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Abstract

Essays On Monetary Policy Transmission

by

Mario R. González

In this dissertation, I contribute to the study of how monetary policy shocks are transmitted through the economy. I contribute to this literature by analyzing how different economic structures can alter the transmission of monetary policy shocks, both at an international level, by considering its regional impact, and at a domestic level, by discussing the implications of different levels of financial constraints and by studying how local financial markets react to monetary policy announcements.

At the international level, the empirical literature has found that banks, through their complex interconnections, play an important role in the transmission of monetary policy decision in the countries they serve. It has also been found that international banks activate a cross-border internal capital market to accommodate for monetary shocks. In order to assess these findings from a theoretical point of view, in the first essay, I develop a novel regional open economy dynamic stochastic general equilibrium model by combining different aspects of a two-country type model and a small open economy type model. The results are consistent with those of the empirical literature; when banks with international presence are able to activate an internal capital market, the effects of monetary policy on the domestic economy are subdued. This also leads
banks with international presence to transmit monetary policy shocks to other countries where the bank has offices.

At the domestic level, in the second essay I present a medium scale DSGE framework to analyze the effects of monetary policy shocks on the domestic economy. The novel feature of the model is that analyze these effects in the contest of two separate group of firms. The first group of firms finance their operation by selling bonds directly to households. The second group of firms obtain loans from financial institutions and face financial constraints. The results of the model show that financially constrained firms present a subdued response to monetary policy shocks, while unconstrained firms present a stronger response. The results show that models without any financial constraint exhibit a stronger response to monetary policy shocks. In that sense the model implies that monetary policy officials may need to make stronger moves of the monetary policy rate in an economy where financial development is lower and firms face stronger financial constraints.

In the third essay, cowritten with Raul Tadle, we study how the Chilean stock market is affected by monetary policy announcements made by the Central Bank of Chile. We do this by studying the information contained in the monetary policy press releases. Using Automated Content Analysis we built an index, the Sentiment Score that tracks the verbal signals indicating future likely monetary policy decisions. The results show that the Sentiment Score leads changes in the monetary policy rate. We then evaluate how the surprise component of the sentiment score impact Chilean financial assets. We find that from the beginning of the sample to August 2008, the stock markets
seems to react to surprises in the monetary policy rate, but surprises in the sentiment component are not significant. On the other hand, after August 2008 to the end of the sample, we find that surprises in the monetary policy rate are not relevant for the stock market, but surprises in the sentiment component show significant effects on the stock market.
To my kids, Antonia and Gabriel, and my wife, Macarena,

For their endless love, smiles, support and encouragement.
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Chapter 1

Introduction

In this dissertation I contribute to the study of how monetary policy shocks are transmitted through the economy. A thorough understanding of this transmission is crucial for having an effective macroeconomic policy. In spite of the fact that this is one of the most studied topics in macroeconomics, a complete understanding of the mechanisms and channels that take part in the transmission process is still elusive.

The literature on monetary policy transmission can be separated into two broad branches. The first branch studies how monetary policy shocks are transmitted at an international level, in which the structure of financial markets play a crucial role. The second branch of this literature studies how monetary policy shocks are transmitted at a local level. I contribute to this literature by analyzing how different economic structures can alter the transmission of monetary policy shocks, both at an international level, by considering its regional impact, and at a domestic level, by discussing the implications of different levels of financial constraints and by studying how local financial markets
react to monetary policy announcements.

At the international level, the latest financial crisis demonstrated there are crucial and not well-understood linkages in the global financial markets. The empirical literature has found that banks, through their complex interconnections, play an important role in the propagation of shocks from one country to another. Furthermore, these linkages are believed to have important consequences in the transmission of monetary policy in the countries they serve. It has also been found that international banks activate a cross-border internal capital market to accommodate for monetary shocks, which in turn diminishes the effectiveness of monetary policy and transmits those policy decisions to other countries where the bank has a presence.

In order to assess these findings from a theoretical point of view, in the first essay, I develop a novel regional open economy dynamic stochastic general equilibrium model by combining different aspects of a two-country type model and a small open economy type model. A region in this model consists of several small open countries, where actions in one country can affect other countries in the region, but are not able to affect countries located outside of it, i.e. the rest of the world. The results are consistent with results in the empirical literature; when banks with international presence are able to activate an internal capital market, the effects of monetary policy on the domestic economy are subdued. This also leads banks with international presence to transmit monetary policy shocks to other countries where the bank has offices. However, a relevant international propagation mechanism is activated only when a regional bank is combined with financial frictions.
At the domestic level, in the second essay, I present a medium scale DSGE framework to analyze the effects of monetary policy shocks on the domestic economy. The novel feature of the model is that I drop the representative firm assumption by including two distinct groups of firms with different financing structures while keeping the model tractable. The first group of firms, referred to as Unconstrained firms, finance their operation by selling bonds directly to households. The second group of firms obtain loans from financial institutions and face financial constraints. I refer the latter group as Constrained firms.

The results of the model show that firms with different access to financing will respond differently to monetary policy shocks. In particular, financially constrained firms present a subdued response to monetary policy shocks, while unconstrained firms present a stronger response. This is due to the fact that in the presence of a monetary shock and assuming the collateral constraint is binding, the ability of constrained firms to obtain more loans is limited, dampening the effect of monetary policy on the economy. The paper also assesses the effects of varying the level of financial constraints in a model. The results show that models without any financial constraint exhibit a stronger response to monetary policy shocks. In that sense the model implies that monetary policy officials may need to make stronger moves of the monetary policy rate in an economy where financial development is lower and firms face stronger financial constraints.

In the third essay, cowritten with Raul Tadle, we study how the Chilean stock market is affected by monetary policy announcements made by the Central Bank of Chile. For the US there are several studies that cover this area of research, however,
for emerging markets the number of studies is scarce.

In their monthly monetary policy meetings, the Central Bank of Chile decides the monetary policy rate and circulates a press release that effectively explains their decision. The information contained in those monthly documents include policy decisions for the current month, the central bank’s economic outlook, and signals about likely future central bank policy decisions.

We, therefore, examine these monetary policy decisions and the corresponding additional information from the press releases. Using Automated Content Analysis, we identify qualitative information from the statement releases of the Central Bank of Chile and create a quantitative measure for the verbal signals indicate likely future monetary policy decisions. This quantitative measure, which we call sentiment score - proxies for the monetary policy tilt implicit in the policy documents.

We find that the sentiment score leads changes in the monetary policy rate and that when the sentiment does not show relevant movements, there are no changes in the monetary policy rate. We then evaluate how the surprise component of the sentiment score – together with unexpected interest rate changes - impact Chilean financial assets. We find that from the beginning of the sample to August 2008, the stock markets seems to react to surprises in the monetary policy rate, while surprises in the sentiment component are not significant. On the other hand, after August 2008 to the end of the sample, we find that surprises in the monetary policy rate are not relevant for the stock market, while surprises in the sentiment component show significant effects on the stock market.
Chapter 2

International Banking and Monetary Policy in a Small Economy: A Regional Approach

2.1 Introduction

Banks have come a long way from their origins as grain lenders to farmers and traders. They have evolved from standalone institutions to big and complex conglomerates with branches and subsidiaries distributed over several countries. As the latest financial crisis demonstrated, there are crucial and not well-understood linkages in the global financial markets. Nevertheless, the empirical literature has found that the ever more complex interconnectedness among banks has led them to play an important role in the propagation of shocks from one country to another. Furthermore, these linkages are believed to have important consequences for the transmission of monetary policy
in the countries they serve. This paper increase our understanding in both of these
issues by developing a novel general equilibrium model by combining different aspects
of a two-country type model and a small open economy type model to create a region
within an open economy model. A region in this model consists of several small open
countries, where actions in one country can affect other countries in the region, but are
not able to affect countries located outside of it.

The empirical literature on banking explains that global banks transmit shocks
from one country to another by activating an internal capital market. According to
de Haas and van Lelyveld [2010] in an internal capital market parent banks allocate
scarce capital to their subsidiaries. Although earlier papers recognized the fact that
multinational banks were able to transmit home country financial shocks, Peek and
Rosengren [1997], Peek and Rosengren [2000b] and dampen host country shocks, Peek
and Rosengren [2000a], these papers did not explain a formal mechanism for the effects
found and limited themselves to measure the transmission.

The study of internal capital markets in banking at the international level does
not appear to have started until after the 2008 financial crisis. Cetorelli and Goldberg
[2008], de Haas and van Lelyveld [2010], Cetorelli and Goldberg [2010], among others,
show that large globally-oriented banks actively relocate funds of their subsidiaries in
response to changes in domestic liquidity conditions. Cetorelli and Goldberg [2012] also
found that banks with international operations can activate an internal cross-border
internal capital market allowing them to relocate on the basis of relative needs. This,
in turn, leads them to conclude that banks with global operations are able to insulate
themselves from changes in monetary policy, while domestic banks seem to be more affected by monetary policy than previously found.

In order to understand how the presence of banks with international operations affect the propagation of monetary shocks, I present two versions of a quantitative business cycle model with two different banking structures. In the first, a regional bank has subsidiaries in two small countries, and attempts to allocate its resources between them. In the second structure, each country is served by a different foreign bank and can only move resources between the country where it operates and the rest of the world without being able to operate in the other small country. Both regional and foreign banks face operational costs of moving resources from one country to another. Note that this model does not try to explain the international structure of the parent banks that owns subsidiaries in different countries, rather its objective is to understand the consequences of these different structures. If interested into why banks follow a specific international structure refer to Niepmann [2015] and McCauley et al. [2010].

Standard international models are presented in either a two-country world, in the style of Backus et al. [1992] where actions in one country have repercussions in the other country, or in small open economy mold, in the style of Gali and Monacelli [2005] where the actions of one country do not affect the rest of the world. However, several empirical papers have shown that countries are either not big enough to affect the rest of the world, nor small enough for their actions to be completely unnoticed by other countries. For the Asian crisis in 1997, Wade [1998] explained that a wave of financial crises or financial instability was precipitated in Southeast Asia after the devaluation of
the Thai Baht in July 1997. Similarly, Kaminsky and Reinhart [2001] recalled the fact that the Mexican peso crisis in late 1994 had a “tequila effect” on Argentina and other Latin American Countries without affecting the rest of the world. In order to capture this stylized fact, I diverge from the standard models by presenting a regional open economy model, where actions in one country can affect other countries in the region, but these are not able to affect countries located outside of it.

The setup of a regional model also makes sense when analyzing the events that took place in the Asia-Pacific region after the 2008 financial crisis. Remolona and Shim [2015] highlight that during the financial boom of 2001-2007 most cross-border activity took the form of a flow of dollars from the United States to Europe and then to the Asian-Pacific region. With coming of the financial crisis, European banks held back, and banks within the Asian-Pacific region stepped in and soon they came to dominate cross-border activity, so that the bulk of intermediation is now conducted within the region.

To the best of my knowledge, only a handful of papers construct general equilibrium models to look at the role of banks in an international context. Ueda [2010] construct a two-country DSGE to study the latest financial crisis and its effects that propagated immediately due to the globalization of banking. The model includes financial constraints for both the financial intermediaries as well as entrepreneurs. The authors find that under banking globalization adverse shocks that hit one country affect the other and leads to the synchronization of their business cycles on the real and financial sides. Kollmann et al. [2011] use a two-country DSGE model to explore the
consequences of a global banking system. The authors find that bank capital constraints do not have much impact in the transmission of productivity shocks and that when a country is hit by a loan default shock of the size seen in the US during the latest financial crisis the model predicts a global recession. Finally, Dedola and Lombardo [2012] show in a quantitative model that combining financial integration together with financial frictions can be a powerful source of propagation of shocks by synchronizing borrowing costs and spreads across countries. The model that I am presenting, in comparison, makes use of a regional open economy with little ties in the real market to assess the effects of a monetary policy shock in the context of a regional or foreign bank. By cutting the ties in the trade sector the only way to transmit shocks is through their financial connectedness.

The paper is structured in the following way. Section 2.2 presents the model with its two variants, a regional banking sector, Section 2.2.3.1 and a foreign banking sector, Section 2.2.3.2. The following section presents the results of a monetary policy shock in both versions of the model. This section also introduces financial frictions in a very simple way and compare the results with the original version of the model. Finally, Section 2.4 concludes.

