THE EFFECTS OF WORKING CAPITAL CHANNEL ON MONETARY POLICY TRANSMISSION

A Master's Thesis

by

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To my family.

THE EFFECTS OF WORKING CAPITAL CHANNEL ON MONETARY POLICY TRANSMISSION

The Graduate School of Economics and Social Sciences
of
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I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Economics.

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ABSTRACT

THE EFFECTS OF WORKING CAPITAL CHANNEL ON MONETARY POLICY TRANSMISSION

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July 2023

This thesis examines the effects of the working capital channel on monetary policy transmission under a two-sector new Keynesian model, where one of the sectors has working capital requirements. The model follows the framework presented by Woodford (2003). Introducing working capital into the model brings about two additional monetary policy transmission channels: the working capital channel and the substitution channel, relative to the standard new Keynesian model. The working capital channel reduces the effectiveness of monetary policy in stabilizing inflation within the model while also increasing the sensitivity of the output gap to monetary policy. Simultaneously, the substitution channel helps mitigate the impact of working capital on aggregate inflation. Moreover, the presence of the working capital channel gives rise to the distributional effects of monetary policy on the economy. The substitution channel exacerbates the adverse effect of contractionary policy on firms with working capital requirements, whereas expansionary monetary policy leads to a higher demand for the goods produced by these firms.

Keywords: Working capital, Monetary policy transmission, new Keynesian models

ÖZET

İŞLETME SERMAYESİ KANALININ PARA POLİTİKASI AKTARIMINA ETKİLERİ

SAMED KÜÇÜKİKİZ
Yüksek Lisans, İktisat Bölümü
Tez Danışmanı: Prof. Dr. Refet Soykan Gürkaynak

Temmuz 2023

Bu tezde işletme sermayesi kanalının iki sektörlü yeni Keynesyen modelde para politikası aktarımına olan etkileri incelenmektedir. Modelde bir sektörün işletme sermayesi gereksinimleri bulunmakta ve modelin oluşturulmasında Woodford (2003) temel alınmıştır. İşletme sermayesinin varlığı, basit yeni Keynesyen modele göre iki yeni para politikası aktarım kanalı meydana getirmektedir: işletme sermayesi ve ikame kanalları. İşletme sermayesi kanalı, modelde enflasyonu dengeleme açısından para politikasının etkinliğini azaltmaktadır. Ayrıca, işletme sermayesi kanalı nedeniyle çıktı açığı para politikasına daha duyarlı hale gelmektedir. İkame kanalı ise, işletme sermayesinin enflasyon üzerindeki etkisini hafifletmektedir. Bununla birlikte, bu kanal ekonomide para politikasının dağılımsal etkisini ortaya çıkarmaktadır. İkame kanalı, daraltıcı para politikasının olumsuz etkisini işletme sermayesi gereksinimi olan firmalar için artırırken, genişletici para politikası bu firmaların ürettiği ürünlere talebi daha fazla yükseltmektedir.

Anahtar Kelimeler: İşletme sermayesi kanalı, Para politikası aktarımı, Yeni Keynesyen Modeller

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CHAPTER 1

INTRODUCTION

Understanding monetary policy transmission is one of the central parts of the monetary policy literature. The conventional view proposes that monetary policy affects the demand side of the economy by influencing households' saving and investment decisions. According to the dominant demand-side theory, the short-term interest rate as the policy tool would be enough to stabilize the economy, and the central bank would not encounter any trade-off to suppress inflation.

On the other hand, several empirical studies find robust evidence that firms are subject to working capital requirements, making firms pay operational expenses in advance by borrowing from financial intermediaries (Barth & Ramey, 2001; Chowdhury et al., 2006). The working capital constraint makes the interest rate become part of the cost of production, and a change in interest rate also causes a change in the firms' operating cost, so the working capital requirement gives rise to a new channel for monetary policy transmission, which works against the demand-side channels. The channel is called the working capital or cost channel in the literature. The working capital channel restricts the supply of goods by raising the cost of production and leads to increase inflation in the short run under the contractionary monetary policy, even though the rise in interest rates lowers household demand and decreases inflation according to conventional views. Overall, the effects of monetary policy on inflation are mitigated in the presence of a working capital channel since the channel works against the conventional mechanism in the short run.

The cost channel gives the central bank a role in determining which sectors will be more profitable. The unexpected rise in the interest rate decreases sales more for firms with working capital requirements since the relatively high price in the sector leads to lower demand for the firms. Conversely, the expansionary monetary policy has more favorable consequences for firms that require operating cash. This thesis examines how the transmission of monetary policy is affected by firms' working capital heterogeneity and subsequently impacts the overall economy. To answer the question, I build a two-sector new Keynesian model in which one of the sectors has working capital requirements.

The model employed in this thesis is a variant of the two-sector new Keynesian model. In contrast to the model proposed by Ravenna and Walsh (2006), the inclusion of two sectors in the model is a more realistic assumption. This modification significantly alters the impact of the working capital channel on the economy. The working capital channel in the two-sector model leads to inflation differences between sectors, which, in turn, gives rise to a substitution channel. Consequently, the effect of the working capital channel is mitigated compared to the model proposed by Ravenna and Walsh (2006).

While this thesis is not the first to develop a two-sector new Keynesian model or incorporate the working capital channel into a new Keynesian framework, it investigates the transmission of monetary policy in an environment characterized by asymmetric working capital requirements in the two-sector new Keynesian model. Therefore, this study sheds light on monetary policy transmission in an economy with heterogeneous firms and provides insights into the effects of firm-level heterogeneity on monetary policy.

