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INVESTMENT COST CHANNEL AND MONETARY TRANSMISSION

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ABSTRACT We show that a standard DSGE model with investment cost channels has important model stability and policy implications. Our analysis suggests that in economies characterized by supply side well as demand side channels of monetary transmission, policymakers may have to resort to a much more aggressive stand against inflation to obtain locally unique equilibrium. In such an environment targeting output gap may cause model instability. We also show that it is difficult to distinguish between the New Keynesian model and labor cost channel only case, while with investment cost channel differences are more significant. This result is important as it suggests that if one does not take into account the investment cost channel, one is underestimating the importance of supply side effects.
JEL E32, E52
Keywords Cost channel, Investment finance, Taylor rule, Indeterminacy

ÖZ Çalışmada yatırım maliyet kanalını içeren standart DSGE modelinin dikkate değer bir model istikrarına ve politika çıkarımlarına sahip olduğu gösterilmektedir. Yapılan analiz, parasal aktarımın hem arz hem talep yönünden işlediği ekonomilerde, politika yapıcıların yerel teklik özelliğine sahip bir dengeyi sağlama saikıyla enflasyona karşı sert bir duruş sergilemek zorunda kalabileceklerine ve böyle bir ortamda çıktı açığının hedeflenmesinin model istikrarsızlığına neden olabileceğine işaret etmektedir. Çalışmada ayrıca Yeni Keynesyen model ile yalnızca emek maliyeti kanalını içeren durumun ayırt edilmesinin zor olduğu, ancak yatırım maliyeti kanalı dikkate alındığında farklılıkların vurgulu hale geldiği gösterilmektedir. Bu sonuç, yatırım maliyeti kanalı ihmal edildiğinde arz yönlü etkilerin olması gerektiği biçimde değerlendirilemeyeceğini göstermesi açısından önem taşımaktadır.
YATIRIM MALİYETİ KANALI VE PARASAL AKTARIM
JEL E32, E52
Anahtar Kelimeler Maliyet kanalı, Yatırım finansmanı, Taylor Kuralı, Belirlenimsizlik

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1. Introduction

Are supply side effects of interest rates important? There is compelling empirical evidence that cost channels matter. Barth and Ramey (2001) show at the manufacturing industries level strong supply-side channels in the monetary transmission are present in the short to medium run. Ravenna and Walsh (2006) present corroborating econometric evidence for the direct influence of monetary policy on the U.S. inflation adjustment equation. Furthermore, Mayer and Sussman (2004) report empirical evidence that US firms rely on debt relative to equity in financing investment implying the presence of investment cost channel of monetary transmission. In this paper we investigate supply side effects of the monetary transmission, both through labor and investment, analyze their relative importance in monetary transmission and equilibrium determinacy. We particularly emphasize the investment cost channel (Inv-channel).

Altering the standard New Keynesian model by incorporating supply side considerations and money-credit markets have important local determinacy implications. We first find that determinacy regions are much more narrow as compared to the literature and second the Taylor principle is often violated. Our analysis suggests that when the monetary transmission is characterized by supply side as well as demand side channels, inflation conservatism may be paramount to obtain locally unique equilibrium. We show that output gap targeting is prejudicial, narrowing the determinacy region; thereby reinforcing and extending Surico's (2008) findings on the effect of the relevance of labor cost channel (Lab-channel). Here we stress the role played by the investment channel that significantly amplifies the indeterminacy problem as compared to the labor channel. Furthermore, given the importance of investment channel, indeterminacy issues should be also present in financial accelerator models (see Bernanke *et al*., 1996).

Our simulation results suggest that the presence of Inv-channel is enough to generate an amplification to the response of business cycle fluctuations, as the natural increase of interest rates, which are now a direct part of the firm's investment cost, curb investment and production. Moreover key macroeconomic variables behave in a very similar way under the full cost channel case (that is labor and Inv-channels together) and the investment channel case. On the other hand, it is difficult to distinguish between the standard NK model and labor channel only case in terms of dynamic behavior of macroeconomic variables. The paper suggests that if one does not take into account the investment cost channel, one may be underestimating the importance of supply side effects.

2. Model

The economy consists of a representative household, a firm, a financial intermediary (FI) and a central bank.