2.2 The Regional Model

The model takes as a starting point the model presented in papers such as Gali and Monacelli [2005], Christiano et al. [2010a], and Christiano et al. [2011], and
is expanded to create a regional model. The world is populated by a region, which is formed by two small open economies, and the rest of the world, which is considered big relative to the region and the small countries. It follows the spirit of a small open economy model in which the actions taken by agents in the small country cannot affect the rest of the world, however, their actions can have consequences in other countries of the region where they are located.

As traditional small open economy models, the small countries are populated by households, who buy goods, save in the form of bank deposits and provide labor, and firms that hire labor to produce differentiated goods. In addition, the economy is populated by banks that link savings between households and firms and provide working capital loans to firms. In addition, they bring resources from the rest of the world to increase working capital loans. Finally, the central bank uses monetary policy to stabilize inflation by following a simple Taylor rule.

The model is used to study how monetary policy shocks in one country are transmitted to the rest of the region solely through the financial channel. Although this notion seems counter intuitive, there are several papers that show that small economies do little bilateral trade within the countries in their region. In Kaminsky and Reinhart [2001] authors show that this is the case among emerging Asian economies. Along the same lines, Michaely [1996] finds that the share of any single Latin American country in the trade of another country within the region is always low. Only Brazil and Mexico show any significant importance in the trade of any other country within the region. He finds that trading shares above 5 percent are not common. These weak links are not
able to explain how the crisis spread from Thailand to Indonesia and Philippines. Furthermore, the authors support the idea of a model with only-financial-linkages, because they believe that the behavior of foreign banks appeared to have played a role in the propagation of the crisis.

2.2.1 Households

Households buy final goods, provide labor to firms, save by holding bank deposits and consume a basket of goods of the form,

\[ C_{i,t} = \left[ (1 - \gamma)^{1/a} \left( C^h_{i,t} \right)^{(a-1)/a} + (\gamma)^{1/a} \left( C^f_{i,t} \right)^{(a-1)/a} \right]^{a/(a-1)} \]  

(2.1)

where \( C_{i,t} \) is the total consumption basket for time \( t \) in country \( i \), \( C^h_{i,t} \) is the consumption basket of home produced goods in country \( i \), \( C^f_{i,t} \) is the consumption basket of foreign produced goods in country \( i \) and \( a \) is the elasticity of substitution between different country goods in consumption. As \( a \) goes to infinity both goods become perfect substitutes, and as \( a \) goes to zero there is no substitution possible. The coefficient \( \gamma \) measures the weight of the foreign goods in the consumption basket and can be interpreted as a measure of openness of the country. Following the findings of papers such as Kaminsky and Reinhart [2001] and Michaely [1996], it is assumed that trading within region is negligible, so there is no distinction of goods produced within the region from goods produced in the rest of the world. Households in country \( i \) minimize the cost of the consumption bundle, \( P^h_{i,t} C^h_{i,t} + P^f_{i,t} C^f_{i,t} \), subject to the consumption basket, \( C_{i,t} \), by
solving

\[
\min_{C^h_{i,t}, C^f_{i,t}} P^h_{i,t} C^h_{i,t} + P^f_{i,t} C^f_{i,t} \text{ subject to }
\]

\[
C_{i,t} = \left[ (1 - \gamma)^{1/\alpha} \left( C^h_{i,t} \right)^{(a-1)/\alpha} + (\gamma)^{1/\alpha} \left( C^f_{i,t} \right)^{(a-1)/\alpha} \right]^{\alpha/(a-1)}.
\]

The first order conditions can be written as

\[
C^h_{i,t} = (1 - \gamma) \left( \frac{P^h_{i,t}}{P^c_{i,t}} \right)^{-a} C_{i,t}
\]

(2.2)

\[
C^f_{i,t} = \gamma \left( \frac{P^f_{i,t}}{P^c_{i,t}} \right)^{-a} C_{i,t}
\]

(2.3)

\[
P^c_{i,t} = \left[ (1 - \gamma) \left( P^h_{i,t} \right)^{(a-1)/\alpha} + \gamma \left( P^f_{i,t} \right)^{(a-1)/\alpha} \right]^{\alpha/(a-1)}
\]

(2.4)

where, \(P^f_{i,t}\) is the price index of imported goods, \(P^h_{i,t}\) is the price index of domestic goods and \(P^c_{i,t}\) is the aggregate price index, or CPI, for country \(i\). Households minimize the cost of the basket of goods of their home country, \(P^h_{i,t} C^h_{i,t}\) subject to the consumption of the whole basket of goods \(C^h_{i,t} = \int_0^1 C^h_{i,t}(j)^{\frac{\theta-1}{\theta}} dj\) \(\frac{\theta}{\theta-1}\). The first order conditions for this optimization problem are given by \(C^h_{i,t} = \left( \frac{P^h_{i,t}(j)}{P^c_{i,t}(j)} \right)^{-\theta} C^h_{i,t}\), which states that the consumption of an individual good depends on its price relative to the home price index. Then \(P^h_{i,t} = \left[ \int_0^1 \left( P^h_{i,t}(j) \right)^{\frac{1-\theta}{\theta}} dj \right]^{\frac{1}{1-\theta}}\), where \(P^h_{i,t}\) is the price index of domestic produced goods.

I assume that household utility depends on its consumption of the composite good and on its labor supply, based on

\[
U(C_{i,t}, H_{i,t}) = \frac{C_{i,t}^{1-\sigma}}{1-\sigma} - \chi \frac{H_{i,t}^{1+\eta}}{1+\eta}
\]

(2.5)

where \(\sigma\) is the inter-temporal elasticity of substitution parameter, \(\eta\) is the inverse of
labor price elasticity and \( \chi \) is constrained to be positive. Households enter period \( t \) with money balances, \( M_t \), and receive wage payments, \( W_{i,t}H_{i,t} \), at the beginning of the period, which are allocated to purchase consumption goods and to save in the form of bank deposit. Then households face a cash in advance (CIA) constraint of the form

\[
P^c_{i,t}C_{i,t} + D_{i,t} = M_{i,t} + W_{i,t}H_{i,t}
\]  

(2.6)

Later in the period they receive profits from firms and principal plus interest payments on the bank deposits they took at the beginning of the period. Taking all into account the households maximize (2.5) subject to the CIA constraint (2.6) and the budget constraint of the form

\[
P^c_{i,t}C_{i,t} + D_{i,t} + M_{i,t+1} = W_{i,t}H_{i,t} + (1 + r_{i,t}^D)D_{i,t} + M_{i,t} + \Pi^f_{i,t}
\]  

(2.7)

The first order conditions for the household problem come from solving the Lagrangian\(^1\)

\[
L = \max_{C_{i,t};H_{i,t};} \sum_{k=0}^{\infty} \beta^k E \left[ \frac{C^1_{i,t+k} - \sigma}{1 - \sigma} - \frac{H^{1+\eta}_{i,t+k}}{1 + \eta} + \lambda_{i,t+k} \left( (1 + r_{i,t+k}^D) d_{i,t+k} + w_{i,t+k}H_{i,t+k} + m_{i,t} + \frac{\Pi^f_{i,t+k}}{P^c_{i,t+k}} - C_{i,t+k} - d_{i,t+k} - (1 + \pi^c_{i,t+1}) m_{i,t+1} \right) \right]
\]

which are of the form

\[
C^{-\sigma}_{i,t} = \beta E \frac{1 + r_{i,t}^D}{1 + \pi^c_{i,t+1}} C^{-\sigma}_{i,t+1}
\]  

(2.8)

\[
\frac{H^q_{i,t}}{C^{-\sigma}_{i,t}} = w_{i,t}
\]  

(2.9)

Assuming that the law of one price holds then \( P^f_{i,t} = S_{i,t}P_t^* \) where \( S_{i,t} \) is the bilateral exchange rate at period \( t \) between the domestic country currency and the rest

\(^1\)Monetary variables in small letters denote that they have been deflated by the CPI.
of the world currency. As is usual in this literature the terms of trade are defined as
the relative price of foreign and domestic goods

\[\Delta_t = \frac{P_{f,t}}{P_{h,t}} = \frac{S_{i,t} P^*_t}{P_{h,t}} \quad (2.10)\]

and the real exchange rate is the price of foreign goods relative to home country con-
sumer price index

\[Q_{i,t} = \frac{S_{i,t} P^*_t}{P_t} \quad (2.11)\]

2.2.2 Firms

Firms produce differentiated goods using only labor as their production input
using a production technology as

\[Y_{i,t}^h (j) = z_{i,t} H_{i,t} (j) \quad (2.12)\]

, where \(z_{i,t}\) is country specific productivity shock and \(H_{i,t} (j)\) is the amount of labor
hired by firm \(j\). Wage payments take place at the beginning of the period while revenues
from saleS are received at the end of the period, this discrepancy in timing creates the
necessity for firms to obtain bank loans, hence, at the beginning of the period each firm
needs to obtain loans \(L_{i,t} (j) = W_{i,t} H_{i,t} (j)\). These loans are paid at the end of the
period when firms receive the proceeds from their sales. Also it is assumed that firms
face a Calvo style price setting where each period there is a fixed probability \((1 - \omega)\)
that the firm can adjust its price in order to maximize its expected discounted value
of dividends. Each period there are two types of firms: (1) firms that changed prices
last period and (2) firms that did not change prices last period. All firms that changed
price in period $t$ choose the same optimal price, $P_{i,t}^{h_s}$, because they all face the same technology. So at time $t$ the average price is given by

$$P_{i,t}^{1-\theta} = \int_{0}^{1} P_{j,i,t}^{1-\theta} dj$$

$$P_{i,t}^{1-\theta} = \omega \left( P_{1,t}^{h,t} \right)^{1-\theta} + (1 - \omega) \left( P_{i,t}^{h_s} \right)^{1-\theta}.$$  \hfill (2.13)

Firms in country $i$ maximize profits $P_{i,j,t} - (1 + r_t) W_{i,t} H_{i,t} (j)$ subject to the demand curve $Y_{i,t} (j) = \left( \frac{P_{i,t}^{h_s(j)}}{P_{i,t}^{h,t}} \right)^{-\theta} Y_{i,t}^{h}$ and the production function (2.12). From this problem it is found that the real marginal cost is

$$mc_{i,t} = \frac{(1 + r_t^i) W_{i,t}/P_{1,t}^{h,t}}{z_{i,t}}$$  \hfill (2.14)

and firm set prices such as

$$0 = \mathbb{E}_t \sum_{i=0}^{\infty} \Psi_{t,i,j+1}\omega^j \left[ (1 - \theta) \left( P_{k,t}^{s} \right)^{-\theta} \left( \frac{1}{P_{k,t+1}} \right)^{1-\theta} C_{k,t+i} ight]$$

$$+ \theta mc_{k,t+i} \left( P_{k,t}^{s} \right)^{-1-\theta} \left( \frac{1}{P_{k,t+i+1}} \right)^{-\theta} C_{k,t+i}$$

and after some algebraic manipulation it can be expressed as

$$\frac{P_{s,k,t}^{s}}{P_{k,t}} = \frac{\theta}{\theta - 1} \frac{\mathbb{E}_t \sum_{i=0}^{\infty} \Psi_{t,i,j+1}\omega^j mc_{t+i} \left( P_{k,t+i+1}^{s} / P_{k,t} \right)^{\theta} C_{h,t+i}}{\mathbb{E}_t \sum_{i=0}^{\infty} \Psi_{t,i,j+1}\omega^j \left( P_{k,t+i+1} / P_{k,t} \right)^{\theta-1} C_{h,t+i}}.$$  \hfill (2.15)

By defining two new variables $F_t$ and $G_t$ as

$$F_t = \mathbb{E}_t \sum_{i=0}^{\infty} \Psi_{t,i,j+1}\omega^j mc_{t+i} \left( P_{k,t+i+1} / P_{k,t} \right)^{\theta} C_{h,t+i}$$

$$G_t = \mathbb{E}_t \sum_{i=0}^{\infty} \Psi_{t,i,j+1}\omega^j \left( P_{k,t+i+1} / P_{k,t} \right)^{\theta-1} C_{h,t+i}$$

condition (2.15) can be restated in a recursive way as

$$\frac{P_{s,k,t}^{s}}{P_{k,t}} = \frac{\theta}{\theta - 1} \frac{F_t}{G_t} = \frac{\theta}{\theta - 1} \frac{C_{k,t+1}^{1-\sigma} mc_{k,t} + \beta \omega \mathbb{E}_t F_{t+1}}{C_{k,t+1}^{1-\sigma} + \beta \omega \mathbb{E}_t G_{t+1}}$$  \hfill (2.16)
2.2.3 Banks

As was previously stated, the empirical literature finds that international banks in a country will not only increase the transmission of international shocks, but they can also affect how the economy will react to domestic shocks and how these are transmitted to other countries. To explore this claim two versions of the model are presented, in which the only difference is the structure of the international bank. In the first version, a regional bank is the parent company of small bank branches located in the individual countries. This parent bank obtain funds from the rest of the world and distributes them between the banks within the region. Branches in the small countries use these resources together with local deposits to provide working capital loans to firms. Regional banks are able to activate an internal capital market to allocate its resources more efficiently. The fact that the parent bank is owned by households outside the small countries explains why households in the small countries do not receive profits from banks. A detailed description of this structure is presented in Section 2.2.3.1.

