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Dynamic Shock Bank Liquidity Analysis

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***Abstract*—**Simulations are developed in this paper with usual DSGE model equations. The model is based on simplified version of Smets-Wouters equations in use at European Central Bank which implies 10 macro-economic variables: consumption, investment, wages, inflation, capital stock, interest rates, production, capital accumulation, labour and credit rate, and allows take into consideration the banking system. Throughout the simulations, this model will be used to evaluate the impact of rate shocks recounting the actions of the European Central Bank during 2008.

***Keywords*—**CC-LM, Central Bank, DSGE, Liquidity Shock, Non-standard Intervention.

I. Introduction

THE Smets-Wouters model: DSGE [12] – Dynamic Stochastic General Equilibrium – models started to be used by Central Banks since the early 2000 [9], [13]. They are based on both General Equilibrium Theory between supply and demand on all markets [1] at any equilibrium point of the time and Real Cycle Theory relating alternation between growth and loss economic period.

More specifically, present study is based on Smets-Wouters model (2003) used at ECB. This model is used to analyze the Euro zone and make economic projections in order to set its interest rate. Through a system of stochastic equations, it describes 3 types of actors; the households, the companies and the Central Bank, and includes principally nine macroeconomics variables: production, inflation, consumption, investment, labour, capital stock, accumulated capital and interest rates [4]. The model also integrates various friction types slowing down the different shocks [5] which can be used in it in order to depict reality.

But it does not consider the banking sector, the money or the credit offer – actually no DSGE model does – even though they are critical parameters at the origin of 2008 economic crisis.

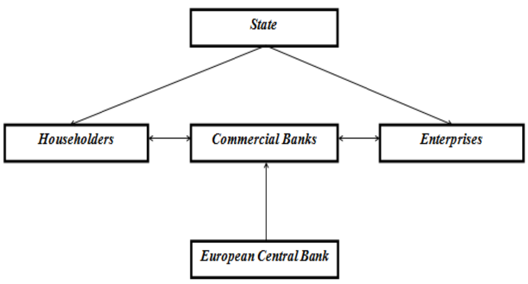

Fig. 1 Economic Agents of DSGE Model

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The CC-LM model: The IS/LM model enhanced by bank credit of Bernanke and Blinder (BB) is used to study liquidity shocks. Similar to DSGE model, this is a neo-Keynesian model of economy based on static prices based on the hypothesis that imperfect substitutability between titles and credits provokes monetary shocks amplification.

This model comprises 3 types of assets, one monetary (Deposits) and two financial non-monetary ones (Credits, Bonds). Economy is divided in 4 markets (Goods, Money, Credit and Bonds) and 3 sectors (Commercial Banks, Central Bank and State, Non-financial agents with household and enterprises).

Compared to traditional IS/LM model [6], a new credit asset is introduced, with commercial bank loans rate. This rate is added to bonds rate, which is considered as the yield rate of general investments in real economy. Another hypothesis is that there is imperfect substitutability between financial assets and banking loans.

II. Problem Description

Since 2008, world economic crisis – started from the United States – has produced an important wave of criticism about economic models in use. Indeed, these models have missed to predict the crisis, and they also failed to bring proper measures to answer its problems, leaving banks and the whole economic system in the lurch.

Monetary stimulus [2] and actions to save the banking system put in use all around the word by the different central banks have neither been based on nor analysed by existing economic models – mostly DSGE models, leading to question the validity of such models [7], [8].

Major raised criticism targets the consideration of money in those models – sometimes considered as non-monetary models by some influent economists [10]. This is why, for better handling of this question, base model, instead of being simplified as much as possible DSGE model, will be a model integrating the banking system through credit rate consideration from CC-LM model.

III. Base Model

To make accurate predictions related to liquidity shocks, base model is resting on a combination of DSGE and CCLM–BB models. There are 2 types of settings in the model, the shocks that will directly impact the DSGE model and the parameters of liquidity injection scenarios. In addition to a prediction about banking liquidity [11], the model will produce as an output the impact of banking credit rates ρ.