2.1. Households

The household is maximizing its discounted lifetime utility given by:

$$\max_{C_t, M_{t+1}, D_t, A_t, H_t} E_t \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \chi \frac{H_t^{1+\eta}}{1+\eta} \right) \quad \beta \in (0,1) \quad \sigma, \eta > 0 \tag{1}$$

where C_t denotes the household's total consumption, H_t denotes labor supply. The family faces the following budget and cash-in-advance (CIA) constraints:

$$C_t + \frac{D_t}{P_t} + \frac{M_{t+1}^d}{P_t} + E_t\left(\frac{Q_{t,t+1}A_t}{P_t}\right) \leq \frac{W_t}{P_t}H_t + \frac{A_{t-1}}{P_t} + \frac{R_t D_t}{P_t} + \frac{M_t}{P_t} + \int_0^1 \Pi_{i,t} di + \Pi_t^{FI} - T_t \tag{2}$$

$$C_t + \frac{D_t}{P_t} \leq \frac{M_t}{P_t} + \frac{W_t}{P_t} H_t \tag{3}$$

where R_t represents the rate of return on the intra-period deposit D_t M_{t+1}^d money holdings carried over to period t+1, A_t alternative physical assets valued at the stochastic discount factor[1] $E_t(Q_{t,t+1})$, $\int_0^1 \Pi_{i,t} di$ dividends accrued from the intermediate producers to households, Π_t^{FI} profits of the FI accrued to the household, and T_t the lump-sum taxes households have to pay. Household needs to allocate money balances and wage income for consumption purposes net of deposits. [2]

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[1] We include a portfolio of assets because we will use the stochastic discount factor $E_t(Q_{t,t+1})$ to explicitly link the firm's problem to the households. Alternatively, we could directly incorporate the relative marginal utilities in the firm's problem. Thus the introduction of the assets does not alter the results presented here.

[2] We assume intra- period deposits, which imply the consumption Euler equation is equivalent to the one in the standard NK model. An alternative specification where deposits clear next period yields an additional channel of monetary transmission through the real balance effect on consumption. In this environment consumption today is determined by the expected consumption two periods ahead $E_t(\hat{c}_{t+2})$, and the future evolution of interest rates. This forward looking aspect when combined with the presence of cost channels has important implications for determinacy, as discussed in Aksoy, Basso, Coto Martinez (2009).

2.2. Firms

The final goods representative firm produces goods combining a continuum of intermediate goods $i \in [0,1]$. We obtain the standard demand function and aggregate price level, stated below.

$$Y_t = \left[\int_0^1 y_{i,t}^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}},\ y_{i,t} = \left(\frac{p_{i,t}}{p_t}\right)^{-\varepsilon} Y_t \text{ and } P_t = \left[\int_0^1 p_{i,t}^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \quad (4)$$

The intermediate sector is constituted of a continuum of firms $i \in [0,1]$ producing differentiated goods with the CRS technology:

$$y_i = K_i^{\alpha} H_i^{1-\alpha} \quad (5)$$

where K is the capital stock and H is the labor used in production. The firm hires labor and buys capital (goods) in the capital market. It is assumed that the firm must borrow money to finance these expenses. We first solve the intermediate firms' pricing decision given the real marginal cost and then for the cost minimization problem. Firm i, when allowed, sets prices $P_{i,t}$ according to a Calvo pricing scheme:

$$\max_{P_{i,t}} E_t \left\{ \sum_{s=0}^{\infty} P_{t+s} Q_{t,t+s} \omega^s y_{i,t+s} \left[\frac{P_{t,i}}{P_{t+s}} - \Lambda_{t+s} \right] \right\} \quad (6)$$

subject to the demand function, where Λ_t is the real marginal cost of the firm.[3] We obtain the real marginal cost, by solving firm's intertemporal cost minimization problem.

$$\min_{K_{i,t+1}, H_{i,t}} E_t \left\{ \sum_{t=0}^{\infty} Q_{t,t+1} (R_{L,t}^{\nu_1} W_t H_{i,t} + R_{L,t}^{\nu_2} P_t I_{i,t}) \right\} \quad (7)$$

subject to the production function (5) and investment equation $I_{i,t} = K_{i,t+1} - (1-\delta) K_{i,t}$, where W_t is the nominal wage, and $R_{L,t}$ the rate the bank charge for the loan made in period t, to be paid in t+1 and Λ_t is the multiplier of the constraint (5)[4]. Expression $R_{L,t}^{\nu_1} W_t H_{i,t} + R_{L,t}^{\nu_2} P_t I_{i,t}$

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[3] Although we have firm specific capital, because of the Cobb-Douglas production function, the ratio of capital and labor is constant across firms. Therefore, the marginal cost here is the same across firms and do not depend on the firm's specific capital and its price history as it does in Woodford (2005).