In the second version of the model each foreign bank has branches in only one of the countries. This condition inhibits it from distributing international loans to other countries within the region. Foreign banks obtain resources from the rest of the world and, together with local deposits, provides working capital loans to firms. A detailed description of this structure is presented in Section 2.2.3.2

The results are consistent with the results of the empirical literature, when banks with international presence are able to activate an internal capital market the
effects of monetary policy on the economy are subdued. This also leads to banks with international presence to be able to transmit monetary policy shocks to other countries where the regional bank has offices.

2.2.3.1 Regional Bank: International banks with presence in multiple countries

In this setting the international bank is the holding company of smaller banks located in countries 1 and 2. The local banks in these countries are subsidiaries\(^2\) of the foreign bank and provide loans only to firms located in their individual countries. These branches obtain resources by collecting deposits from households in their own countries and by receiving transfers from the parent bank. The parent bank obtains foreign loans, \(I_t\), denominated in the world currency, and transfers a percentage \(\phi_t\) of these resources to Country 1 and the rest \((1 - \phi_t)\) to Country 2. Using these loans, branches are able to charge an interest rate of \(r^f_{i,t}\) for loans made in country \(i\) in the period \(t\).

In order to carry out their business, the parent bank incurs in several costs. First it must pay an interest \(r^D_{i,t}\) for the deposits collected in country \(i\) and an interest \(r^I_t\) for the international interbank loans. Following Schmitt-Grohe and Uribe [2003] I assume an international debt elastic interest rate in the form of

\[
1 + r^I_t = (1 + r^w) \left( 1 + \psi^I \left( \frac{I_t}{\bar{I}} - 1 \right) \right)
\]  

where \(\bar{I}\) is an exogenous steady state level of international loans and \(r^w\) is an exoge-

\(^2\)In the context of this paper I am going to use the terms subsidiary and foreign branch as interchangeable. The difference between the two, although important, is not the focus of research in this paper.
nous world interest rate. In addition, the global bank incurs a cost of distributing the resources obtained from international lenders between its offices which is of the form

$$f(\phi_t) = \frac{\psi_1}{2} (\phi_t I_t - \bar{\phi} \bar{I})^2 + \frac{\psi_2}{2} ((1 - \phi_t) I_t - (1 - \bar{\phi}) \bar{I})^2$$  \hspace{1cm} (2.18)

This reduced form cost reflects the assumption that it is costly to move funds from one country to another. This cost is not only related to regulations that banks must comply with, but also to the operational cost of transferring the funds from one place to another. Financial institutions rely on complex IT systems for transferring funds. These systems can be internally developed or can be off-the-shelf transfer systems. Depending on the needs of the institutions these systems can be as small as one terminal located in their main office with no full time staff dedicated to these operations, or as large as having a separate funds transfer department with dedicated staff. In addition, financial institutions must pay a fee to the payment system. The functional form presented here is not intended to provide an exact replication of reality, but rather to incorporate the fact that these international transfers are costly.

In this version all the decisions are made at the parent bank level, taking into account the regulation in the individual countries. Banks must be fully established in the individual countries which means that loans made by the domestic banks must be financed either by deposits, $D_{i,t}$, transfers from the central bank, $X_{i,t}$, or transfers from the parent company, $S_{i,t}I_{i,t}$. This restriction implies that for any country $i$ at time $t$ the balance sheet identity

$$L_{it} = D_{it} + S_{i,t}I_{it} + X_{i,t}$$  \hspace{1cm} (2.19)

\footnote{In the US these systems interface with Fedwire Funds Service or CHIPS payments}
must hold, where $I_{1,t} = \phi_t I_t$, $I_{2,t} = (1 - \phi_t) I_t$, $S_{i,t}$ is the bilateral exchange rate between the domestic currency and the Rest of the World currency and $X_{i,t} = M_{i,t+1} - M_{i,t}$.

Then global bank maximizes their profits given by

$$
\Pi^b_{t+1} = \left(1 + r^D_{1,t}\right) \frac{L_{1t}}{S_{1,t+1}} + \left(1 + r^D_{2,t}\right) \frac{L_{2t}}{S_{2,t+1}} - \left(1 + r^D_{1,t}\right) \frac{D_{1t}}{S_{1,t+1}} - \left(1 + r^D_{2,t}\right) \frac{D_{2t}}{S_{2,t+1}} - \left(1 + r^I_{1,t}\right) I_t \bar{I}_1 - \frac{\psi^b_1}{2} (I_{1,t} - \bar{I}_1)^2 - \frac{\psi^b_2}{2} (I_{2,t} - \bar{I}_2)^2
$$

subject to (2.17) and (2.19). First order conditions of this problem are given by

$$
\begin{align*}
r^I_{1,t} &= r^D_{1,t} \\
r^I_{2,t} &= r^D_{2,t}
\end{align*}
$$

$$
\begin{align*}
\mathbb{E}_t \left(1 + r^D_{2,t}\right) \left(\frac{S_{2,t}}{S_{2,t+1}}\right) + \psi^b_1 (I_{1,t} - \bar{I}_1) &= \mathbb{E}_t \left(1 + r^D_{1,t}\right) \left(\frac{S_{1,t}}{S_{1,t+1}}\right) + \psi^b_2 (I_{2,t} - \bar{I}_2)
\end{align*}
$$

$$
\begin{align*}
\mathbb{E}_t \left[\phi_t \left(1 + r^D_{1,t}\right) \left(\frac{S_{1,t}}{S_{1,t+1}}\right) + (1 - \phi_t) \left(1 + r^D_{2,t}\right) \left(\frac{S_{2,t}}{S_{2,t+1}}\right) - \psi^b_1 \phi_t (I_{1,t} - \bar{I}_1) - \psi^b_2 (1 - \phi_t) (I_{2,t} - \bar{I}_2)\right] &= (1 + r^w) \left(1 + \psi^I \left(\frac{1}{\bar{b}} - 1\right) + \psi^I \left(\frac{1}{\bar{b}}\right)\right)
\end{align*}
$$

Conditions (2.21) and (2.22) state that the interest rate of loans charged in either country will equal the interest rate they have to pay for the deposits they receive. This means that banks are going to demand funds until the marginal profit equal zero. The first order conditions also imply that the regional bank will distribute funds so that the deposit interest rate paid in each country, accounting for expected changes in the nominal exchange rate and for distributing costs, are equalized, condition (2.23). Finally, condition (2.24) states that the weighted average interest rate paid by domestic banks, accounting for expected depreciation and transfer costs, will equalize the interest
rate that the regional bank has to pay to international lenders. Note that this condition differs slightly from the one in Schmitt-Grohe and Uribe [2003], because in that paper the authors assume that each individual household is small enough that it can borrow everything it needs from the rest of the world without affecting the domestic level of international borrowing. This leads to the result that in steady state the interest rate premium is nil. In the model presented in this paper there are only two countries, each of them can generate alter the equilibrium and affect the dynamics of the region. Then in the steady state the domestic interest rate is given by

\[(1 + r^D_1) = (1 + r^D_2) = (1 + r^w) (1 + \psi^I),\]

where the interest rate premium is greater than zero.

It is important to note that in this model each agent faces a slightly different interest rate on which to base its decisions. Households base their consumption and savings decisions on the real interest rate given by

\[rr^{d}_{i,t} = \frac{1 + r^d_{i,t}}{1 + \pi^{c}_{i,t+1}},\]

while foreign banks, interested in profits in the foreign currency, base their decisions of how much to borrow from international lenders and how to allocate these resources on the exchange rate adjusted interest rate,

\[rs^{d}_{i,t} = \left(1 + r^D_{i,t}\right) \left(\frac{S_{i,t}}{S_{i,t+1}}\right).\]

### 2.2.3.2 Foreign Bank: International banks with presence in individual countries

In this version of the model the are two independent foreign banks, each of which has offices in only one of the countries; therefore, the foreign banks are only able to provide loans to firms located in a single country. Foreign banks obtain resources from household deposits located in the country where the bank has offices and from
taking loans from the rest of the world. Foreign banks face the same type of costs that regional banks face. First, they pay an interest $r_{i,t}^D$ for the deposits collected in country $i$ and an interest $r_{i,t}^I$ for the international loans. Following Schmitt-Grohe and Uribe [2003], I assume an international debt elastic interest rate in the form of

$$1 + r_{i,t}^I = (1 + r_w) \left(1 + \psi_i^I \left(\frac{I_{i,t}}{I_i} - 1\right)\right)$$  \hspace{1cm} (2.25)

where $\bar{I}$ is an exogenous steady state level of international loans and $r^w$ is an exogenous world interest rate. In addition, international banks incur in a cost of distributing the resources obtained from international lenders between its offices. Such cost is of the form

$$f(I_{i,t}) = \frac{\psi_i^h}{2} (I_{i,t} - \bar{I}_i)^2$$  \hspace{1cm} (2.26)

Banks must be fully established in the individual countries which means that loans made by the domestic banks must be financed either by deposits, $D_{i,t}$, transfers from the central bank, $X_{i,t}$, or transfers from the parent company, $S_{i,t}I_{i,t}$, this restriction implies that for any country $i$ at time $t$ the identity

$$L_{it} = D_{it} + S_{i,t}I_{it} + X_{i,t}$$

must hold and where $X_{i,t} = M_{i,t+1} - M_{i,t}$. Then foreign banks maximize their profits given by

$$\Pi_{i,t+1}^b = \left(1 + r_{it}^I\right) \frac{L_{it}}{S_{1,t+1}} - (1 + r_{it}^D) \frac{D_{it}}{S_{1,t+1}} - (1 + r_{it}^I) I_t - \frac{\psi_i^h}{2} (I_{i,t} - \bar{I}_i)^2$$

subject to (2.25) and the balance sheet condition. The first order condition in this
model are given by

\[ r_{i,t}^I = r_{i,t}^D \]  \hfill (2.27)

\[ \mathbb{E}_t (1 + r_{i,t}^D) \left( \frac{S_{i,t}}{S_{i,t+1}} \right) = (1 + r^w) \left( 1 + \psi_I^f \left( \frac{I_{i,t}}{I_i} - 1 \right) + \psi_I^f \left( \frac{I_{i,t}}{I_i} - 1 \right) \right) + \psi^h (I_{i,t} - \bar{I}_i) \]  \hfill (2.28)

As in the case with the regional bank, condition (2.27) states that the interest rate charged by the banks equalizes the interest rate the bank has to pay for deposits. Condition (2.28) states that the interest rate paid for deposits after adjusting for depreciation expectation and transfers costs equalizes the relevant international interest rate. By having offices in only in one of the countries international shocks are transmitted from the rest of the world into individual countries, however, the foreign bank is not able to transmit shocks generated from one country in the region to the others.