Barth III and Ramey (2001) study the working capital channel for US industries. They find that an interest rate shock partly impacts real activity and inflation through the working capital channel. Ravenna and Walsh (2006) and Chowdhury et al. (2006) combine cost channel with the traditional new Keynesian model and provide empirical evidence for the significance of cost channel in monetary policy by using GMM for the aggregate data of 5 industrialized countries. Tillmann (2008) finds that the cost channel significantly improves the fit of the inflation dynamics in various new Keynesian models. Besides the aggregate data, empirical studies which use firm-level data also indicate the significance of cost channel in monetary policy transmission. Mahmoudzadeh et al. (2018) use survey data to show the working capital channel in Iranian enterprises. Galindo Gil (2021) also set a partial equilibrium model with working capital loans and finds the working capital channel quantitatively important with high variance among the different sectors. Suveg (2022) uses Swedish firm-level data and again provides evidence for the working capital channel.

Chapter 2 presents the model. Chapter 3 discusses the impulse responses of economic variables to a monetary policy shock. Finally, Chapter 4 concludes the paper.

CHAPTER 2

THE MODEL

I build a two-sector new Keynesian model following Woodford (2003). The economy is divided into two sectors indexed by $s \in \{1, 2\}$. A monopolistically competitive continuum of firms is indexed by $i \in [0, 1]$. N_s represents the allocation of firms in each sector, where the intervals of goods belonging to the two sectors are $N_1 = [0, n_1]$ and $N_2 = [n_1, 1]$. n_1 represent sector size of sector 1 and respectively n_2 is sector size of sector 2 ($n_1 + n_2 = 1$). Firms are monopolistic and competitive in their sector and adjust the prices with a certain probability in each period (i.e., Calvo type).

The only difference between sectors is the existence of working capital requirements in one of them. I choose the simple model to focus on the exact distributional and economy-wide effect of the working capital channel under a monetary policy shock. Hence, I set sectors has the same price stickiness and production function. Also, labor is completely mobile within each sector but immobile across sectors.

2.1 Representative Household

The household derives utility from a composite consumption good and supplies different types of labor to the continuum of firms in each sector. I assume the following CES function for composite consumption good, C_t, and CES aggregate for the ith variety good in sector s.

$$C_t = \left[n_1^{\frac{1}{\varphi}} (C_{1,t})^{\frac{\varphi-1}{\varphi}} + n_2^{\frac{1}{\varphi}} (C_{2,t})^{\frac{\varphi-1}{\varphi}} \right]^{\frac{\varphi}{\varphi-1}} \tag{1}$$

$$C_{s,t} = \left[{n_s}^{-\frac{1}{\theta}} \int_{N_s} c_{s,t}(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}$$

Also, the aggregate structure of composite consumption and sectoral goods gives us price indices for aggregate and sector level given by

$$P_{s,t} = \left[{n_s}^{-1} \int_{N_s} P_{s,t}(i)^{1-\theta} di \right]^{\frac{\theta}{\theta-1}}$$

$$P_t = \left[n_1 (P_{1,t})^{1-\varphi} + n_2 (P_{2,t})^{1-\varphi} \right]^{\frac{1}{1-\varphi}}$$

The static problem of household is minimizing expenditure by allocating income within and between sectors. Given aggregate consumption good C_t and price indices, the optimal demand for goods in the sector s is given in equation 2. Additionally, household allocates income between ith goods in sector s by solving expenditure minimization problems subject to sectoral consumption composite. The demand for ith good is given in equation 3.

$$C_{s,t} = n_s \left(\frac{P_{s,t}}{P_t} \right)^{-\varphi} C_t \tag{2}$$

$$C_{s,t}(i) = \frac{1}{n_s}\left(\frac{P_{s,t}(i)}{P_{s,t}}\right)^{-\theta} C_{s,t} \tag{3}$$

The dynamic problem of household maximizes the discounted lifetime utility subject to aggregate budget constraint. Household chooses optimum C_t, $H_{1,t}$, $H_{2,t}$ and B_t.

$$\max_{\{C_t, H_{1,t}, H_{2,t}, B_t\}} \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{H_{1,t}^{1+\eta}}{1+\eta} - \frac{H_{2,t}^{1+\eta}}{1+\eta}\right)$$

s.t

$$C_t + \frac{B_t}{P_t} = \frac{W_{1,t}H_{1,t}}{P_t} + \frac{W_{2,t}H_{2,t}}{P_t} + \frac{(R_{t-1})B_{t-1}}{P_t} + \sum_{s=1}^{2}\left(\frac{\Pi_{s,t}}{P_t} - \frac{T_{s,t}}{P_t}\right)$$

The problem is the same with the standard new Keynesian model, except household divides their labor force into two sectors with $H_{1,t}$ and $H_{2,t}$. Household supplies the labor force to the industries and earn wage income represented by $W_{1,t}$ and $W_{2,t}$. Also, the household owns the firms in two sectors, and $\Pi_{s,t}$ represents profit coming from firms. The government has two functions in the model. First, the government subsidizes firms for labor hired by the firm, and second, it applies lump-sump taxes, represented by $T_{s,t}$, to the household. The existence of a government is the only model purpose since it removes distortions of monopolistic competition at a steady state. Household starts time t with initial bond stock B_{t-1}, and they need to decide how much to consume, C_t, and invest on a bond, B_t, which is the interest-bearing financial asset. Solving households' problem yield optimality conditions.

$$C_t^{-\sigma} = \beta(R_t)E_t\left(\frac{P_t}{P_{t+1}}C_{t+1}^{-\sigma}\right) \tag{4}$$

$$\frac{H_{1,t}^{\eta}}{C_t^{-\sigma}} = \frac{W_{1,t}}{P_t} \tag{5}$$

$$\frac{H_{2,t}^{\eta}}{C_t^{-\sigma}} = \frac{W_{2,t}}{P_t} \tag{6}$$

2.2 Firms

Firms use sector-specific labor with the following linear production functions.

$$Y_{s,t}(i) = A_{s,t}H_{s,t}(i) \tag{7}$$

There are two differences between firms operating in the two sectors. First, productivity is sector-specific, denoted by $A_{s,t}$. Second, firms are exposed to different marginal costs. While sector 1 pays the cost of production before revenue is realized by borrowing, in other words, the firms in sector 1 are subject to the working capital requirements, firms in the second sector pay the cost of input after revenue is generated.