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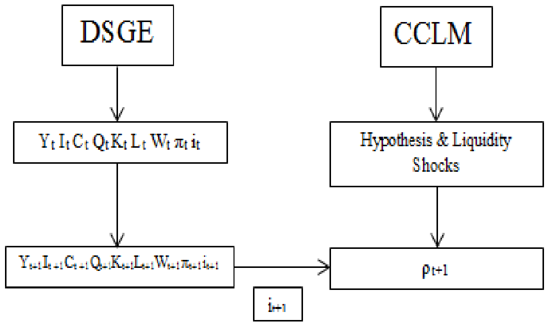

Fig. 2 Global model display

Two types of scenarios are considered to depict the different ways liquidity is injected by ECB: increase in loans – reduction in bonds buying (B) and increase in loans (L) –, and increase in liquidity – reduction in bonds buying (B) and increase in liquidity (Q) [3].

Banks balance sheet is described by the required reserves (τD) – with τ the obligatory reserve rate fixed at 9% –, the bonds (B), the loans (L) and the liquidity reserves (Q), see Fig. 3.

ASSETS	LIABILITIES
τ D	τ D
B	(1 – τ) D
L	
Q	

Fig. 3 Simplified balance sheet

As main hypothesis, in order to determine the link between the rate determined with DSGE model and bank balance sheets, it is supposed that banking system exchanges are frozen because of economic crisis. The netting on balance sheet fields translates this phenomenon of economic crisis. Looking to proportion of leading elements in bank balance sheet assets – requirements (τD), reserves (q), loans (λ) and bonds (Γ) – permits immediately to write the relations :

$$\begin{cases} \lambda = \left(\frac{L}{(1-\tau)D}\right) \\ q = \left(\frac{Q}{(1-\tau)D}\right) \\ \Gamma = \left(\frac{B}{(1-\tau)D}\right) \\ \lambda + \Gamma + q = 1 \end{cases} \qquad (1)$$

After calculation λ, q and Γ give for instance results represented on the Fig. 4:

ASSETS	LIABILITIES
τ D= 5.5433%	τ D=5.55433%
Γ= 36.15995%	(1 – τ) D=94.445673%
λ = 58,28691 %	
q = -0,00119%	

Fig. 4 Simplified balance sheet proportions

Structure of banking wallet is function of rate bonds, loans and securities. From this fact, one can infer the correlation between different financial instrument rates from the system:

$$\begin{cases} \lambda = \alpha\, i + \beta\, \rho \\ \Gamma = \gamma\, i + \delta\, \rho \end{cases} \qquad (2)$$

Solving (2) based on 4 quarters between 2012 and 2013 and with the help of fSolve() from Matlab, one gets the following parameter values:

$$\delta = -451{,}1424089\ ;\ \gamma = 635{,}5767251 \qquad (3)$$
$$\beta = 590{,}7945587\ ;\ \alpha = -785{,}2692224$$

IV. Simulations

Using Excel DSBL software developed elsewhere, a whole set of simulations has been run in order to identify the main variables affected by a rate shock. To get this information rate shocks from 5% to 100% have been analysed. Even if shocks higher than 20% are not realistic and may reach model limits rather fast, they are still interesting in a short term view (1 quarter or 2) and have been run in accordance with the other simulations. As apparent on Figs. 2-4, there are actually 4 variables significantly affected by the rate shock in SW9 model: Consumption C, Investment I, Capital real value Q and Production Y (with triggering shock Rate displayed at right bottom of the panels). Other ones are very weakly affected. To check this observation, simulations have been run with previous four sensitive macroeconomic parameters and by setting other variables to 0, see Figs. 8-10.