[4] Investment decisions are firm-specific. In order to avoid complications that will arise due to combination of firm specific capital and Calvo pricing, we assume the existence of a capital market between firms. This allows firms to buy and sell capital at the background. Note that as shown by Sveen and Weinke (2007) the relevant difference of considering firm specific capital is that the parameter κ in the New Keynesian Phillips Curve will be smaller, implying greater price stickiness. Our results are not qualitatively affected by introducing firm specific capital.

characterizes the costs of firms given that they need to borrow from the FI to finance wage and investment payments[5]. Parameters $\nu_1 \in [0,1]$, $\nu_2 \in [0,1]$ specify the importance of the cost channel of labor and investment, respectively. Full cost channel is represented by $\nu_1 = \nu_2 = 1$; only Lab-channel is present when $\nu_1 = 1, \nu_2 = 0$ and only Inv-channel is present when $\nu_1 = 0, \nu_2 = 1$. The stochastic discount factor in period t for period t is given by $Q_{t,t} = 1$.

2.3. Financial Intermediary and Central Bank

The FI gets deposits from the household and lends money to the firms in the form of loans (L). Formally the FI problem is to maximize $R_{L,t} D_t - R_t D_t$ over D_t. That implies $R_{L,t} = R_t$. In equilibrium the demand for credit to pay the production input must be equal to the supply of credit made by the banking system. The credit supply is determined by deposits. Therefore, the credit market condition is given by $\nu_1 W_t H_t + \nu_2 P_t I_t = D_t$.

The central bank follows a Taylor rule in setting interest rates (where $\bar{x}$ denotes the steady state of x):

$$\frac{R_t}{\bar{R}} = \left(\frac{R_{t-1}}{\bar{R}}\right)^{\varepsilon_r} \left[\left(\frac{\pi_t}{\bar{\pi}}\right)^{\varepsilon_\pi} \left(\frac{Y_t}{\bar{Y}}\right)^{\varepsilon_Y}\right]^{1-\varepsilon_r} \tag{8}$$

2.4. Equilibrium

Consumer problem is represented by the standard Euler conditions:[6]

$$\beta E_t \left(\frac{R_t C_{t+1}^{-\sigma}}{\pi_{t+1}}\right) = C_t^{-\sigma} \tag{9}$$

$$\frac{\chi H_t^{\eta}}{C_t^{-\sigma}} = \frac{W_t}{P_t} \tag{10}$$

From the consumer problem we obtain the stochastic discount factor:

$$Q_{t,t+1} = \beta E_t \frac{\lambda_{t+1}}{\lambda_t \pi_{t+1}} = \beta E_t \left[\frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma} \pi_{t+1}}\right]$$

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[5] Note that as $R^{\nu_1} WH \approx WH + (R-1)\nu_1 WH$ the cost function used in the firm's problem is equivalent to having the firm paying the full labor costs and the net interest rate on the portion $\nu_1 WH$ that needed to be borrowed. That implies the firm has only a portion $1-\nu_1$ of the labor costs at its disposal at the beginning of the period, when wages must be paid. The same applies for investment.

[6] The Euler equation stated holds as an equality as long as $D_t > 0$ which is the case at equilibrium.

The goods market clearing condition reads:

$$Y_t = C_t + I_t \tag{11}$$

The capital and labor market clearing condition are given by $K_t = \int_0^1 K_{i,t} di$ and $H_t = \int_0^1 H_{i,t} di$.