Firms in sector 1 solve the following cost minimization problem.

$$\min_{H_{1,t}} \quad (1-\tau_1)R_t\frac{W_{1,t}H_{1,t}\left(i\right)}{P_t} + \lambda_{1,t}(Y_{1,t}\left(i\right) - A_{1,t}H_{1,t}(i))$$

τ_1 is the fraction of government subsidy to firms for each labor. The firms pay the full operative cost by borrowing, so R_t represents the cost of borrowing in the financial market. The solution to the problem leads to the real marginal costs in equation (8) for firms operating in sector 1.

$$\varphi_{1,t} = MC_{1,t} = (1-\tau_1)\frac{R_tW_{1,t}}{P_tA_{1,t}} \tag{8}$$

Firms in the second sector also solve a similar problem, except they are not exposed to the working capital requirements.

$$\min_{H_{2,t}} \quad (1-\tau_2)\frac{W_{2,t H_{2,t}(i)}}{P_t} + \lambda_{2,t}(Y_{2,t}(i) - A_{2,t}H_{2,t}(i))$$

The problem's solution is the following real marginal cost for firms not subject to the working capital channel.

$$\varphi_{2,t} = MC_{2,t} = (1-\tau_2)\frac{W_{2,t}}{P_t A_{2,t}} \tag{9}$$

Firm i in sector s chooses $P_{s,t}(i)$ to maximize stochastic discounted profit after observing the $MC_{s,t}$ and demand within sector s.

$$\max_{P_{s,t}(i)} \sum_{j=0}^{\infty} \omega^j \Delta_{j,t+j} \left[\frac{P_{s,t}(i)}{P_{t+j}} Y_{s,t+j}(i) - MC_{s,t+j} Y_{s,t+j}(i) \right]$$

s.t.

$$Y_{s,t}(i) = \frac{1}{n_s}\left(\frac{P_{s,t}(i)}{P_{s,t}}\right)^{-\theta} Y_{s,t}$$

A random selection of $(1-\omega)$ firms is permitted to adjust their prices at any time. A fraction of firms (ω) continues to charge set prices (Calvo, 1983). Also, the profit is discounted by a stochastic discount factor $\Delta_{j,t+j}$. The model implies the following SDF.

$$\Delta_{j,t+j} = \beta^j \left(\frac{C_{t+j}}{C_t}\right)^{-\sigma}$$

The first-order condition of the problem gives the optimum reset price for each firm i in sector s.

$$p^*_{s,t} = \left(\frac{\theta}{\theta - 1}\right) \frac{E_t \sum_{j=0}^{\infty} (\beta\omega)^j Y_{t+j}^{-\sigma} P_{s,t+j}^{\ \theta} Y_{s,t+j} MC_{s,t+j}}{E_t \sum_{j=0}^{\infty} (\beta\omega)^j Y_{t+j}^{-\sigma} P_{s,t+j}^{\ \theta} Y_{s,t+j} P_{t+j}^{-1}} \tag{10}$$

2.3 Natural Level of Output

As mentioned in the previous section, the ω fraction of firms has the right to change price, and the price of the other firms becomes constant. Thus, the price in sector s at time t is written as:

$$P_{s,t} = \left[(1-\omega){p^*_{s,t}}^{1-\theta} + \omega {P_{s,t-1}}^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{11}$$

The flexible output is an equilibrium output under prices fully flexible; in other words, the natural output is the output level when ω is equal to 0 in the model. Under this environment, firm optimization problems lead to marginal cost equal to the inverse of the constant markup $\frac{\theta-1}{\theta}$ for both sectors. Using the fact with equations (5) and (6), the flexible output for each industry can be derived respectively for sector 1 and sector 2. The derivation of the natural output level enables us to reach the usual representation of the Euler equation and Philips curve in terms of the output gap. The output gap is the difference between output and the natural level output. x_t and $x_{s,t}$ represent the aggregate and sectoral output gaps.

2.4 Monetary Policy

Monetary authority reacts to any deviation in aggregate inflation by using interest rates to stabilize the economy. The reaction function of monetary policy is written by

$$R_t = (P_t/P_{t-1})^{\phi} exp(v_t)$$

where v_t is the shock to monetary policy following the AR(1) process. The determinacy condition of similar models which contain the cost channel is discussed in previous articles (Ida, 2023). For the sake of simplicity, we do not derive the determinacy condition of the model. The reaction parameter, ϕ, is chosen to be greater than unity for determinacy.