### 2.2.4 International Risk Sharing

In this section, starting from previously determined optimality conditions I derive several relations directly and some macroeconomic definitions. The different banking arrangements presented in this paper have important consequences in terms of risk sharing among countries within a region and between those countries and the rest of the world.
2.2.4.1 International Risk Sharing in the Presence of a Regional Bank

From equations (2.23) and (2.24) it can be seen that the relationship between the interest rate of deposits in Country $i$ and the rest of the world is given by

$$1 + r_{i,t}^D = E_t \left[ (1 + r^w) \left( 1 + \psi^I \left( \frac{I_i}{I} - 1 \right) + \psi^J \left( \frac{I_i}{I} \right) \right) + \psi^b (I_{i,t} - I_i) \right] \left( \frac{S_{i,t+1}}{S_{i,t}} \right)$$

(2.29)

According to (2.29) the interest rate differential between Country $i$ and the rest of the world depends on the depreciation expectations, the resources borrowed by the regional bank, and how much of those resources were sent to Country $i$. More specifically, if there is an increase in resources borrowed by the bank or in the resources sent to Country $i$ there will be an increase in the interest rate of deposits in that country. Along the same lines, an increase in the depreciation expectations will also increase the interest rate in Country $i$. Finally, an increase in the interest rate sensitivity parameter $\psi^I$ or in the transfer cost parameter $\psi^b$ will also lead to an increase in the interest rate in Country $i$.

Just as households in each individual country of the region, households in the rest of the world consume according to their Euler equation, which in this case is of the form

$$(C^*_t)^{-\sigma} = \beta E_t \frac{1 + r^w_t}{1 + \pi_{t+1}^*} (C^*_t)^{-\sigma}$$

(2.30)

Combining equations (2.8), (2.29) and (2.30) together with the real exchange rate definition, (2.11), leads to the relation between consumption levels at Country $i$ and the
rest of the world in terms of real exchange rates and financial costs,

\[
\left( \frac{C_{i,t}}{C_{i,t+1}} \right)^{-\sigma} = \mathbb{E}_t \left\{ \frac{(1 + r^w) \left[ 1 + \psi^I \left( \frac{I_t}{I} - 1 \right) + \psi^J \left( I_{1,t} - I_1 \right) + \psi^b \left( I_{1,t} - I_1 \right) - \left( Q_{i,t+1} - Q_{t+1} \right) \right]}{1 + r^w} \right\} \left( \frac{Q_{i,t+1}}{Q_{i,t}} \right) \left( \frac{C_{i,t+1}^*}{C_{i,t+1}} \right)^{-\sigma}
\]

Equation (2.31) states that there are several factors that play a role in the difference between changes in consumption of Country \( i \) and that of the rest of the world. First, an increase in the sensitivity of the interest rate to changes in foreign lending widens the gap between consumption changes. Similarly, this effect is also reached by increases in the cost of moving funds across countries and by changing the funds borrowed by the regional bank and sent to Country \( i \). Therefore, in order to increase the co-movement between consumption is necessary to decrease the cost of transferring funds or to decrease the sensitivity of the interest rate to changes in internationally borrowed funds.

On the other hand, risk sharing can also be analyzed within a region. Combining two versions of equation (2.8), one for each country, and equation (2.29) and leads to condition (2.32), which is analogous to (2.31),

\[
\left( \frac{C_{1,t}}{C_{1,t+1}} \right)^{-\sigma} = \mathbb{E}_t \left\{ \frac{(1 + r^w) \left[ 1 + \psi^I \left( \frac{I_t}{I} - 1 \right) + \psi^J \left( I_{1,t} - I_1 \right) + \psi^b \left( I_{1,t} - I_1 \right) - \left( Q_{1,t+1} - Q_{1,t} \right) \right]}{1 + r^w} \right\} \left( \frac{Q_{1,t+1}}{Q_{1,t}} \right) \left( \frac{C_{2,t}}{C_{2,t+1}} \right)^{-\sigma}
\]

According to this condition, only the cost of moving funds across countries and the differential in the resources sent to each country will widen the gap in the change in consumption in between Country 1 and Country 2. It is worth noticing that risk sharing is stronger between countries within a region than between individual countries and the rest of the world. This occurs in spite of the fact that there is no trade in goods between countries of a region. Notice that in absence of transaction costs, conditions (2.31) and
(2.32) reduce to the standard expression where there is perfect risk sharing.

### 2.2.4.2 International Risk Sharing in the Presence of a Foreign Bank

Combining equations (2.8), (2.28) and (2.30) together with the real exchange definition, (2.11), leads to the relation between consumption levels at Country \( i \) and the rest of the world in terms of real exchange rates and financial costs,

\[
\left( \frac{C_{i,t}}{C_{i,t+1}} \right)^{-\sigma} = \mathbb{E}_t \left\{ \frac{(1 + r^w) \left[ 1 + \psi_i \left( \frac{I_{i,t}}{I_i} - 1 \right) + \psi_i \left( \frac{I_{i,t}}{I_i} - \bar{I}_i \right) \right]}{1 + r^w} \right\} \left( \frac{Q_{i,t+1}}{Q_{i,t}} \right) \left( \frac{C_i^*}{C_{i,t+1}} \right)^{-\sigma} \tag{2.33}
\]

Analogous to equation (2.31), condition (2.33) states that an increase in the sensitivity of the interest rate to changes in foreign lending, or in the cost of moving funds across countries, or in the amount of the funds borrowed by the foreign bank and sent to country \( i \) widens the gap between consumption changes. Now when comparing the risk sharing that takes place between both countries of the region, then the condition changes to

\[
\left( \frac{C_{1,t}}{C_{1,t+1}} \right)^{-\sigma} = \mathbb{E}_t \left\{ \frac{(1 + r^w) \left[ 1 + \psi_1 \left( \frac{I_{1,t}}{I_1} - 1 \right) + \psi_1 \left( \frac{I_{1,t}}{I_1} - \bar{I}_1 \right) \right]}{(1 + r^w) \left[ 1 + \psi_2 \left( \frac{I_{2,t}}{I_2} - 1 \right) + \psi_2 \left( \frac{I_{2,t}}{I_2} - \bar{I}_2 \right) \right]} + \psi_2 \left( I_{2,t} - \bar{I}_2 \right) \right\} \left( \frac{Q_{1,t+1}}{Q_{1,t}} \right) \left( \frac{C_{2,t}}{C_{2,t+1}} \right)^{-\sigma} \tag{2.34}
\]

Now, except for the international interest rate, \( r^w \), there are no similar terms in the top and the bottom part of the fraction inside the braces of (2.34). Therefore, any type of increased risk sharing between countries 1 and 2 that took place with the regional bank disappears in the foreign bank version.
2.2.5 Equilibrium

As stated previously, the rest of the world is assumed to be large with respect to countries 1 and 2. It is assumed that international trade takes place; however, households are not concerned with the origin of the goods consumed as long as they can be separated between foreign and domestic. Each firm is able to sell its production either to domestic households or to the rest of the world, then, in order for equilibrium to be obtained, all of the production of each firm must equal its consumption, this means that

\[ Y_{i,t}(j) = C_{i,t}(j) + C^*_{i,t}(j) \] (2.35)

where \( C^*_{i,t}(j) \) is the foreign consumption of goods produced in country \( i = 1, 2 \) by firm \( j \). Using conditions, (2.2) and (2.3) in condition (2.35) and integrating over \( j \) goods the demand for the output of country \( i \) is given by

\[ Y_{i,t} = (1 - \alpha) \left( \frac{P_{i,t}}{P_t} \right)^{-\alpha} C_{i,t} + \alpha \left( \frac{P_{i,t}}{S_{i,t} P_t^*} \right)^{-\alpha} C^*_{i,t} \] (2.36)

where \( C^*_{i,t} \) is the foreign consumption of goods produced in country \( i \), \( C^*_{i,t} = \int_0^1 C^*_{i,t}(j) \, dj \).

2.2.6 Central Banks

The policy regime used in both versions of the model is a standard Taylor rule, (2.37), which is a classic way to characterize monetary policy. According to the Taylor rule, the monetary authority in country \( i \) adjusts the nominal interest rate, \( r_{i,t}^D \), in response to deviations of CPI inflation, \( \pi_{i,t}^c \), from its steady state value. The reaction of monetary policy to changes in inflation is measured by the parameter \( \zeta_\pi \), which is
assumed to be greater than 1, the parameter $\zeta_g$ measures the reaction of monetary policy to changes in growth and $u_{i,t}$ denotes exogenous monetary policy shocks.

$$1 + r^{D}_{i,t} = \frac{1}{\beta} (1 + \pi^*_t)^{\zeta_r} \left( \frac{Y_{i,t}}{Y_{i,t-1}} \right)^{\zeta_g} (1 + u_{i,t})$$ (2.37)

It is assumed that monetary policy shocks follow the process

$$u_{i,t} = \rho_u u_{i,t-1} + \varepsilon_{i,t}$$

2.2.7 Calibration

The parameters used in both versions of the model for households and firms are either within the range of the ones used in the New Keynesian literature or set to obtain reasonable values for some key steady-state ratios, see Table 2.1. As with the rest of the model, the countries are kept symmetrical, both are the same size with same parameter values and the same steady state. This is done in order to better understand the effects of monetary policy shocks in the presence of international banks in both countries, having different sized countries or different parameters would alter the results and the implications of this financial structure.

The discount rate of households in both countries, $\beta_i$, is set equal to 0.99 with this value, the annual interest rate of deposits is set to 4%. The parameter that measures the (inverse of) intertemporal elasticity of substitution, $\sigma$, is set to 1. The value of $\chi_i$ is chosen to ensure that in the steady state households allocation time to work is close to 0.34; this yields $\chi_i = 7$. The parameter $\eta_i$ is assumed to be equal to 27.
Table 2.1: Parameters Calibration: Households and Firms

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_1$</td>
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<td>$\beta_2$</td>
<td>0.99</td>
</tr>
<tr>
<td>$\sigma_1$</td>
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<td>$\sigma_2$</td>
<td>1</td>
</tr>
<tr>
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<td>$\chi_2$</td>
<td>7</td>
</tr>
<tr>
<td>$\eta_1$</td>
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<td>$\eta_2$</td>
<td>1</td>
</tr>
<tr>
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<td>$\theta_2$</td>
<td>6</td>
</tr>
<tr>
<td>$\omega_1$</td>
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<td>$\omega_2$</td>
<td>0.75</td>
</tr>
<tr>
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<td>$\gamma_2$</td>
<td>0.4</td>
</tr>
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<td>2</td>
<td>$\alpha_2$</td>
<td>2</td>
</tr>
<tr>
<td>$\rho_{u1}$</td>
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<td>$\rho_{u2}$</td>
<td>0.9</td>
</tr>
<tr>
<td>$\rho_{z1}$</td>
<td>0.9</td>
<td>$\rho_{z2}$</td>
<td>0.9</td>
</tr>
<tr>
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<td>$\phi_{\pi2}$</td>
<td>1.5</td>
</tr>
<tr>
<td>$\sigma_{u1}$</td>
<td>0.0025</td>
<td>$\sigma_{u2}$</td>
<td>0.0025</td>
</tr>
</tbody>
</table>

1, which implies that the utility is quadratic in leisure, and a labor supply elasticity of 1. The parameter that measures the elasticity of substitution among goods of an individual country, $\theta_i$, is set to 6 with the objective to obtain a markup of 1.2, while goods from different origin have an elasticity of substitution of 2. The Calvo parameter, $\omega_i$, is set to 0.75, so that the expected time between price adjustments is one year. The value of $\gamma_i$ which measures the openness of the economy is set to 0.4. The value of the sensitivity of monetary policy to changes in inflation is set to 1.5, the size of the monetary policy shock is set to 0.0025, to account for surprise changes of 25 basis points and the autocorrelation coefficient of monetary policy shocks is set to 0.5.

On the other hand, the parameters used in the banking sector are not readily available in the literature, so the calibration is set according to information available from different sources, see Table 2.2. For the parameter that measures the elasticity of the interest rate to changes in the level of international loans, $\psi^I$, the parameter is
set to 0.001 which is in line with the values used in Garcia-Cicco et al. [2010], Chang and Fernandez [2013] and de Groot et al. [2016], giving a much higher elasticity to changes in the level of foreign loans than the one used in Schmitt-Grohe and Uribe [2003]. The parameter that measures the cost transferring funds between countries is calibrated according to the worldwide average price of remittances published in the report “Remittance Prices Worldwide”, The World Bank [2016]. This report monitors the cost of sending money across all regions of the world. The report shows that the cost for sending remittances has decreased to 7.42 percent, showing a continuous decrease from the 9.67 percent level of 2009. Is important to note that this is the cost that consumers face when sending remittance and is not the actual cost for the financial institution, but it serves as an upper bound to these type of costs. Taking this information into account the parameter $\psi_b$ is set to 0.05, lower than the cost to the public.