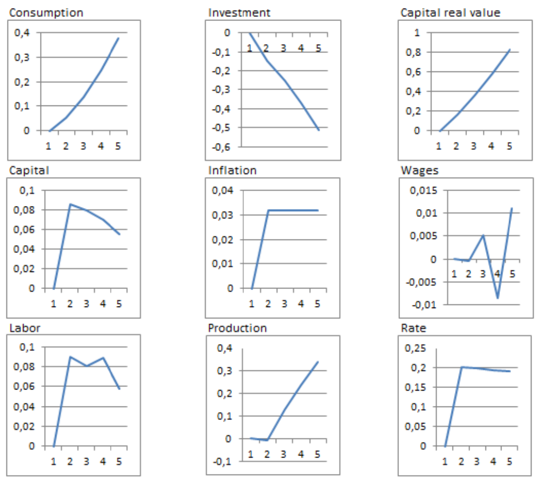

Fig. 5 Impact of 20% rate shock on SW9

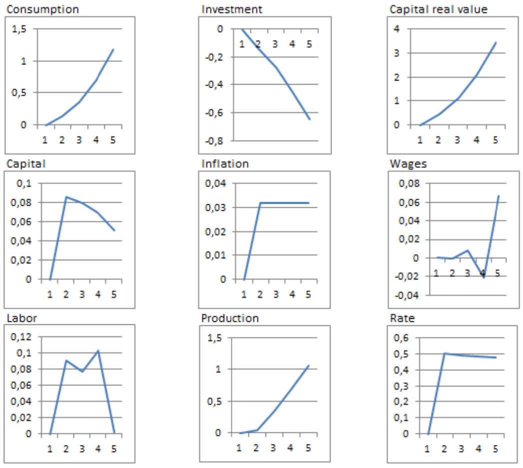

Fig. 6 Impact of 50% rate shock on SW9

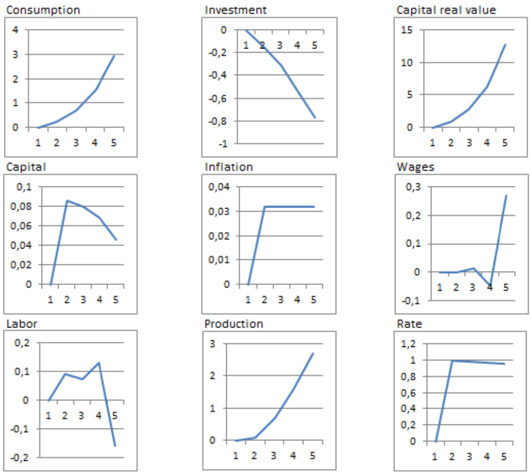

Fig. 7 Impact of 100% rate shock on SW9

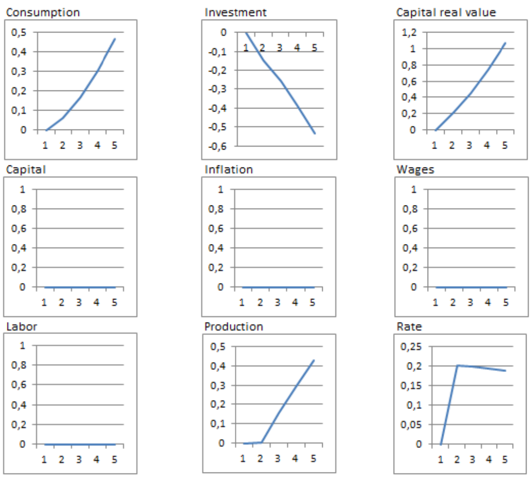

Fig. 8 Impact of 20% rate shock on SW4

Comparison of Consumption C, Investment I, Capital Real Value Q and Production Y in Figs. 8-10 for restricted SW4 dynamics with corresponding ones 5,6,7 for full SW9 dynamics shows almost same time dependence for the different considered rate shock heights of 20%, 50%, 100%. In addition correlation coefficient $\mathcal{C}$ calculated between the two sets of results gives respectively the values $\mathcal{C}$(20%)= .998, $\mathcal{C}$(50%)= .999 and $\mathcal{C}$(100%)= 1.0 justifying model reduction.