2.5 Market Clearing and Equilibrium Conditions

The equilibrium is defined as the distribution of goods and prices that comply with the monetary policy rule, the market-clearing condition, firms' optimality conditions, households' optimality conditions, and budget constraints (Carvalho et al., 2021).

$$B_{t-1} = 0$$

$$H_{s,t} = \int_{N_s} H_{s,t}(i)^{1-\theta} di \quad \forall s$$

$$\sum_{s=1}^{2} \left(\int_{N_s} Y_{s,t}(i) \right) = \sum_{s=1}^{2} \left(\int_{N_s} C_{s,t}(i) \right) + G_t$$

The first equation is the market clearing condition for the asset market. The second and third one are labor and goods market clearing conditions. Also, the followings are aggregate equality constraints for wage and labor.

$$W_t = n_1 W_{1,t} + n_2 W_{2,t}$$

$$H_t = H_{1,t} + H_{2,t}$$

2.6 Log-Linearized Model

We solve the model by log-linearizing the equilibrium condition around a deterministic zero inflation steady state. Hat notation represents the deviation from the steady state.

Equation (12) is the usual IS equation in the traditional new Keynesian model which comes from the linearization of Euler. The demand function of sector s gives us the relationship between sector s goods and aggregate demand; hence we reach the sectoral output gap equation by linearizing the demand equation for sector s. The transition of aggregate demand into sectoral goods is written in equations 13 and 14. The price ratio $P_{2,t}$ over $P_{1,t}$ is denoted by p_t. The last two equations demonstrate how comparatively high prices in the sector result in relatively low demand for the corresponding goods, meaning household replaces expensive goods with reasonably priced ones.

$$\hat{x}_t = E_t\{\hat{x}_{t+1}\} - \frac{1}{\sigma}(\hat{R}_t - E_t\{\hat{\pi}_{t+1}\}) \tag{12}$$

$$\hat{x}_{1,t} = \varphi n_2 \hat{p} + \hat{x} \tag{13}$$

$$\hat{x}_{2,t} = -\varphi n_1 \hat{p} + \hat{x} \tag{14}$$

The linearized version of the optimum price equation (10-11) gives each sector's Philips curve. Woodford (2003) and Erten (2019) describe a detailed derivation of Philips equations for the two-sector new Keynesian model. In contrast to those, the model implies a different marginal cost, which contains the working capital channel for sector 1. By using these insights, I derive the below inflation dynamics for each sector.

$$\pi_{1,t} = \beta E_t\{\pi_{1,t+1}\} + \kappa(\sigma + \eta)\hat{x}_t + \kappa\hat{R}_t + \kappa n_2(1 + \eta\varphi)\hat{p}_t \tag{15}$$

$$\pi_{2,t} = \beta E_t\{\pi_{2,t+1}\} + \kappa(\sigma + \eta)\hat{x}_t - \kappa n_1(1 + \eta\varphi)\hat{p}_t \tag{16}$$

The algebraic operation on aggregate price using price ratio between sectors leads to following the law of motion of the price ratio (Woodford, 2003). Additionally, the aggregate inflation will be the weighted average of sectoral inflation due to the aggregate price index.

$$\hat{p}_t = \hat{p}_{t-1} + \pi_{2,t} - \pi_{1,t} \tag{17}$$

$$\pi_t = n_1\pi_{1,t} + n_2\pi_{2,t} \tag{18}$$

Lastly, the linearization of the monetary policy rule closes the model with the AR(1) process of the monetary policy shock v_t in equations (19) and (20).

$$\hat{R}_t = \phi\pi_t + v_t \tag{19}$$

$$v_t = \rho v_{t-1} + \epsilon_t \tag{20}$$

CHAPTER 3

THE RESULTS

3.1 Calibration

In this section, I examine the response of variables to a monetary policy shock. I initially set the model parameters with zero steady-state conditions for the impulse response analysis. The parameters are based on existing literature for the standard new Keynesian model (Ida, 2023). The small changes in the parameters' values do not impact the main conclusion of the thesis. The persistence parameter for the monetary policy shock ρ is chosen transitory to make the variation between sectors since the persistent monetary policy shock eliminates the working capital channel influences on the model, which is beyond the scope of the thesis.

Table 1: Parameters of the Model

Parameter	Calibrated Value	Description
β	0.99	household's discount factor
σ	1	risk aversion coefficient
η	1	inverse Frisch elasticity of labor supply
ω	0.75	price stickiness
κ	(1-ω)$(1-\beta\omega)/\omega$	parameter in Philips curve
ρ	0.2	persistence of monetary policy shock
φ	2	elasticity of substitution between sectors' goods
ϕ	1.2	coefficient of inflation in monetary policy rule

Besides the parameters in Table 1, n_1 is left to be set, which is the sector size of sector 1. In Chapter 3.2, I choose to set an equal sector size for both sectors to investigate the transmission of monetary policy in the model. The analysis will cover both aggregate and sector-level variables, discussing their respective impulse responses to a monetary policy shock.

In chapter 3.3, I put different values for the sector size to robust the understanding of the monetary policy transmission mechanism under the asymmetric working capital in the economy. When n_1 equals 0, the model converges to a standard new Keynesian model. Also, we will see the largest impact of the working capital channel when all firms have working capital requirement with $n_1 = 1$. We draw the impulse of variables to a monetary policy shock for the different values of $n_1 \in [0, 1]$ to understand the effects of the composition of firms in terms of the working capital requirements on the economy.

I present the impulse response of variables to a contractionary monetary policy shock for different values of discount factor (β). $1/\beta$ is the steady state value of the interest rate in the model. Variation in β implies how the level of steady-state interest rate impacts on the model dynamics. I question whether the higher steady-state interest rate enlarges the inflation between sectors since the interest rate is part of the cost of production in sector 1. The impulse response analysis in Chapter 3.4 enables us to investigate how variables in the model behave in different steady-state interest rates.

I will examine the mechanism of monetary policy shock on the economy in Chapter 3.2. In addition, I will present the impulse response of variables to a monetary policy shock for different sector sizes in Chapter 3.3. Finally, I will draw the variables' impulse responses for different discount factor values in Chapter 3.4.