Finally, for the steady state level of international loans I follow a different approach by studying three different scenarios. The alternative scenarios come from divergent business approaches from different banking systems, which, in turn, have important effects on the type of banking structures. McCauley et al. [2010] show that there are still two markedly different types of banking structures. In the first one, followed mainly by Japanese and German banks, deposits are taken in the home office and are later distributed among their branches in emerging markets to provide loans in these jurisdictions. In this type of structure international loans are an important source of funding for the subsidiary banks. On the other hand, in the structure followed
Table 2.2: Parameters Calibration: Banks

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\psi_f$</td>
<td>0.001</td>
<td>Elasticity of foreign interest rate to increases in foreign loans</td>
</tr>
<tr>
<td>$\psi_b$</td>
<td>0.05</td>
<td>Cost of sending money abroad</td>
</tr>
<tr>
<td>$I$</td>
<td>0.185</td>
<td>Steady state level of international loans, regional bank version</td>
</tr>
<tr>
<td>$I_1$, $I_2$</td>
<td>0.0925</td>
<td>Steady state level of international loans, foreign bank version</td>
</tr>
</tbody>
</table>

by Spanish banks, subsidiaries are mainly financed by local deposits and international loans are a less relevant source of financing. I compare the consequences of these two different financing structures for the transmission of monetary policy shocks. In the baseline scenario I assume an intermediate structure where working capital loans are equally financed by deposits and international loans. In the Japanese/German bank type structure I assume working capital loans are financed in 85 percent by international loans. On the other hand, in the Spanish bank type structure I assume working capital loans are financed in 15 percent by international loans.

### 2.3 Results

In this section I study the dynamics of the model using impulse responses. I focus on a contractionary monetary policy shock in Country 1 that increases the real interest rate paid to deposits. As mentioned earlier, I study two versions of the same model to compare the results of the model with a regional bank, that creates a financial link among the countries of a region, with that of a foreign bank, that only has offices in one country and does not create a financial link among countries of a region.

In the second part of the analysis I present an extension where a reduced form
of financial frictions is introduced. Following Garcia-Cicco et al. [2010] I assume that increases in foreign debt lead to a rise in the interest rate because of a higher default probability. In the third part of this section, I present some sensitivity analysis in which I change the steady state level of foreign loans to analyze the effects of changing the financing structure of regional banks in the local economy.

2.3.1 Monetary Policy Shock

The transmission of a monetary policy shock within countries of a region is studied by analyzing the model impulse responses to an unanticipated 25 basis points increase in the deposit rate, which in this case is the policy rate. The transmission mechanism of monetary policy shocks in this model takes place through changes in the real interest rate, changes in depreciation expectations of the nominal exchange rate, the cost channel and the arbitrage condition of the relevant interest rate for banks in an open economy environment. The effects of a monetary policy shock in Country 1 for the baseline model can be seen in figures 2.1 and 2.2. Note that a positive realization of $u_{1,t}$ in (2.37) should be interpreted as a contractionary monetary policy shock, which leads to an increase in nominal interest rate given inflation and the output gap.

Note that contrary to what is usually found in the literature, a positive realization of $u_{1,t}$ leads to an unambiguous decrease in the nominal rate. This is due to the fact that an increase in the real interest rate, together with a fall in output, leads to a decline in the amount of loans demanded from firms. This decrease in loans is distributed between a fall in deposits and international loans. Noting that the total
reaction of deposits is the sum of two opposing forces: a fall in deposit demand from banks, and an increase in supply from households who wish to increase savings, the bulk of the adjustment of bank liabilities comes from the fact that it reduces the amount of international loans, which by conditions (2.24) and (2.28) leads to a reduction in the nominal interest rate.

Figure 2.1: Effects of Monetary Policy Shock: Financial Variables

The short run positive co-movement between nominal interest rate and infla-
tion after a nominal shock is identified in the literature as Neo-Fisherianism. As is
described by Garin et al. [2016], this phenomenon is explained by the forward looking
nature of the model. Therefore, to alter the response of nominal interest rate after a
monetary policy shock requires adding a number of backward looking elements into the
model, such as habit formation, sticky information, adaptive expectations or “rule of
thumb” price setters, among other options. These options were discarded in order to
keep the model simple.

In terms of real variables, as expected, a monetary policy contraction leads to
an initial decrease in output, consumption, labor, wages, deposits and loans in Country
1, in both versions of the model and the effect of the shock has mostly disappeared after
40 quarters. Overall, the dynamics of the model are in line to the responses documented
in the literature, with the exception of the humps shown in output, hours and inflation.
These humps in the model are attributed to the Neo-Fisherianism present in the model,
to the Calvo pricing setting and, in a smaller part, to the financial cost of borrowing
money abroad and distributing in countries within the region.

Figure 2.1 and Figure 2.2 are also used to compare both versions of the model.
Figure 2.1 shows that the decrease in foreign loans in the Regional Bank version of
the model is slightly stronger than the decrease in Foreign Bank version of the model.
This difference is compensated by having a stronger increase in deposits in the Regional
Bank version of the model. Taking both effects into account, there is no difference in
the loans given to firms in Country 1 in both versions of the model. On other hand,
note that although there is a reaction in the Country 2 in the Regional Bank version
of the model, the effect is small. Taking all into account, the response in Country 1 in both versions of the model is practically the same in terms of real variables and with the exception of the effect on some financial variables, while the transmission to the rest of the region is limited in the presence of a regional bank and non-existent in the presence of separated foreign banks.

Figure 2.2: Effects of Monetary Policy Shock: Real Variables

![Figure 2.2: Effects of Monetary Policy Shock: Real Variables](source: Author's Calculations)
2.3.2 Monetary Policy Shock with Financial Frictions

During the last years the economic literature has reached a consensus that financial frictions are essential to explain empirical regularities of emerging economies, Neumeyer and Perri [2005] and Garcia-Cicco et al. [2010]. In the model developed in this paper, there are no financial frictions presents except for the debt elastic interest rate which increases when the level of bank foreign debt is higher than its steady state level. However, this feature in the model does not act as a financial friction; rather it is used only to introduce stationarity to an otherwise non-stationary model without affecting its short run dynamics as the smallest parameter possible is used.
A simple way to introduce financial frictions in a small open economy was used in Garcia-Cicco et al. [2010] who increased the value of the parameter that governs the interest rate elasticity to changes in foreign loans. This notion is borrowed from the sovereign debt literature where increases in the foreign debt lead to increases in the interest rate because of an increase in the default probability. The authors used data for Argentina from 1900 to 2005 to estimate a RBC model using bayesian methods and
found that the interest rate is highly sensitive to changes in the foreign debt level. In particular, the posterior median of the interest rate elasticity was estimated to be 2.8, which implied that an increase of the stock of external debt of one percentage point of GDP leads to an increase in the country premium over half a percentage point. Along the same lines, Alvarez-Parra et al. [2013] consider a reduced form of this type of friction where the country spread responds to the output gap.

The version of the model presented in this section is modified from the one in the previous section by following the methodology just described. In particular, I increase the value of the parameter that governs the elasticity of the interest rate, $\psi^I$, from 0.001 to 2.8. In this setting the role of the elasticity parameter is no longer limited to introduce stationarity, but also to serve as a reduced form financial friction.
Introducing financial frictions into the model dramatically changes the dynamics in both versions of the model, figures 2.3 and 2.4. First, the introduction of financial frictions reduces the amount of loans that the global bank obtain from the rest of the world. In the Regional Bank version, although there is some response of international loans, the magnitude of this response has reduced drastically. Similarly, the magnitude
of foreign loans in the Regional Bank version is decreased so as to look as zero when compared to the response of other variables. Another important difference is that, by introducing financial frictions, the regional bank decides to move funds from Country 1 into Country 2. This result would be showing that banks that activate an internal capital market are also financially constrained and the movement of funds from one country to another is possibly cheaper to do internally rather than obtaining external resources.

The presence of financial frictions creates a relevant mechanism for transmitting monetary policy shocks from one country to another. In terms of output, the Regional Bank version of the model shows a stronger impact than the one in the Foreign Bank version. However, this stronger response of output is accompanied by a reduced response in inflation. Finally, notice also that Country 2 also sees a reduction in inflation after a contractionary monetary policy shock.

This results imply that the sole presence of global banks with international subsidiaries is not enough to create a relevant transmission of monetary policy shocks from one country to another. For the activation of the internal capital market is necessary for the bank as a global institution to face some sort of financial constraint, which in this case is in the form a debt elastic interest rate.

2.3.3 External Financing Sensitivity Analysis

In this section I present two sensitivity analyses to understand the effect that changing the sources of financing that the regional bank uses for providing working
capital loans to firms has on the monetary transmission mechanism. I change the value of the steady state value of the international loans in the baseline version, and in the financial frictions version, in order to emulate a Spanish type of banking structure and a Japanese/German type of banking structure. I model a Spanish type of banking structure as having a low percentage of foreign loans, that for this exercise is assumed to be 15%. On the other hand, I model a Japanese/German type structure as having a high percentage of foreign loans, which for this exercise is assumed to be 85%. The aim of this exercise is to assess if the transmission of the monetary policy shock within the region depends on the level of external financing of the countries in the region or if it is unaffected by it.

2.3.3.1 No Financial Frictions

This section presents the sensitivity analysis of the regional bank model version presented in Section 2.3.1. As stated before I will compare the results from this section, where the steady state level of loans are financed by deposits and international loans in equal parts, to a version that emulates the German/Japanese type of bank structure and a Spanish type bank structure. Figure 2.5 shows the effects of changing the steady state level of international loans on the financial variables, while the effects on real variables are shown in figure 2.6.
In terms of financial variables, the results show that for Country 1 the response to the monetary policy shock is the same regardless the source of the funds. In contrast, some differences can be seen on the response of the financial variables of Country 2 when...
the percentage of external finance is from 50 percent to 15 percent. In this case, in the presence of a monetary policy shock in Country 1, the reaction of the real interest rate and the foreign loans is stronger than in the other two cases. Similarly, the nominal exchange rate has a stronger reaction given by the fact the foreign exchange adjusted interest rate has a stronger decrease compared to the other two scenarios. These effects lead to a stronger decrease in the level of deposits taken by households in Country 2.
The difference in the responses of the financial variables in Country 2 to different levels of external financing seems to have a strong effect on real variables. By changing the reaction of financial variables, the real variables in Country 2 almost seem
unaffected by changes in the level of external financing in the presence of monetary policy shocks. On the other hand, the reaction of real variables in Country 1 seems to be unaffected by the level of external financing. An interesting exercise would be to incorporate some sort of financial friction to the banking sector that would allow it to have a variable markup with respect to the monetary policy rate.

Figure 2.7: Sensitivity Analysis of the Regional Bank Model with Financial Frictions: Financial Variables

2.3.3.2 Financial Frictions

This section presents the sensitivity analysis to the regional bank model version presented in Section 2.3.2 in which the regional bank faces financial frictions. As stated
before I compare the results from Section 2.3.2, where the steady state level of loans are financed by deposits and international loans in equal parts, to a version that emulates the German/Japanese type of banking structure and a Spanish type of banking structure. Figure 2.7 shows the effects of changing the steady state level of international loans on the financial variables, while the effects on real variables is shown in figure 2.8.

The results show stark differences with what was presented in the previous section. The introduction of financial frictions dominates the dynamics of the response of the variables to a monetary policy shock and the effect of changing the level of foreign financing is now irrelevant. This result could potentially imply that the structure of the foreign bank is not important to the response of a monetary policy shock in the presence of financial frictions.
The fact that the dynamics of the model are not affected by changing the level of foreign loans in presence of financial frictions helps draw some conclusions regarding the determinants of the dynamics of the model. First, by introducing financial frictions banks would respond the same way regardless their financing sources. Second, in spite of the fact that banks also have to pay for moving resources from one country to another, the response of the bank is unaffected. I also did some simulation exercises that altered the level of the parameter that measures the cost of moving funds from one country to another and the responses of the variables in the model were only mildly affected after
the level of the parameter $\psi^b_i$ was unreasonable high. This assuming that the level of
the parameter $\psi^b_i$ is related to the worldwide average price of remittances.