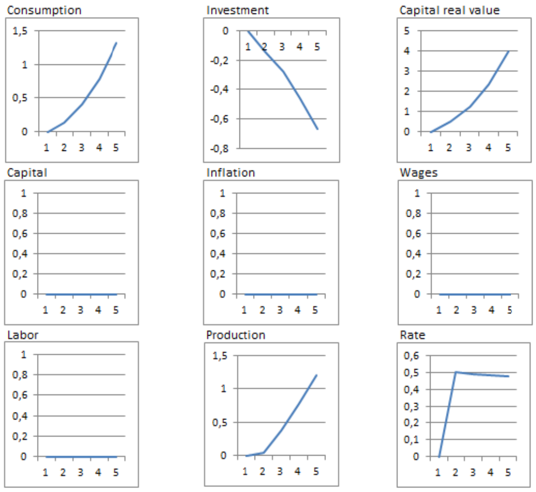

Fig. 9 Impact of 50% rate shock on SW4

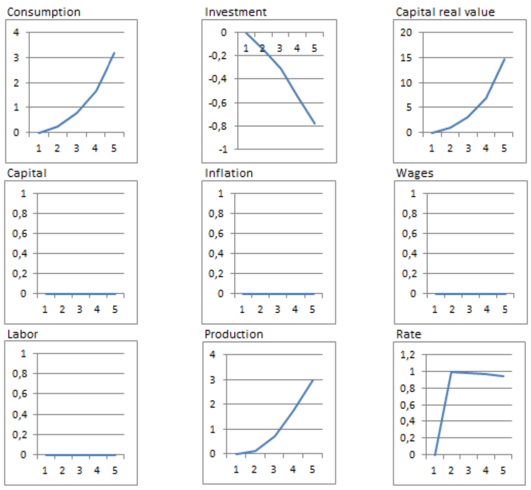

Fig. 10 Impact of 100% rate shock on SW4

The importance of remaining variables Inflation, Labor, Capital and Household Income is limited with respect to first four ones, see Fig. 11, especially regarding the fast shock growing rate with the log-linearized equations.

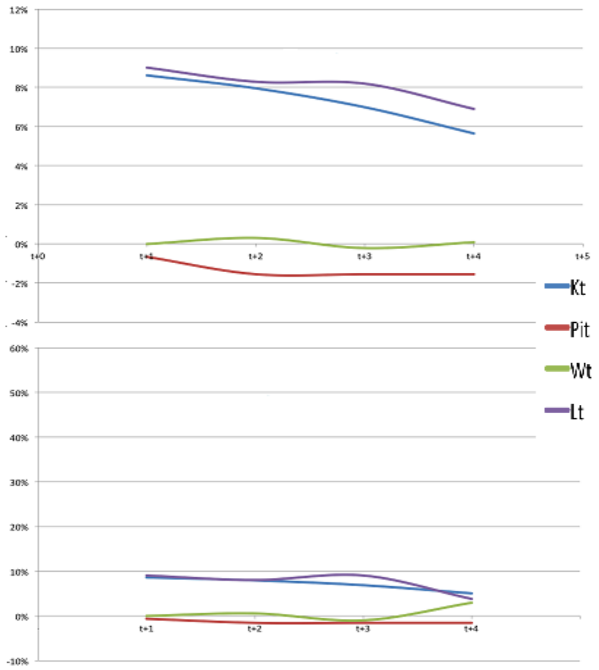

Fig. 11 Impact of a 10% and 50% Rate Shock on Kt Pit, Wt and It

V. Model Reduction

The hypothesis has been made that the economy is closed and populated exclusively by a continuum of economic agents. Equations of SW9 system can globally be expressed in linear form:

$$A_t\mathbf{X}_t + B_{t-1}\mathbf{X}_{t-1} + C_{t+1}\mathbf{X}_{t+1} = \mathbf{S} \qquad (4)$$

where $\mathbf{X}_t$ is system 9-vector state, $\mathbf{S}$ is system source term and A, B, and C stand for time-dependent system matrix parameters. Based on analytic approach combined with simulations discussed in previous part, initial SW9 system now reduces to simplified SW4 system

$$\mathbf{V}_t + \mathrm{B}\mathbf{V}_{t-1} + \mathrm{C}\mathbf{V}_{t+1} = \mathbf{S}_0 + r_{\Delta R}\,\mathbf{S}_1 \qquad (5)$$