3.2 Impulse Responses to a Monetary Policy Shock

Given the parameters in Table 1 with equal sector size, Figure 1 shows the impulse of variables to a contractionary monetary policy shock. The shock is applied to the exogenous part of the interest rate rule, and the magnitude of the shock is ten basis points. There are three driving forces on the economy under the monetary policy shock.

First, as standard theory explains, the rise of interest rates affects the saving decision of the household via the Euler equation. The lower demand transmits a negative output gap via equation 12. Then, the Philips curves imply lower inflation for both sectors because of the decrease in the output gap. In both sectors, the channel operates similarly and to the same degree. The demand side channel under the contractionary monetary policy shock works in the direction of reducing inflation and output gap.

The second channel is the working capital channel, in which the tightening of monetary policy leads to a higher cost of production in the first sector, which is subject to the working capital requirements. Firms in sector 1 have to borrow to finance production and the higher interest rate increase cost of production for those firms. Hence, the inflation dynamic of sector 1 in equation 15 implies that a higher interest rate positively impacts inflation in sector 1. The channel is asymmetric between sectors since there is no working capital requirement for the firms in the second sector.

The working capital channel leads to a relatively higher inflation rate in the first sector, and the channel mitigates the effects of contractionary policy on inflation. The cost channel does not directly influence the model's aggregate output gap. The channel initially impacts first sector inflation; then, the expected aggregate inflation is affected by the first sectors' inflation. In the end, the aggregate inflation plays a role in output gap dynamics with IS curve.

The different inflation dynamics between sectors introduce a third way to transmit monetary policy. Due to the working capital channel, the contractionary monetary policy causes greater inflation to come about instantly in sector 1. The relatively high inflation in sector 1 leads to lower demand for the firms' goods because household substitutes high price goods with lower ones. Variation of $\hat{p}_t$ in the model reveals the transmission. The asymmetric effect of monetary shock leads to negative $\hat{p}_t$, which implies price development towards the advantage of firms in the second sector. While the decline in $\hat{p}_t$ in Philips curves has an inflationary effect on the second sector, its impact is deflationary on the first sector.

Furthermore, this mechanism leads to an amplification of the output gap disparities between sectors. Equations 13 and 14 explicitly demonstrate that the divergence in the output gaps of sectors is primarily attributable to the changes in $\hat{p}_t$. The negative $\hat{p}_t$ drives a relatively lower output gap in sector 1, so the firms with working capital requirements suffer more from tightening monetary policy. The substitution channel mitigates the effects of the working capital channel on the economy. The substitution channel prevents large differences in inflation and then the output gap between the sectors.

Figure 1 clearly illustrates the outcomes of the three channels for monetary policy transmission. First, the demand-side channel decreases both sectors' inflation and output gap. The initial decrease in inflation in sector 1 implies demand-side channel is dominant to the working capital channel under the calibration. The working capital channel leads to higher inflation in the first sector than in the second sector. While inflation is -1.5% in sector 1, it is -2% in the other because of the contractionary monetary policy at time 1. The inflation difference between sectors constitutes the substitution channel in the two-sector model.

The negative $\hat{p}_t$ alleviate the difference in inflation and leads to various output gap between sectors. As was expected, the output gap is small between sectors since the three-channel work against each other and prevent large inflation differences. In addition, the influence of the demand-side channel on the aggregate output gap is notably more dominant than that of the substitution channel on output gaps. Despite the small difference, the negative $\hat{p}_t$ makes a lower output gap in the first sector relative to the second one until the model reaches the steady state. The strength of substitution could be seen in the variation of inflation between sectors. Despite the working capital channel's initial inflationary effect in sector 1, a quarter later, inflation in the second sector is higher than in the first sector.