2.4 Conclusion

In this paper I present two versions of a novel regional open economy dynamic
stochastic general equilibrium model with two different international banking structures.
This is done in order to understand how the presence of banks with international op-
erations affects the transmission of monetary policy shocks in the countries they serve
and what are the propagation mechanisms of monetary shocks among countries linked
financially. In the first version, a regional bank has subsidiaries in both countries, and
attempts to administrate its resources between those countries. In the second structure,
each country is served by a different foreign bank which are not able to move resources
between countries.

First, the results show that the presence of a regional bank do not seem to affect
the response of real or financial variables as these do not show a relevant difference when
compared to the response of these variable when a foreign bank is present. In terms
of shock propagation, the results show that in a world without financial frictions the
presence of a regional bank does not guarantee an important transmission of monetary
policy shocks to other countries within the region. Although some transmission takes
place, the magnitude of the transmission is rather small.

When financial frictions are introduced into the regional bank model, a relevant
propagation mechanism is activated as shown by the responses of both real and nominal variables in both countries. This result shows that the finding of the empirical literature that weaker responses of monetary policy shocks in small countries is not only related to the presence of a foreign bank, but also to those banks being somewhat financially constrained at the parent level. The intuition is that if parent banks find it too costly to obtain new resources to balance the rate of return in their subsidiaries, they need to activate their internal capital market. The sensitivity analysis that was done in the model shows that varying the sources of the banks financing structure should not have a major effect on the transmission of monetary policy shocks, especially when the regional bank faces financial frictions.

This work can be further expanded by introducing a richer banking sector into the model. For instance a structure of monopolistic competition in the banking industry, where banks can adjust the interest rate charged as a markup of the policy rate, could lead to banks being insulated from monetary policy shocks.
Chapter 3

Monetary Policy Effects in Financially Constrained and Unconstrained Firms

3.1 Introduction

After the meltdown of the securitized assets market and the Lehman Brothers failure, a full banking panic followed. This resulted in a substantial increase in the cost of corporate and bank borrowing. During this period governments promoted liquidity and solvency with a variety of actions. This financial crisis, which led several economies into recession, highlighted the need of achieving a better understanding of the mechanisms through which monetary policy and financial frictions interact.

The aim of this paper is to study the role that financial frictions play in the transmission of monetary policy shocks to the rest of the economy. For this, I develop a New Keynesian general equilibrium model with financial frictions. The novel feature of
the model is that it drops the representative firm assumption by including two distinct
groups of firms with different financing structures, while keeping the model tractable. In
the first group, firms obtain resources directly from households, whereas in the second
group firms need to obtain resources through a financial intermediary and face collateral
constraints. This assumption is based on the idea that firms in the first group release
more information to the public, so investors have a better understanding of the firm.
This allows for these firms to finance their production using cheaper bonds sold directly
to the public. On the other hand, I assume that for the second group of firms it is
too expensive to release credible information to the public, so they decide to use bank
loans which are more expensive and require collateral. In this context banks have an
advantage in the creation of information and diminishing the asymmetries of information
between agents. Monetary models generally base their analysis on the aggregate effects
of monetary shocks; however, by studying the effects on firms separated by their level
of financial access may shed light on the transmission of monetary policy to the rest of
the economy and allow us to answer questions like, do all firms react the same way to
monetary policy shocks? Would the policy recommendation change by looking at firms
separately

There is a vast empirical literature that shows that the level of access to exter-
nal financing varies from firm to firm. Papers within this literature usually divide those
firms according to their level of access to financing. One type of firms is characterized by
having access to a wide variety of sources of external financing, including public trading
instruments such as commercial paper and bonds, with relatively low financial cost for
the company. On the other hand, a second group of firms is usually characterized by having access only to a limited number of instruments, which are generally not publicly traded and relatively expensive and by requiring to possess some kind of collateral for their loans, which in turn limits the amount of resources they can borrow. However, there is still no agreement on the fundamental reasons that explain why some firms have easier access to financing than others.

One theory states that size is the main determinant of a firm's access to external financing. The usual hypothesis is that small firms are informationally opaque, which cause them to be unable to obtain resources by selling bonds and stocks. When small firms need to obtain external financing they may raise funds by selling equity participation directly to private investors or through debt financing in terms of loans and credit lines. Supporting this view, Gertler and Gilchrist [1994], studying the financial data of manufacturing firms, established the basic facts about small firms financing. The authors found that small firms rely more heavily on banking finance compared to the mean of the manufacturing industry and that, for the most part, they do not issue commercial papers. In contrast, they found that large firms rely heavily on the commercial paper market for short term financing, while banking financing was moderately used for long term financing. In the same avenue Berger and Udell [2002] find that the main sources of debt finance for small firms are commercial banks and financial institutions.

Another strand of the literature hypothesizes that the heterogeneous access to financing is due to differences in the age of firms. Using restricted data from the
Kauffman Firm survey Robb and Robinson [2012] find that new firms rely heavily on external debt financing, such as, bank loans, business bank loans and business credit lines, and that owners use their personal assets as collateral. Further supporting this view, Haltiwanger et al. [2012] show that when age is taken into account there is not a negative relationship between firm size and growth. Fairlie and Krashinsky [2012] show that there still exists a positive relationship between the creation of new businesses and wealth. The literature on entrepreneurship interprets this relationship as providing evidence of the existence and importance of liquidity constraints for new firms. However, Hurst and Lusardi [2004] found that although some households are constrained from borrowing, this constraint is not empirically relevant.

Finding the answer to what causes firms to have different access to financing is beyond the scope of this paper. However, the fact that firms present different access to financing presents an important challenge to the conduction of monetary policy. Firms with different access to finance will respond differently to monetary policy shocks. Berger and Udell [2002] found that small firms are especially vulnerable to shocks to the financial system. Similarly, Duygan-Bump et al. [2015] found that the decrease in lending to small firms was an important driver of unemployment during the Great Recession. With this feature in mind I study what are the consequences for monetary policy transmission of having such structure in an economy. For that, I build a theoretical model in which unconstrained firms sell corporate bonds to households to obtain external financing, while constrained firms have to obtain funds from banks and face a collateral constraint.
This paper is organized as follows: Section 3.2 presents a review of the literature that studies the effects monetary policy shocks in the economy. Section 3.3 presents the theoretical model, while Section 3.4 presents the calibration. Finally, Section 3.5 presents the results and Section 3.6 concludes and details avenues for further research.

### 3.2 Related Literature

The topics dealt in this paper cover different strands of the macroeconomic literature. First, it studies the transmission of monetary policy shocks to the rest of the economy. As can be expected this branch of the literature is vast, so making a comprehensive literature review is beyond the scope of this study. Most papers in this literature follow the works of Christiano et al. [2005], who, in a immensely influential paper, study the mix of nominal rigidities that can account for the inertia in inflation and persistence in output to a monetary policy shock. Another highly cited paper was written by Smets and Wouters [2007]. In this study, for the US economy, the authors estimate a general equilibrium model, which includes a number of real and nominal frictions. A complete review of medium sized monetary model literature can be found in Christiano et al. [2010c].

A second topic covered in this paper is the role of financial frictions in business cycles. The literature on financial frictions tries to depict the fact that borrowers cannot obtain unlimited funds from lenders and that various financing sources have different costs for the agents; in other words, the irrelevance theorem by Modigliani and Miller
no longer applies. Two very influential papers in the business cycle literature that relate financial frictions with macroeconomics are

Bernanke and Gertler [1989] and Kiyotaki and Moore [1995]. In the first one, the authors introduced a costly state verification problem between borrowers and lenders in a real business cycle model. In this case, the magnitude of the financial constraint is determined by the parameter that determines the auditing cost. In Kiyotaki and Moore [1995] the authors study how credit constraints interact with aggregate economic activity over the business cycle. The authors study how small temporary shocks are able to generate large and persistent fluctuations in output and asset prices. In this case lenders demand collateral for the funds they provide, so the borrower’s credit limit is affected by the price of collateral assets that in turn is affected by the size of the credit limits. The interaction between credit limits and assets prices ends up creating a transmission mechanism by which the effects of the shocks persist, amplify and spread out.

Bernanke et al. [1999] present a framework to study the role of financial frictions in business cycles. Their model includes price stickiness, money, and investment delay. The authors find that under reasonable parametrization of the model, the financial accelerator channel has a significant influence over the monetary policy shocks, by increasing the effects on output, investment and the nominal rate. Finally, the authors do not find important differences when they include heterogenous firms, hence they conclude that the propagation of shocks in the one or two sector versions of the model is roughly the same.

More recent studies include Iacoviello [2005] who develops a monetary business
cycle model with nominal loans and collateral constraints tied to housing values. The novel feature in his paper is the inclusion of nominal debt which further increase the effects of monetary policy shocks. Iacoviello [2005] imposes the collateral constraint on the fixed asset used in production. Quadrini [2011] presents a simple two period model in which he describes the business cycle implication of a general equilibrium model with collateral constraints. He finds that financial frictions, through the investment channel, have limited impact on labor. By introducing working capital into the model he is able to increase the amplification effects of productivity shocks of the model. Taking this factor into account, the model presented in this paper introduces a working capital channel. These models, in spite of several similarities with this study, do not take into account the role of financial intermediaries in the propagation of monetary shocks as is being done in this paper.

In the context of the latest financial crisis, Gertler and Kiyotaki [2010] develop a framework to understand how disruptions in financial intermediation can induce a crisis. Similarly, Christiano et al. [2010a] augment a monetary DSGE model to include a banking sector and financial markets with agency problems in financial contracts. These models differ from what it is presented here in that they focus more on the business cycles implications of financial constraints, while this paper is more focused on the implications for monetary policy.

In the context of implications of financial frictions on monetary policy, Kiyotaki and Moore [2012] present a model characterized by differences in liquidity across assets. In their model, agents choose to hold money because of a speculatory motivation i.e. in
order to be able buy assets in case an opportunity arises. The model is used to study the role of government policy through open market operations which change the mix of assets held by the private sector. Therefore, monetary policy acts by changing the bundle of financial assets held by private agents. In contrast, in the model presented in this paper, monetary policy is done by injecting money into the economy.

More recently Curdia and Woodford [2015] extend the basic New Keynesian model for monetary transmission by allowing a varying spread between the interest rates available for lenders and borrowers. Their results suggest that New Keynesian models do not need to have any fundamental modification to account for the observed varying interest rate spread that exists in the economy, hence the fundamental lessons of the traditional NK model still apply.

Further papers that are closer to what is presented in this study include the works of Fisher [1999] and De Fiore and Uhlig [2014]. In Fisher [1999], the author develops a general equilibrium model with a costly state verification in order to assess the lending view of monetary transmission. His paper is very similar to this study in that it separates big firms from small firms and analyses the effects of monetary policy on them. However, several differences arise from the structure of the model. First, his model uses the limited participation assumption to model monetary policy shocks, while I make a richer model by incorporating new and modern techniques and frictions into the model, which makes it better suited to analyze the dynamics of the variables in the model. In addition, he focuses on studying the validity of the lending view for the US, while I try to understand the propagation of monetary policy shocks through different
In the study by De Fiore and Uhlig [2014] they develop a model in which heterogenous firms endogenously choose the best capital structure. The main focus of their paper is to understand which are the main determinants of capital structure of firms. They find that differences in capital structure between US and European firms can result from lower levels of information disclosure about firm’s credit risk in Europe relative to the US. In the model presented in this paper, heterogenous firms choose whether to finance production using bonds or bank loans and the focus is to understand how monetary policy shocks are propagated through heterogenous firms.