with diagonal matrices

$$\mathrm{B} = \mathrm{diag}\{-\frac{1-\tau}{1-\tau+\bar{r}^k}, 0, -\frac{1}{1+\beta}, -\frac{h}{1+h}\} \qquad (6)$$
$$\mathrm{C} = \mathrm{diag}\{0, 0, -\frac{\beta}{1+\beta}, \frac{1}{1+h}\}$$

source terms $\mathbf{S}_0 = \mathrm{col}(S_1,S_2,S_3,0)$, $\mathbf{S}_1 = \mathrm{col}(0,0,0,S_4)$

$$r_{\Delta R}S_4 = -\frac{1-h}{(1+h)\sigma_c}\left[\left(\hat{R}_{t-1} - E_t\hat{\pi}_{t+1}\right) + \frac{1-h}{(1+h)\sigma_c}\hat{\varepsilon}^b{}_t\right] \qquad (7)$$
$$S_1 = -\left(\hat{R}_t - \hat{\pi}_{t+1}\right) + \frac{\bar{r}^k}{1-\tau+\bar{r}^k}E_t\hat{r}^k{}_{t+1} + \eta^Q{}_t$$
$$S_2 = \varepsilon_t^G\,;\; S_3 = \frac{\varphi}{1+\beta}\hat{Q}_t + \hat{\varepsilon}_t^I$$

and reduced state vector

$$\mathbf{V}_t = (\hat{Q}_t, \hat{Y}_t, \hat{I}_t, \hat{C}_t)^T \qquad (8)$$

Splitting rate dependent terms, analytical solution of (5) writes $\mathbf{V}(n) = \mathbf{V}(n,0) + \mathbf{V}(n,\mathbf{S})$ with, in discretized form

$$\mathbf{V}(n,0) = \sum_{\varepsilon=\pm1}\varepsilon\Delta^{-1}(-\lambda_\varepsilon)^{n+1}\{\lambda_\varepsilon\mathbf{V}(0,0)+\mathbf{BY}(0,0)\}$$
$$\mathbf{V}(n,\mathbf{S}) = \Delta^{-1}\sum_{\varepsilon=\pm1}\lambda_\varepsilon[1-(-\lambda_\varepsilon)^{n+1}][1+\lambda_\varepsilon]^{-1}\mathbf{C} \qquad (9)$$

where Δ = $\mathrm{Diag}[\Delta_1,\Delta_2,\Delta_3,\Delta_4]$, $\lambda_\varepsilon=\mathrm{Diag}[\lambda_{\varepsilon1},\lambda_{\varepsilon2},\lambda_{\varepsilon3}, \lambda_{\varepsilon4}]$, $\Delta_j = [A_j^2-4B_j]^{-1/2}$, $\lambda_{\varepsilon j}= .5[A_j+\varepsilon\Delta_j]$, and $[A_1, A_2, A_3, A_4] = [-\{1+\bar{r}^k(1-\tau)^{-1}\}^{-1}, 0, -(1+\beta^{-1}),1+h]$, $[B_1,B_2,B_3,B_4]=[0,0, \beta^{-1},h]$, $[C_1,C_2,C_3,C_4]=[S_1(n),S_2(n), -(1+\beta^{-1})S_3(n),r_{\Delta R}(1+h)S_4(n)]$, and $\mathbf{V}(0,0)$ is the 4-vector of initial conditions at n=0, whereas $\mathbf{Y}(0,0) = \mathbf{V}(-1,0)$ when available, or 0 if not.

VI. Conclusion

From present study it can be first concluded that regular approach with SW9 model to analyze a rate shock can be done with very good precision with a much simplified analytically solvable SW4 model. Present study also shows that monetary policies led by the ECB have almost no impact on credit rate if they are not directly linked to a budgetary policy, and so they have no effect on economy recovery. Indeed even though liquidity injection is real, banks do not follow Central Banks, and do not grant the proper credit offer that could match actual industrial and commercial activity demand. In other words, the contraction of credit supply is not yet solved.

Another aspect of present economy that would need to be studied in order to integrate it in a more accurate model is the link between monetary mass and interest rate. They are today not correlated anymore as a consequence of the large monetary mass distributed by Central Banks in the markets, but it is absolutely critical to re-correlate these two variables so that all aspects of liquidity injection can be represented in a model.

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