Investment evolves according to:

$$I_{i,t} = K_{i,t+1} - (1-\delta)K_{i.t} \tag{12}$$

The price setting equation is given by solving (6):

$$P_{i,t} = \frac{\varepsilon}{\varepsilon - 1} \frac{E_t\left\{\sum_{s=0}^{\infty} P_{t+s} Q_{t,t+s} \omega^s \Lambda_{t+s} y_{i,t+s}\right\}}{E_t\left\{\sum_{s=0}^{\infty} P_{t+s} Q_{t,t+s} \omega^s \frac{y_{i,t+s}}{P_{t+s}}\right\}} \tag{13}$$

Finally, from the firm problem we obtain the demand for capital and labor and the optimal price. After some manipulations we obtain the equilibrium conditions:

$$\Lambda_t = \frac{R_t^{\nu_1} W_t H_{i,t}}{P_t Y_{i,t}(1-\alpha)} \tag{14}$$

$$R_t^{\nu_2} = \beta E_t\left\{\frac{R_t}{\pi_{t+1}}\left[\Lambda_{t+1}\frac{\alpha Y_{i,t+1}}{K_{i,t+1}} + (1-\delta)R_{t+1}^{\nu_2}\right]\right\} \tag{15}$$

As conditions (14) and (15) reveal, the real marginal cost of the firm will be, among others, a function of both current and future expected short term rates. The Inv-channel also shows the impact of the expected labor supply decisions on the real marginal cost. Ravenna and Walsh (2006) derive their aggregate supply equation based on the impact of policy changes on labor cost financing. To get Ravenna and Walsh (2006), we need to remove the cost channel in investment. In this case, expected labor supply and nominal rates in period t still affect the real marginal costs. By assuming $\nu_1 = 0$ we obtain Inv-channel only (see Kurozami and Van Zandweghe, 2008). In this case, both current and expected interest rates still influence real marginal costs.[7]

The equilibrium of the economy is defined as the allocation set $\{C_t, H_t, K_{t+1}, M_{t+1}, Y_t\}$ and the vector of prices $\{p_{i,t}, P_t, W_t, R_t, \Lambda_t\}$ such that the household, the final good firm and intermediate firms maximization

[7] Dow (1995) obtains a similar expression for investment using a slightly different discount factor, since firms have to pay the capital input in advance and an increase in nominal interest rates raises the capital cost.

problems, the market clearing conditions and the government budget constraint, given by equations (5), (4), (8), (9) - (15), hold.

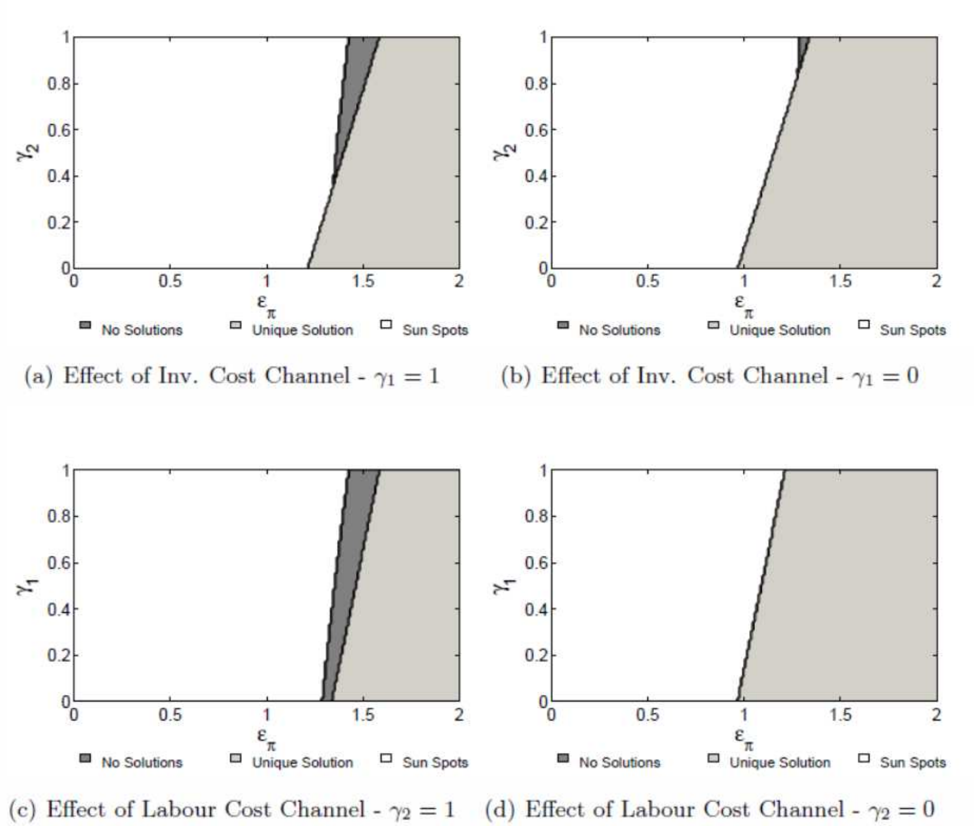
For the numerical exercise, we set the parameter of intertemporal elasticity of substitution $\sigma = 1$, the parameter of intertemporal elasticity of labor supply η =1.03, the discount factor, β =0.99, the depreciation rate, δ =0.05 per quarter, the steady state share of labor income in total output of 66%, i.e. α =0.36, the Calvo parameter ω =0.66. We set the share of steady state consumption s_c =0.625, and the share of steady state investment s_I =0.275.

