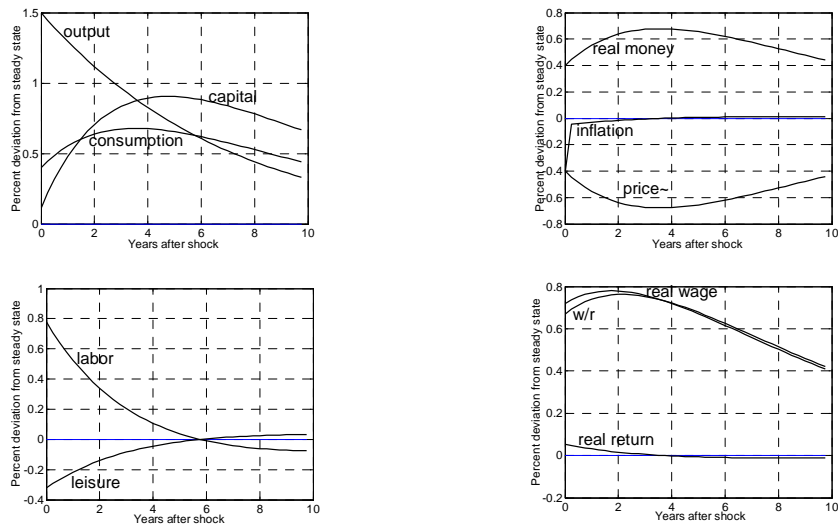


Figure 7. Impulse responses to 1 % productivity shock, Cash-in-Advance model

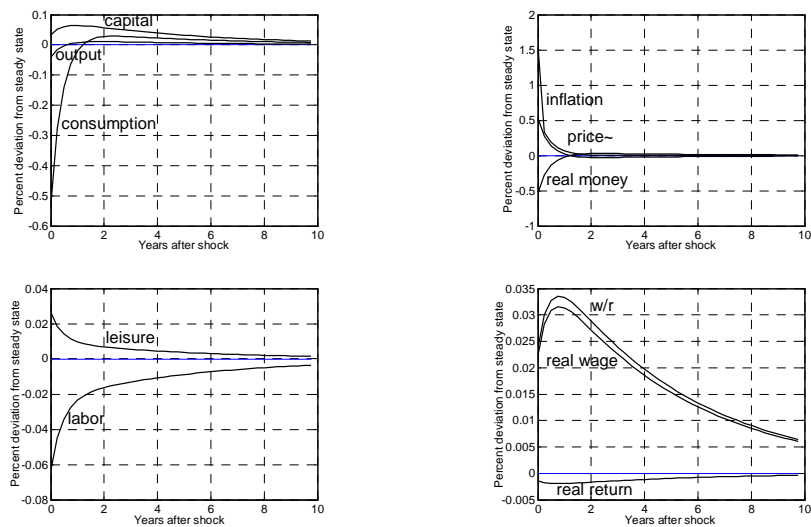


Figure 8. Impulse responses to 1 % money shock, Cash-in-Advance model

## A4. Impulse Responses in the Shopping Time Model

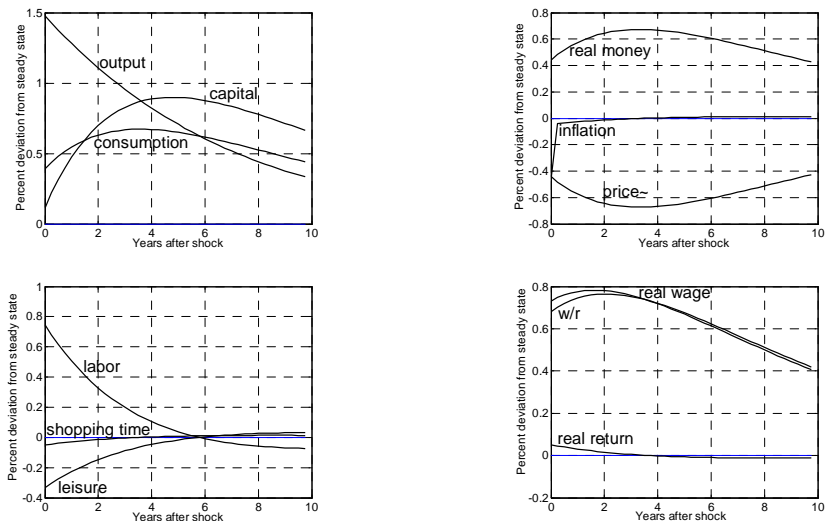


Figure 9. Impulse responses to 1 % productivity shock, shopping time model

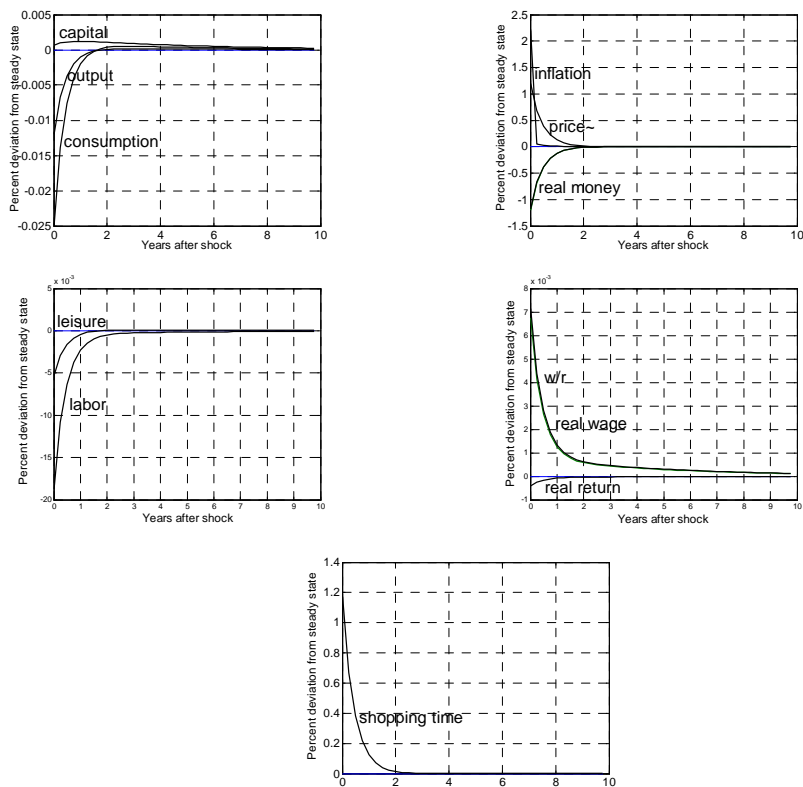


Figure 10. Impulse responses to 1 % money shock, shopping time model

## A5. Business cycle measures - the triangle approximation

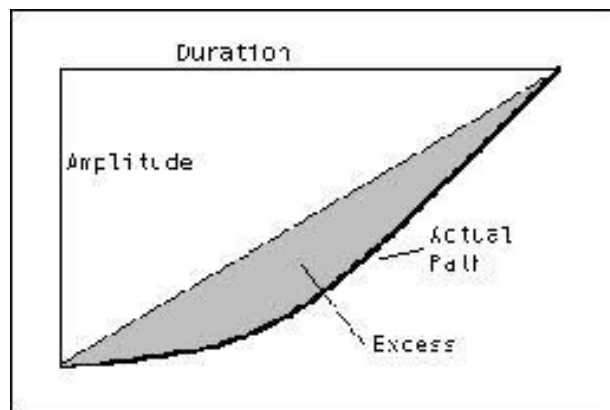


Figure 11. Triangle approximation

Four business cycle measures of interest, as presented in Harding and Pagan (2002) and that are found in Table 5, are the following:

- Duration of the cycle - measured in number of periods
- Amplitude of the cycle - measured in percentage of the base value
- Cumulative movement - the total gain or loss during the cycle
- Excess movement - the deviation of the cumulative movement from its triangle approximation

Figure 11 illustrates these measures on a triangle approximation of a recovery phase of the cycle. The base of the triangle is the cycle duration ( $D_i$ ) and the height is the cycle amplitude ( $A_i$ ). This results in the triangle approximation of the cumulative movement of  $C_{Ti} = \frac{1}{2}(D_i A_i)$ . However, this approximation will differ from the actual cumulative movement ( $C_i$ ) (the area below the actual path) by  $E_i = (C_{Ti} - C_i + 0.5A_i)/D_i$ , which is called excess movement (the dark area on the figure). The term  $0.5A_i$  "removes the bias that arises in using a sum of rectangles ( $C_i$ ) to approximate a triangle" (Harding and Pagan, 2002).

The excess movement is especially useful in studying the asymmetric behavior of the phases of the cycle. In particular, the lower the excess movement

is (the dark area), the faster the recovery from the recession is (that is, the higher the cumulative movement is relative to the triangle approximation, the steeper the actual path is relative to the linear approximation).