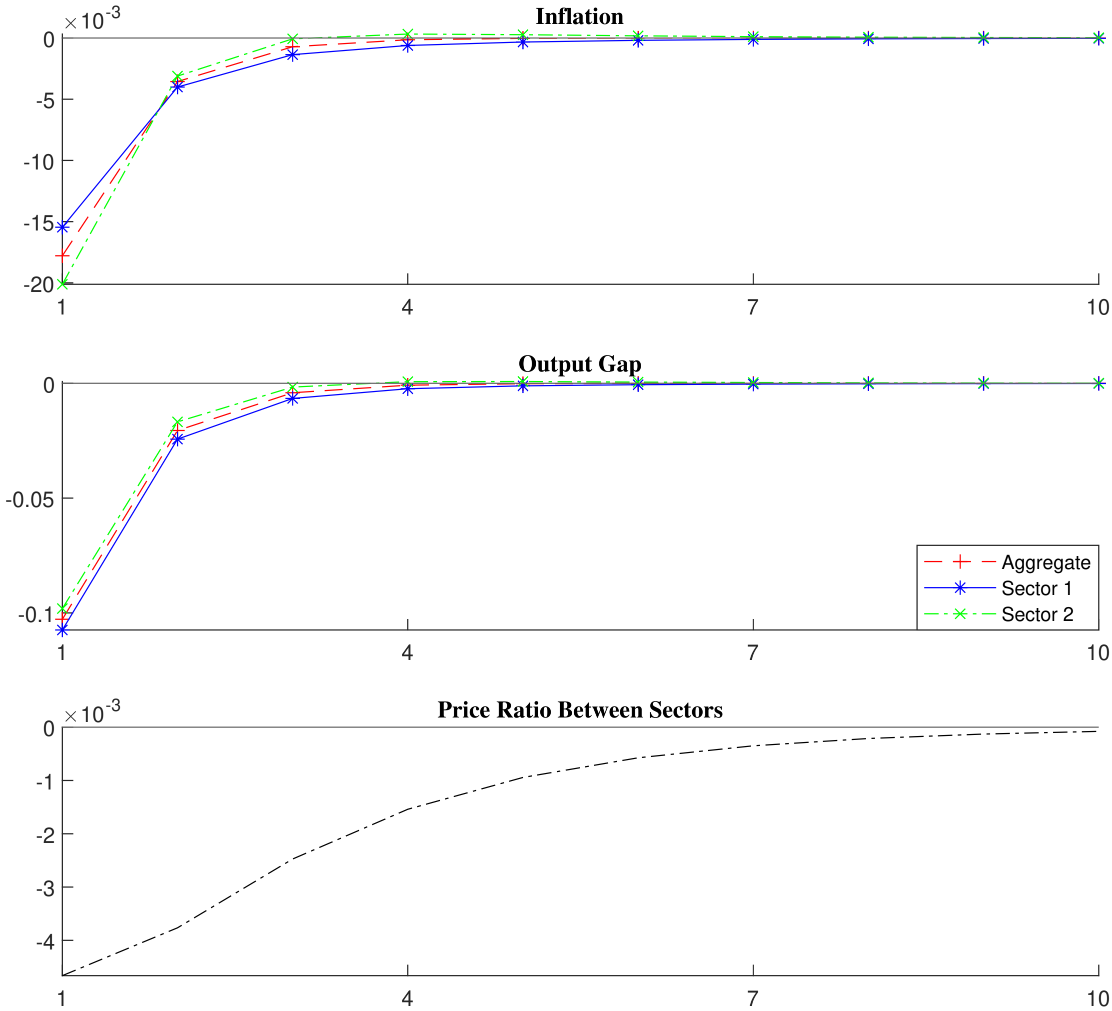

Figure 1: Responses to a Contractionary Monetary Policy Shock

The impulse of variables to the contractionary monetary policy shock in Figure 1 describes the effects of adding asymmetric working capital channel into the two-sector new Keynesian model. The transmission of monetary policy under the model is complicated relative to the textbook new Keynesian model and worth noting for policymakers due to several reasons.

In economies where firms need working capital, monetary policy may not be as effective on inflation as expected. Also, firms operating with the working capital requirements encounter higher demand shock in the model due to tightening monetary policy, so the output gap may shrink more than expected.

In addition to the contributions of the working capital channel to the standard new Keynesian model, the typical calibration employed in the literature does not generate the neo-Fisher effect or substantial fluctuations in inflation and the output gap (Ali & Qureshi, 2022). The two-sector model, closer to the real world than one sector, prevents such effects under the monetary policy shock due to the substitution channel. In other words, the working capital channel advances our understanding of how monetary policy is transmitted throughout the economy, whereas the model also highlights the continuing dominance of traditional channels for monetary policy.

In the following section, I examine the effect of sectoral composition on the economy. It increases our perception of the working capital channel's effectiveness for monetary policy transmission.

3.3 Impulse Responses to a Monetary Policy Shock for Different Sector Size

I draw the impulse of variables to the contractionary monetary policy shock for the model with various values for the $n_1 \in [0, 1]$. The relationship between variables and sector size is monotone for all values of n_1, so Figure 2 only depicts the impulse responses for the $n_1 \in \{0, 0.3, 0.7, 1\}$. Figure 2 focuses on the relationship between sector size and aggregate inflation as well as the output gap.

We see the two extremes in Figure 2. $n_1 = 1$ implies all firms in the economy are subject to the working capital requirements, and the dynamics of model becomes the same with Ravenna and Walsh (2006). The other extreme is $n_1 = 0$, which makes the model the standard three-equation new Keynesian model. As mentioned above, the impulse of variables to the tightening monetary policy shock will be within two extremes. Furthermore, Figure 2 features the impulse responses for two additional sector sizes, specifically 0.3 and 0.7. These values indicate that 30% and 70% of the economy, respectively, are subject to the working capital requirements within the model.

The initial impact of the contractionary monetary policy shock on aggregate inflation in the standard three-equation new Keynesian model leads to a decrease in inflation to -2.1%. However, when all firms in the economy are subject to the working capital requirements, tightening monetary policy reduces inflation to -1.4%. In the case of the two-sector model with other values of n_1, where the monetary policy transmission incorporates the substitution channel alongside the working capital channel, the initial impact on aggregate inflation is -1.6% when 30% of the economy is subject to the working capital requirements. For $n_1 = 0.7$, the immediate impact lowers inflation to -1.9%.

In addition to inflation, we observe a widening aggregate output gap as n_1 increases. Although the variation in the output gap is small for different values of the n_1, the monetary authority encounters relatively high inflation and lower output gap response to interest rate hikes in the presence of a working capital channel. The outcome is the worst case for the monetary policy, making the working capital channel important to study. Monetary authorities need to identify the size of the economy vulnerable to working capital requirements before a monetary policy decision.

Moreover, the findings are robust for monetary policy transmission under the presence of asymmetric working capital channel described in Chapter 3.2. The working capital channel extenuates monetary policy's effectiveness on inflation and lowers the output gap for the economy. In addition, firms needing working capital are more adversely affected in a possible contractionary monetary policy shock, so the working capital channel in the two-sector model introduces a distributional role in the economy for the monetary policy.