3. Model Determinacy

Woodford (2003) discusses conditions for determinacy of equilibrium within the setting of a cashless NK framework (Taylor principle). He argues that when a monetary policymaker targets output gap next to inflation she effectively relaxes the conditions for equilibrium determinacy. He also shows that interest rate smoothing is useful in obtaining a locally unique equilibrium. While we concur that interest rate smoothing is indeed important to achieve a unique local equilibrium, targeting output gap is in fact counter productive for determinacy purposes. We find that uniqueness of equilibrium is harder to obtain in the presence of cost channels and money-credit markets. Both cost channels are important for this result. However, we find that the presence of Inv-channel narrows down the parameter space that the policymaker can use to stabilize the economy more significantly than the Lab-channel.

Figure 1 illustrates the effect of the two types of cost channel on indeterminacy when the monetary policy rule has no interest rate inertia (ε_r =0) and targets inflation and output (ε_y =0). While in the NK model the monetary authority ensures uniqueness responding more than one to one to an inflation deviation that is not sufficient in the case both cost channels are in place; the inflation parameter must be greater than 1.6 to ensure determinacy. Although both labor and invest cost channels contribute to that result, an economy with Inv-channel requires a stronger response to inflation deviation than when only the Lab-channel is present.

Figure 1. Cost Channel Effects – Varying ν_1 and ν_2

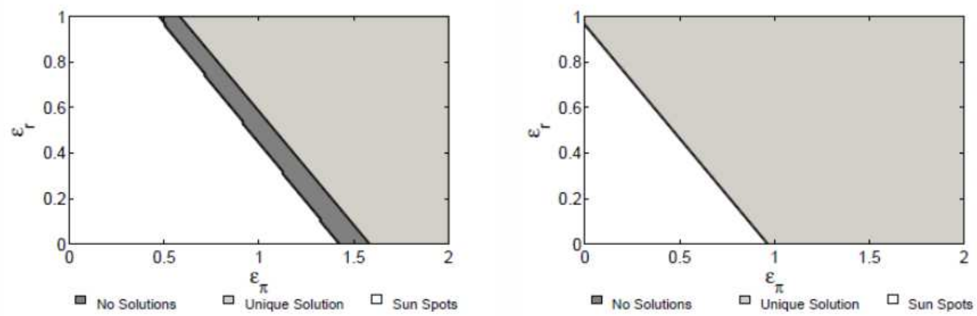


(a) Effect of Inv. Cost Channel - $\gamma_1 = 1$ (b) Effect of Inv. Cost Channel - $\gamma_1 = 0$

(c) Effect of Labour Cost Channel - $\gamma_2 = 1$ (d) Effect of Labour Cost Channel - $\gamma_2 = 0$

Figure 2 focuses on the effect of interest rate smoothing on indeterminacy when cost channels are present. Cost channels have little effect on indeterminacy comparing to a standard NK model. In both cases, interest rate smoothing helps increasing the determinacy region.