3.3 A Monetary Policy Model of Financial Frictions with Heterogeneous Agents

The model takes as a starting point a medium sized monetary model as shown in Smets and Wouters [2007], Christiano et al. [2005] and Christiano et al. [2010b] and modifies it to analyze the behavior of the economy with heterogeneous firms. The novelty of the model is that it separates the firms in the economy into two groups. In the first group, firms are assumed to release enough information, so that investors fully understand all aspects of the firm. This feature allows them to finance their production directly from households by selling bonds. This group is denoted as Unconstrained firms.

Firms that belong to the second group, named as Constrained firms, are as-
sumed to be informationally opaque, which means that it is too costly for them to release enough information to the public. This assumption leads to investors avoiding financing this type of firms. To obtain financing these firms need to borrow from commercial banks, which are assumed to collect all the necessary information. This allows banks to diminish the informational asymmetry between banks and constrained firms. These assumptions rely on contemporary theories on financial intermediation which have shown that banks are more efficient than the market in solving informational problems. Among other reasons, banks have economies of scale in the production of information and they have access to inside information of firms, De Fiore and Uhlig [2011]. In addition, financial firms can use a number of technologies based on 'hard' and 'soft' information to reduce the information wedge present in small firms, Berger and Frame [2007]¹.

In spite of the ability of banks to decrease informational asymmetry, some firms of this group will not be able to pay back their debts and banks know that they will not able to fully recover their loans. So in order to provide loans, banks demand collateral against the future value of the capital of the firm, so capital works not only as a factor of production but also as collateral. This assumption follows the results of Avery et al. [1998], who found that personal commitment and collateral are important to firms seeking loans. Secured lending is very common in the US, according to Berger and Udell [1990], nearly 70 percent of all commercial and industrial loans in the United

¹Hard information technologies include ‘small business credit scoring’ (which is similar to consumer credit scoring), asset-based lending, factoring, fixed asset lending and leasing. Soft lending technology refers to “relationship lending”. Under relationship lending banks are able to obtain information over time through contact with the firms and their owners.
States are secured by collateral assets.

Another modification from the model presented in Christiano et al. [2010b] is motivated by the need for firms to have collateral. For this reason it is allowed for firms to be the owners of the capital, which they use as collateral, instead of the traditional assumption that firms rent capital from households.

Constrained firms as well as unconstrained firms face a working capital constraint, produce differentiated final goods and buy capital from capital producers. The need to finance their production comes from the working capital constraint, i.e. they receive the proceeds from sales of their production at the end of each period, so they borrow resources to pay for operating costs.

The rest of the model is populated by households, financial intermediaries and a central bank. The model includes a number of frictions that are now standard in the monetary literature such as, external habit formation, cost of investment, cost of adjusting prices and wage adjusting frictions. These modifications also make the model less forward looking, which according to Garin et al. [2016] helps breaking the Neo-Fisherianism on the model. The model includes monetary policy shocks, so it can be used to understand the behavior of heterogeneous firms in the presence of this type of shocks. The model also includes an aggregate technology shock that affects both type of firms. The objectives and constraints of the agents in the model are described in the following subsections.

Households are utility-maximizing agents who supply labor, save in the form...
of bonds or deposits and consume a basket of final goods produced by firms. Calvo-
style wage setting frictions are modeled by assuming there is a continuum of households
indexed by \( l \in [0, 1] \). Each of these households is assumed to provide a specialized labor
input, \( h_{j,t} \) to a labor packer who in turns offers this service to a good producing firm. By
adopting a Dixit-Stiglitz type framework to model aggregation of labor I ensure that
each household has some monopolistic power, but it still leaves room for competing
against the other households.

This model follows the timing convention used by Christiano et al. [2005] in
which households enter period \( t \) with financial wealth, \( M_t \), and the assets market opens
at the beginning of the period.\(^2\) At the start of the period households receive wage
payments and they decide how much savings they will have in the form of bonds, bought
directly from unconstrained firms, and in the form of bank deposits. The remaining cash
balances \( M_t + W_t H_t - D_t - B_t \) are used for purchasing consumption goods.

For their consumption decision, each period household \( l \) must decide its con-
sumption basket, which is of the form,

\[
C_t(l) = \left[ \int_0^1 c_{jt}(l) \frac{\theta_{p-1}}{\theta_p} dj \right]^{\frac{\theta_p}{\theta_p-1}}
\]  

(3.1)

where \( c_t(l) \) is the total consumption for household \( l \) at time \( t \), \( c_{jt}(l) \) is the consumption
of household \( l \) of goods made by firm \( j \) and \( \theta_p \) is the elasticity of substitution between
different firms’ goods in consumption. As \( \theta_p \) goes to infinity both goods become perfect
substitutes, and as \( \theta_p \) goes to zero there is no substitution possible. Households choose
their consumption bundle by minimizing its cost, \( \int_0^1 p_{jt} c_{jt} dj \), subject to (3.1) by solving

\(^2\)This timing convention was first introduced by Lucas [1982]
The first order conditions lead to the following optimality condition:

\[
\begin{align*}
\min_{c_{jt}} & \int_0^1 p_{jt} c_{jt}(l) dj \\
\text{subject to} & \quad c_t(l) = \left[ \int_0^1 c_{jt}(l) dj \right]^{\frac{\theta_p}{\nu - \theta_p}}.
\end{align*}
\]

Condition (3.2) states that the consumption of an individual good depends on its price relative to the aggregate price index, \(P_t\). Condition (3.3) states that the aggregate price index is an average of the individual prices weighted by the elasticity of substitution among goods. Without any loss of generality one can assume that a percentage \(\omega_{cu}\) of firms are considered unconstrained while the \(1 - \omega_{uc}\) percent remaining face financial constraints. Taking into account that firms consume both types of goods then (3.3) can be stated as

\[
P_t^{1-\theta_p} = (1 - \omega_{cu}) \left( P_t^c \right)^{1-\theta_p} + \omega_{cu} \left( P_t^u \right)^{1-\theta_p}
\]

where \(P_t^u\) refers to the price of unconstrained firms and \(P_t^c\) refers to the price of constrained firms.

Assuming that household utility depends on its consumption of the composite good, presents external habit formation, and is separable between consumption and labor, then its utility function is given by

\[
U(C_t(l), H_t(l)) = \ln (C_t(l) - \tau C_{t-1}) - \chi \frac{H_t(l)}{1+\eta}
\]

where \(C_t(l)\) is the consumption made by household \(l\) at period \(t\), \(C_{t-1}\) is the average
lagged consumption level of the economy, \( \tau \) is a measure of external habit formation, \( \eta \) is the inverse of labor price elasticity and \( \chi \) is a parameter that affects the relative valuation of utility from consumption and labor and is constrained to be positive. Given the additive separability of consumption and employment in utility, the efficient allocation of consumption within households imply \( C_t(l) = C_t \)

Households enter period \( t \) with money balances, \( M_t \), and receive wage payments, \( W_t H_t \), at the beginning of the period, which are allocated to purchase consumption goods and to intra-period savings in the form of bank deposits, \( D_t \), and corporate bonds \( B_t \). Then households face a cash in advance (CIA) constraint of the form

\[
P_t C_t + D_t + B_t = M_t + W_t H_t
\]

Later in the period they receive profits from firms and banks and principal plus interest payments from the savings assets, deposits and bonds, they purchased at the beginning of the period. Taking all into account the households maximize (3.5) subject to the CIA constraint (3.6) and the budget constraint of the form

\[
P_t C_t + B_t + D_t + M_{t+1} = W_t H_t + \left(1 + r^d_t\right) D_t + \left(1 + r^b_t\right) B_t + M_t + \Pi^u_t + \Pi^c_t + \Pi^b_t
\]

where \( r^b_t \) is the nominal interest earned by lending funds to unconstrained firms, \( r^d_t \) is the nominal interest paid by banks. The variables \( \Pi^u_t, \Pi^c_t, \Pi^b_t \) are the dividends that households receive from unconstrained firms, constrained firms and banks, respectively.

The part of the problem that is not related to the labor market has the following
optimality conditions:

\[ \lambda_t \left( 1 + r_t^d \right) = \frac{1}{C_t - \tau C_{t-1}} \quad (3.8) \]

\[ \lambda_t = \beta E_t \left( \frac{1 + r_t^b}{1 + \pi_{t+1}} \right) \lambda_{t+1} \quad (3.9) \]

\[ \lambda_t = \beta E_t \left( \frac{1 + r_t^d}{1 + \pi_{t+1}} \right) \lambda_{t+1} \quad (3.10) \]

Equation (3.8) shows that households care about the consumption path. Equations (3.9) and (3.10) are the Euler equations, these state that households will be indifferent between holding corporate bonds or bank deposits as long as \( r_t^b = r_t^d \).

Now, regarding the part of the household problem that deals with wage setting, each period a randomly selected fraction, \((1 - \omega_w)\), of households is given the opportunity to adjust their wage according to market conditions to a wage \( W_t^* (l) \), the rest \( \omega_w \) of the households just are only able to index last period wages according to inflation. It is assumed that non-adjusting households index their nominal wage according to inflation at a rate \( \nu \in [0, 1] \). This means that non-updating households receive a wage of \((1 + \pi)^\nu W_{t-1} (l)\). Analyzing the case that household \( l \) is not able to adjust its wage since period \( t \), at \( t + 1 \) and at \( t + 2 \) its wage would be

\[ W_{t+1} = (1 + \pi_t)^\nu W_t^* (l) \]

\[ W_{t+2} = ((1 + \pi_{t+1})(1 + \pi_t))^\nu W_t^* (l) = \left( \frac{P_{t+1}}{P_{t-1}} \right)^\nu W_t^* (l), \]

respectively. Then for any period \( t + s \) where household have not been able to adjust their wages for the last \( s \) periods the non updated wage can be expressed as

\[ W_{t+s} (l) = \left( \frac{P_{t+s-1}}{P_{t-1}} \right)^\nu W_t^* (l) \quad (3.11) \]
Recalling that households offer their labor service to a labor packer, who aggregates all of households labor into one service using the following technology,

\[ H_t = \left( \int_0^1 H_t(l) \frac{\theta_w - 1}{\theta_w} dl \right)^{\frac{\theta_w}{\theta_w - 1}}, \quad \theta_w > 1. \] (3.12)

Then the demand of the labor packer for \( H_t(l) \) is given by

\[ H_t(l) = \left( \frac{W_t(l)}{W_t} \right)^{-\theta_w} H_t \] (3.13)

which states that demand for household \( (l) \) services depends on their wage relative to the aggregate wage level, given by

\[ W_t^{1-\theta_w} = \int_0^1 W_t(l)^{1-\theta_w} dl \] (3.14)

In addition, note that the labor packer must provide labor services to all firms in the economy, then the labor is dividing among the firms following

\[ H_t^{\theta_w - 1} H_t = (1 - \omega_{cu}) (H_t^c)^{\theta_w - 1} + \omega_{cu} (H_t^u)^{\theta_w - 1} \] (3.15)

where \( H_t \) is the total time worked by the individual, \( H_t^c \) is the time worked by the individual in the constrained firm, \( H_t^u \) is the time worked by the individual in the unconstrained firm. Households then solve their wage decision problem taking into account the decisions made by the labor packer. More formally, by replacing the labor demand, (3.13), the indexation of wages, (3.11), and the aggregate wage level, (3.14), into the utility function, (3.6), budget constraint, (3.7) and the CIA constraint, (3.6), the wage setting problem becomes

\[ \mathcal{L} = \mathbb{E}_t \sum_{s=0}^{\infty} (\beta \omega_w)^s \left\{ -\chi \left( \frac{\left( \frac{P_{t+s}}{P_{t-1}} \right)^{\nu} W_t(l)^{1-\theta_w(1+\eta)}}{W_{t+s}^{1+\eta}} H_t^{1+\eta} \right) + (\lambda_{t+s} + \mu_{t+s}) \left( \left( \frac{P_{t+s}}{P_{t-1}} \right)^{\nu} W_t(l) \right)^{1-\theta_w} W_{t+s}^{-\theta_w} H_t \right\} \]

64
where \( \lambda_t \) is the Lagrangean multiplier of the budget constraint and \( \mu_t \) is the Lagrangean multiplier of the CIA constraint. The first order conditions of this problem, after some algebraic manipulation, are given by

\[
\begin{align*}
    w^*_t &= \frac{\theta_w}{\theta_w - 1} \lambda_t \frac{G_{1t}}{G_{2t}} \\
    \text{where} \\
    G_{1,t} &= E_t \beta \omega (1 + \pi_t)^{-\nu(1+\eta)} (1 + \pi_{t+1})^{\theta_w(1+\eta)} \left( \frac{w^*_t}{w_t} \right)^{-\theta_w(1+\eta)} G_{1,t+1} \\
    &\quad + \left( \frac{w^*_t}{w_t} \right)^{-\theta_w(1+\eta)} H^1_{t+\eta} \\
    \text{and} \\
    G_{2,t} &= E_t \beta \omega (1 + \pi_t)^{\nu(1-\theta_w)} (1 + \pi_{t+1})^{-\theta_w(1+\eta)} \left( \frac{w^*_t}{w_t} \right)^{-\theta_w} G_{2,t+1} \\
    &\quad + \left( \frac{w^*_t}{w_t} \right)^{-\theta_w} H_t \lambda_t
\end{align*}
\]

\textbf{Capital Producers}

Capital producers are a group of agents who aggregate goods produced from different types of firms in order to make capital.