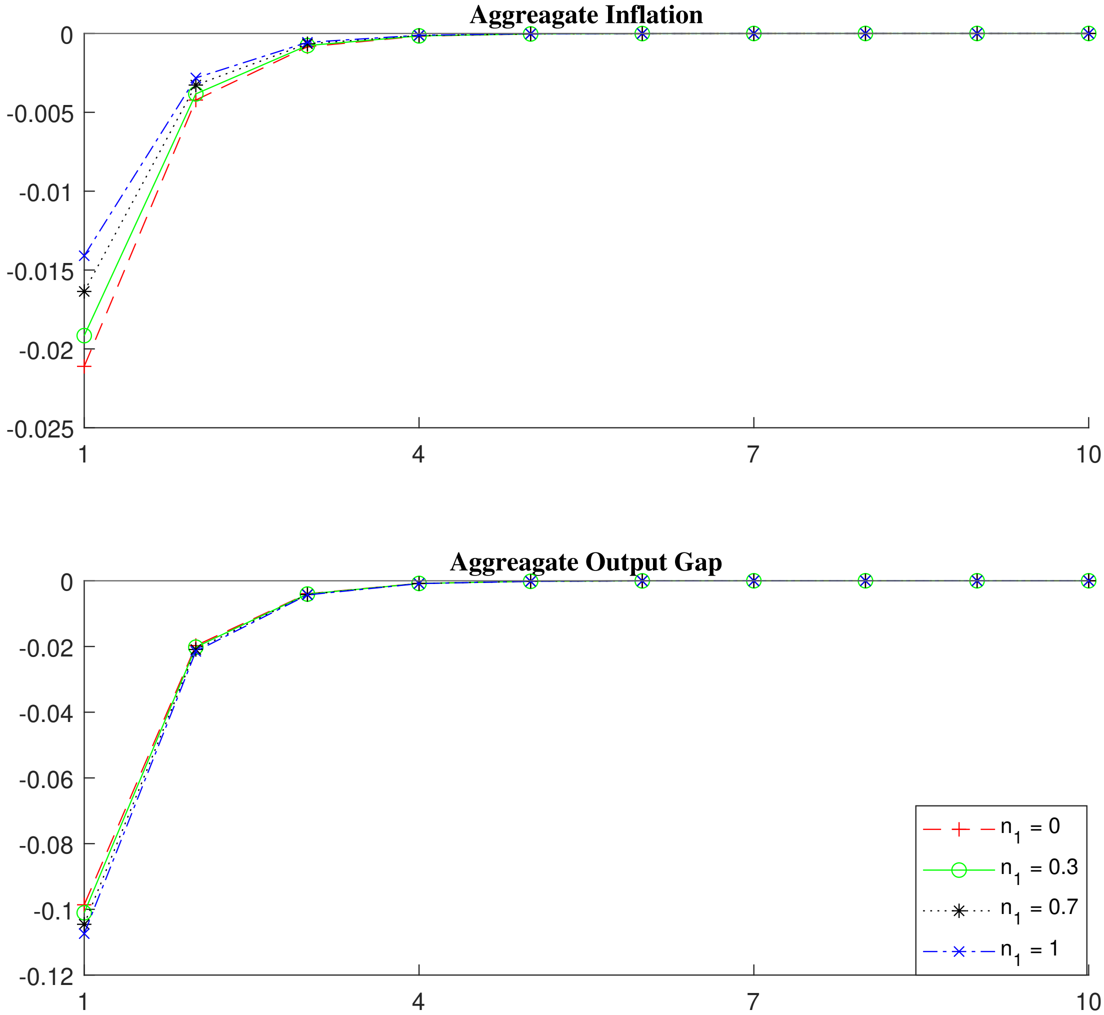

Figure 2: Responses to a Contractionary Monetary Policy Shock for Different Sector Size

3.4 Impulse Responses to a Monetary Policy Shock for Different Values of Discount Factor Paramater

Figure 5 indicates the impulse response of all variables to the contractionary monetary policy shock for $\beta \in \{0.75, 0.9, 0.99\}$. The model's other parameters are the same as in Table 1, and the sector size is equal. Although the value of 0.75 is not realistic for the model, $1/\beta$ implies the steady-state interest rate, which comes from the Euler equation. I aim to examine the effects of various steady-state interest rate values on the model. The different values of the steady-state interest rate have the potential to cause variation between sectors since firms differ in terms of the interest rate being part of the marginal cost.

The lower discount factor amplifies the effectiveness of monetary policy on inflation within the model. An unexpected ten basis point interest rate hike leads to an initial decline in aggregate inflation to -2.5% in the model with $\beta = 0.75$, whereas in the base model with β equal to 0.99, aggregate inflation decreases to -1.7%. The impact on sectoral inflations follows a similar pattern. Sectoral inflations in the model exhibit a more pronounced response to the monetary policy shock when the steady-state interest rate is high. However, the change in the discount factor has a negligible effect on both the aggregate and sectoral output gaps.

To examine the distributional effect of monetary policy shock at different steady-state interest rate levels, the impulse response of the price ratio between sectors ($\hat{p}$) to the monetary policy shock is presented. $\hat{p}$ experiences a greater decline in the model with higher steady-state interest rates, indicating a larger inflation difference between sectors compared to the base model. The presence of the working capital channel in the model contributes to the divergence of inflation between sectors. As the discount factor β decreases, the coefficient κ in the Philips equation of sector 1 increases, specifically in front of R_t. This leads to a strengthening of the working capital channel relative to the base model. Consequently, the combined effects of the three monetary policy transmission channels ultimately amplify the inflation differences between sectors for the lower discount factor.

Furthermore, a higher steady-state interest rate intensifies the adverse impact of tightening monetary policy on firms in sector 1. As previously discussed in Chapter 3.2, the variation in the output gaps between sectors in the model is primarily influenced by the price difference between sectors. Therefore, the higher price ratio between sectors results in greater disparities in the output gaps between them.