Figure 2. Cost Channel Effects – Interest Rate Smoothing (ε_y =0.5)

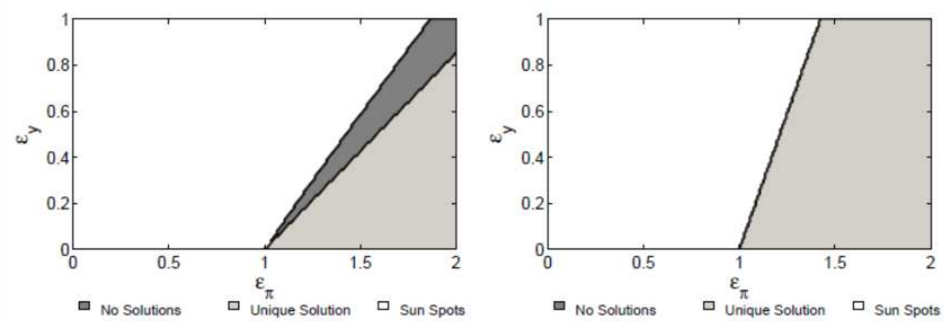


(a) Full Cost Channel (b) No Cost Channel or NKM model

In Figure 3 we look at the determinacy effects of altering the monetary policy response to output deviations (ε_y). As Figure 3 (d) shows, increasing output targeting has a mildly positive effect, increasing the determinacy region in the benchmark NK model. When cost channels are present, however, increasing the output gap parameter decreases the area of determinacy. When both channels are present, and ε_y =1, the monetary authority can not guarantee stability even if it changes interest rates by two times the inflation deviation. Once again, although both cost channels are important for this result, the Inv-channel appear to contribute more than the Lab-channel.

This is because, with cost channels, while a contractionary policy change leads to a contraction of the economy, it leads to a decrease in inflation via the demand channel and an increase via the supply channels. Targeting output together with inflation requires aggregate demand channels dominating the supply channels (see also Surico, 2008, with a cost channel only in labor).

Figure 3. Cost Channel Effects – Output Targeting (ε_r =0)



(a) Full Cost Channel (b) Labour Cost Channel

(c) Investment Cost Channel (d) No Cost Channel or NKM model

We conclude that indeterminacy problems are much more severe within these model settings. The Taylor-Woodford principle that prescribes simple conditions for ensuring macroeconomic stability is often violated. If the macroeconomic environment includes supply side as well as demand side considerations, a very aggressive stand against inflation is paramount to achieve model determinacy.

4. Monetary Transmission

The analysis of the stability of model indicated that an interest rate rule with parameters ε_y =0.5, ε_π =1.5 delivers model stability under all types of cost channels if and only if there is strong interest rate smoothing. Therefore we will run model simulations where ε_r =1. We analyze the response of key macroeconomic variables given a policy shock ($\varepsilon_{r,t}$), with an autocorrelation coefficient equal to 0.5 and a standard deviation set equal to 1% in the case of following cases[8]:

- full cost channel ($\nu_1 = \nu_2 = 1$),
- no-cost channel or NK model with investment ($\nu_1 = \nu_2 = 0$),
- only Lab-channel ($\nu_1 = 1, \nu_2 = 0$),
- only Inv-channel ($\nu_1 = 0, \nu_2 = 1$).