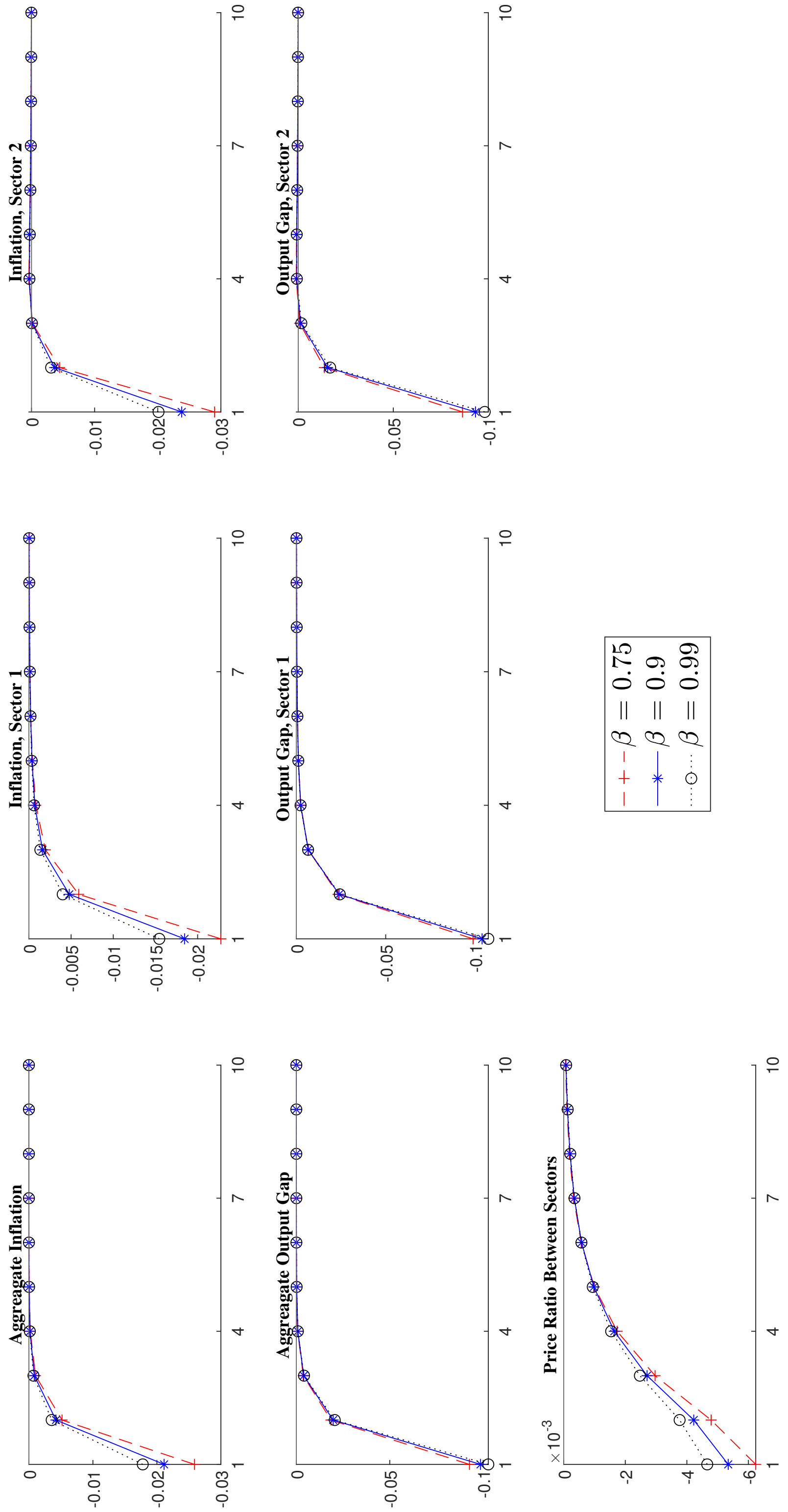

Figure 3: Responses to a Contractionary Monetary Policy Shock for Different Values of Discount Factor

CHAPTER 4

CONCLUSION

This study examines monetary policy transmission in the two-sector new Keynesian model with the asymmetric working capital channel by following Woodford (2003), and Ravenna and Walsh (2006). In addition to the demand-side channel of monetary policy, two sector frameworks with the working capital introduce two more channels for the transmission of monetary policy: the working capital and substitution channels.

The paper finds that the working capital channel decreases the effectiveness of the monetary policy on inflation and strengthens the impacts of monetary policy on the output gap. Besides the aggregate effect, while the substitution channel acts against the firms that need working capital in the tightening monetary policy, it operates in favor of the firms during the expansionary monetary policy. Hence, measuring the working capital channel in the economy is crucial for monetary policy decisions. Otherwise, the monetary authority encounters difficulties in determining the correct interest rate to stabilize inflation and ignores the distributional effects of the monetary policy.

The study has some limitations and identifies promising areas for future research. The model's labor side is silent regarding mobility and stickiness. Labor is immobile between sectors, and incorporating labor mobility into the model could enhance the robustness of my study. Additionally, the labor market has no frictions in the model. The model could be expanded by introducing wage stickiness or matching frictions in the labor market. Furthermore, the production side of the model has room for improvement. Currently, the firms do not include capital in their production function. Moreover, the firms with working capital requirements do not face financial frictions when borrowing. Further studies could enhance the model by incorporating capital into the framework and developing the financial market, thus aligning it more closely with real-world dynamics.

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