Figure 4. Impulse Responses – Policy Shock

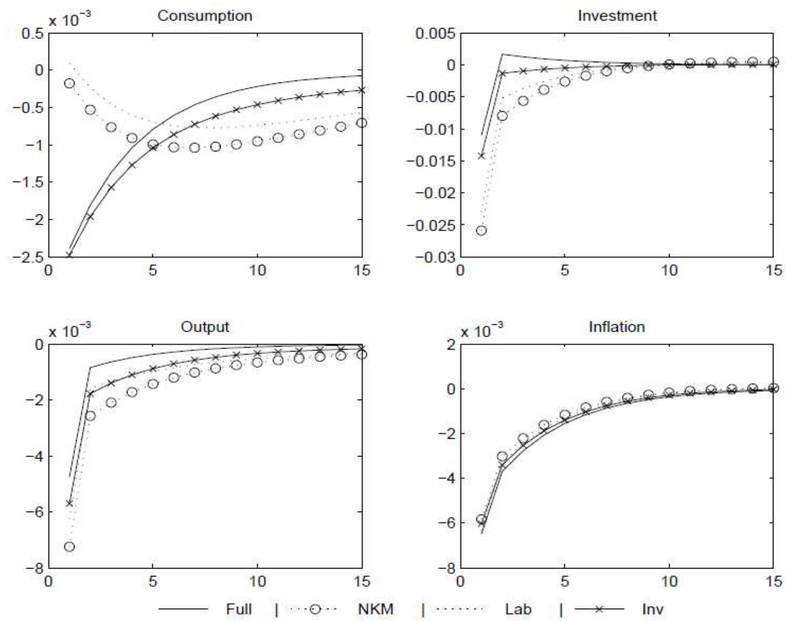


Figure 4 shows the comparison of consumption, investment, output and inflation with respect to this monetary policy shock. Here, the output-inflation trade off result is absent. A contractionary monetary policy shock yields a decline in inflation and output in line with NK arguments. The impulse responses of the model with full-cost channel and the Inv-channel only are similar to each other but significantly different to the responses observed for the models with no-cost and Lab-channel. The NK model and the Lab-channel model yield very similar impulse responses.

[8] We have also analyzed the impulse responses to investment, taste and inflation shocks. In these cases we do not observe a significant difference between labor and investment cost channels.

As Christiano *et al*. (2005) point out, one of the main discrepancies of the NK model with investment in relation to the data is that after a contractionary monetary policy shock, investment moves to strongly driving output down but consumption responses are quite flat. In order to correct this anomaly they introduce investment adjustment costs. As Figure 4 shows the models without Inv-channel are subject to the same problem. This is not the case when the Inv-channel is present. Investment and output respond less and consumption falls after a monetary policy shock[9].

5. Conclusions

Our analysis suggests that in economies characterized by supply side well as demand side channels of monetary transmission, policymakers may have to resort to a much more aggressive stand against inflation to obtain locally unique equilibrium. In such an environment targeting output gap may cause model instability. We show that the Inv-channel, also assumed by Bernanke *et al*. (1996), is the main driver of this result, hence, indeterminacy issues should be present in financial accelerator models.

Our simulation results suggest that the presence of Inv-channels is enough to generate an amplification to the response of business cycle fluctuations, as the increase of interest rates, which are now a direct part of the firm's investment cost, curb investment and production. Key macroeconomic variables behave in a very similar way under the full cost channel case and the Inv-channel case. On the other hand, it is difficult to distinguish between the standard NK model and the model including only the Lab-channel. This result is important as it suggests that if we does not take the Inv-channel into account, we underestimate the importance of supply side effects in monetary transmission.

References

Aksoy,Y., H.S.Basso, and J.Coto Martinez, 2009, Liquidity Effects and Cost Channels in Monetary Transmission, Birkbeck Working Papers in Economics and Finance 0902.

Barth,M.J.III. and V.A.Ramey, 2002, The Cost Channel of Monetary Transmission. In: NBER Macroeconomic Annual, MIT Press, Cambridge, MA, pp.199-239.

Bernanke,B., M.Gertler, and S.Gilchrist, 1996, The Financial Accelerator and the Flight to Quality, The Review of Economics and Statistics, pp.1-15.

Christiano,L.J., M.Eichenbaum and C.Evans, (2005), Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy, Journal of Political Economy 113:1-45.

Dow,J.P., 1995, The Demand and Liquidity Effects of Monetary Shocks, Journal of Monetary Economics 36: 91-115.

[9] Note, however, that the model with investment adjustment cost generates hump-shaped investment responses, while the model with the investment cost channel in this simple form does not.

Kurozumi,T. and W.Van Zandweghe, 2008, Investment, Interest Rate Policy, and Equilibrium Stability, Journal of Economic Dynamics and Control 32:1489-1516.

Mayer,C. and O.Sussman, 2004, A New Test of Capital Structure, CEPR Discussion Papers 4239.

Ravenna,F. and C.Walsh, 2006, Optimal Monetary Policy with the Cost Channel, Journal of Monetary Economics 53:199-216.

Surico,P., 2008, The Cost Channel of Monetary Policy and Indeterminacy, Macroeconomic Dynamics 12:724-735.

Sveen,T. and L.Weinke, 2007, Firm Specific Capital, Nominal Rigidities and the Taylor Principle, Journal of Economic Theory 136:729-737.

Woodford,M., 2003, Interest and Prices: Foundations of a Theory of Monetary Policy, Princeton University Press.