First, they minimize the cost of the investment basket,

\[
\min_{I_{jt}} \int_0^1 p_{jt} I_{jt} dj \quad \text{subject to} \quad I_t = \left[ \int_0^1 \frac{\theta_{p-1}}{\theta_{p}} I_{jt}^{\theta_p-1} d\mu \right]^{\theta_p-1}.
\]

where \( \theta_p \) is elasticity of substitution of capital. The first order conditions lead to the
following optimality conditions:

\[ I_{jt} = \left( \frac{P_{jt}}{P_t} \right)^{-\theta_p} I_t \]  \hspace{1cm} (3.19)
\[ P_t = \left( \int_0^1 P_{jt}^{1-\theta_p} dj \right)^{1/(1-\theta_p)} \]  \hspace{1cm} (3.20)

By assuming that the elasticity of substitution of capital is the same as the one used for consumption ensures that the allocation of investment expenditure of firms across goods is in the same proportion as consumption expenditure.

**Unconstrained Firms**

As stated before, it is assumed that unconstrained firms disclose all the information required by the public, so information asymmetries do not present a relevant problem for them. This assumption allows unconstrained firms to borrow directly from households on the debt market without having to go to financial intermediaries.

The timing of the model is similar to that of working capital models, where at the beginning of the period agents receive information about the productivity shock. At this point firms decide how much to produce and how much to spend in new capital. The technology used by unconstrained firms to produce is appropriately described by the following production function

\[ f \left( H_{j,t}^u, K_{j,t-1}^u, z_t \right) = z_t \left( H_{j,t}^u \right)^{1-\alpha} \left( K_{j,t-1}^u \right)^\alpha, \]  \hspace{1cm} (3.21)

where \( H_{j,t}^u \) is the amount of labor hired by the firm \( j \), \( K_{j,t-1}^u \) is the amount of capital used in production by the firm and \( z_t \) is a productivity shock. Investment spending
takes the form

$$I_{j,t}^u = K_{j,t}^u - (1 - \delta)K_{j,t-1}^u + \frac{\psi_p}{2} \left( \frac{I_{j,t}^u}{I_{j,t-1}^u} - 1 \right)^2 I_{j,t}^u,$$  \hspace{1cm} (3.22)$$

where $I_{j,t}^b$ refers to the purchases of capital by firm $j$. Note that investment in this model is subject to adjustment costs, so firms must spend extra resources to obtain their desired level of capital.

Both households and capital producers demand goods from unconstrained firms. This results in the demand function faced by each of the producers to be of the form

$$Y_{j,t}^u = \left( \frac{P_{j,t}^u}{P_t} \right)^{-\theta_p} Y_t$$  \hspace{1cm} (3.23)$$

Unconstrained firms also face menu costs of changing prices, i.e. a cost incurred by the firms due to the price-adjustment process itself. It is assumed that the real costs of changing the nominal prices the firm charge is $^3$

$$\frac{\psi_p}{2} \left( \frac{P_{j,t}^u}{P_{j,t-1}^u} - 1 \right)^2.$$

Firms need to finance all the costs that they face in order to produce and sell their goods, these include: capital investments, $P_t I_{j,t}^u$, wage payments for an amount $W_t H_{j,t}^u$, where $W_t$ are the wages paid on labor, and menu costs. In order to finance these expenditures, unconstrained firms must borrow from households in the form of bonds, equivalent to

$$B_t = W_t H_{j,t}^u + P_t I_{j,t}^u + \frac{\psi_p}{2} \left( \frac{P_{j,t}^u}{P_{j,t-1}^u} - 1 \right)^2 P_t$$  \hspace{1cm} (3.24)$$

$^3$Due to the existence of firm specific the usual Calvo-pricing assumption is replaced by quadratic cost of adjusting prices.
households charge an interest rate, \( r^b_t \), for these bonds which, along with the principal, have to be paid at the end of the period. Then the total amount that firms must pay back to households is equivalent to \((1+r^b_t)B_t\). Then the unconstrained firm problem becomes

\[
\max_{y_{jt}, H^u_{jt}, I^u_{jt}} P^u_{jt} Y^u_{jt} - \left( 1 + r^b_t \right) W^u_{jt} H^u_{jt} - \left( 1 + r^b_t \right) P^u_{jt} I^u_{jt} - \left( 1 + r^b_t \right) \frac{\psi_p}{2} \left( \frac{P^u_{jt}}{P^u_{jt-1}} - 1 \right)^2 P_t
\]

subject to (3.21), (3.22) and (3.23).

From the first order conditions, assuming that \( b_t \) is the Lagrangian multiplier for the output condition, \( u_t \) is the Lagrangian multiplier of the investment relation, and omitting the firm indicator, then the following optimality conditions are obtained:

\[
w_t \left( 1 + r^b_t \right) = \left( 1 - \alpha \right) \beta \left( \frac{K^u_{t-1}}{H^u_t} \right)^\alpha \gamma^u_t
\]

\[(1 + r^b_t) = \mathbb{E}_t \left( 1 + \pi_{t+1} \right) Q_{t+1} \left( \alpha \beta_{t+1} \left( \frac{H^u_{t+1}}{K^u_{t+1}} \right)^{1-\alpha} \gamma^u_{t+1} \right. \]

\[
\left. + (1 - \delta) v^u_{t+1} \right)
\]

(3.25)

(3.26)

The optimality conditions (3.25) and (3.26) are the same as the ones obtained in the standard RBC model except for the fact that now the interest rate, \( r^b_t \), and the Lagrangian multiplier, \( \gamma^u_t \), appear modifying both the marginal productivity of labor

\[Q_{t+1} = \beta \frac{\gamma_{t+1}}{\gamma_t}\]

\[\text{Note that } Q_{t+1} = \beta \frac{\gamma_{t+1}}{\gamma_t}\]
and of capital. From these it can be seen that the marginal productivity of labor and capital are going to be higher than the standard case. This is due to the fact that now firms must also pay for the financial cost of using production inputs.

Condition (3.27) can be restated as

\[
P^u_t = \frac{\theta_p}{\theta_p - 1} \gamma^u_t P_t
\]

which can be restated as

\[
P^u_t = \left( \frac{\theta_p}{\theta_p - 1} \right) (\gamma^u_t + \Omega^u_t) P_t
\]

where

\[
\Omega^u_t = \mathbb{E}_t \frac{\psi_p}{(\theta_p - 1) \theta_p Y_t} \left\{ (1 + r^b_{t+1}) (1 + \pi_{t+1}) (1 + \pi^u_{t+1}) Q_{t+1} - (1 + r^b_t) (1 + \pi^u_t) \pi^u_t \right\} \left( \frac{P^u_t}{P_t} \right)^{\theta_p}
\]

and acts as a second source of cost for the firm coming from the fact that for a firm is costly to change prices.\(^5\) This condition states that an unconstrained firm will choose to charge higher prices if it expects growing inflation. Similarly, the unconstrained firm will charge higher prices if it expects higher interest rates in the future. In other words, unconstrained firms will charge a higher price if

\[
(1 + r^u_{t+1}) (1 + \pi_{t+1}) (1 + \pi^u_{t+1}) Q_{t+1} > (1 + r^u_t) (1 + \pi^u_t) \pi^u_t.
\]

If prices are totally flexible then \(\psi = 0\), condition (3.30) reduces to the usual condition on New Keynesian models. Condition (3.30) also shows that there is a wedge between marginal costs and firm prices due to the markup, \(\theta_p/ (\theta_p - 1)\), introduced by the monopolistic competition. From this condition it can be seen that the price of unconstrained goods is not only increased by the marginal cost but also by the variable \(\Omega^u_t\).

\(\text{\textsuperscript{5}}\)In a New Keynesian model with prices à la Calvo this cost does not appear as is not costly for firms to change prices.
Constrained Firms

As previously mentioned, constrained firms cannot get resources directly from households, because they find it too costly to provide information to the market. This assumption has two consequences on the finances of constrained firms. First, they can only borrow funds from banks, since these have special advantages in monitoring firms and producing information. In addition, banks provide only secured lending, so these firms must provide collateral for the loans they obtain from banks.

The timing and the basic structure is similar to that of unconstrained firms. Technology is given by the production function

\[
f \left( H_{j,t}^c, K_{j,t}^c, z_t \right) = z_t \left( H_{j,t}^c \right)^{1-\alpha} \left( K_{j,t-1}^c \right)\alpha,
\]

(3.31)

where \( H_t^j \) is the amount of labor hired by the constrained \( j \) firm, \( K_{j,t-1}^c \) is the amount of capital used in production by the constrained firm \( j \) in period \( t \) and \( z_t \) is a productivity shock. Investment spending in new capital by the firm \( j \) is given by

\[
I_{j,t}^c = K_{j,t}^c - (1 - \delta)K_{j,t-1}^c + \frac{\psi_I}{2} \left( \frac{I_{j,t}^c}{I_{j,t-1}} - 1 \right)^2 I_{j,t}^c,
\]

(3.32)

which follows the structure of unconstrained firms. Constrained firms also face menu costs of changing prices, i.e. a cost incurred by the firm due to the price-adjustment process itself. It is assumed that the real costs of changing the nominal prices it charges is

\[
\frac{\psi_p}{2} \left( \frac{P_t^c}{P_{t-1}^c} - 1 \right)^2.
\]
Taking into account wage payments and investment spending, then the total amount borrowed by constrained firms is then

\[ L_{j,t} = W_t H_{j,t}^c + P_t I_{c,j,t} + \frac{\psi_p}{2} \left( \frac{P_t}{P_t^c} - 1 \right)^2 \] (3.33)

and at the end of the period these firms must pay back \((1 + r_t^l) L_t\), where \(r_t^l\) is the nominal interest rate charged by banks for these loans.

The collateral constraint is modeled following Kiyotaki and Moore [1995]. This constraint requires that the amount borrowed by a firm plus interest cannot be greater than a proportion \(\kappa\) of the expected future value of the firm’s total capital.

\[ \left(1 + r_t^l\right) L_t \leq \kappa P_{t+1} K_t^c. \] (3.34)

A constraint like (3.34) has several interpretations in the literature. The parameter \(\kappa\) can be thought of as a measure for risk. In this interpretation, in a high risk economy \(\kappa\) should be positive and smaller than in a low risk economy where the parameter should be bigger. Also it can be interpreted as the maximum fraction of capital that the producer is able to credibly pledge in cases where it is not able to pay in full. This feature is introduced into the model to capture the idea that there is a proportion of firms that require some sort of collateral or guarantee to secure their lending.

Both households and capital producers demand goods from constrained firms. This results in the demand function faced by each of the producers to be of the form

\[ Y_t^c = \left( \frac{P_t^c}{P_t} \right)^{-\theta_p} Y_t \] (3.35)
Taking all into account the constrained firm problem becomes

$$\max_{Y^c_{j,t}, H^c_{j,t}, I^c_{j,t}} \frac{P^c_{j,t} Y^c_{j,t}}{1 + r^c_{j,t}} W_t H^c_{j,t} - \left(1 + r^c_{j,t}\right) P_t I^c_{j,t} - \left(1 + r^c_{j,t}\right) \frac{\psi_t}{2} \left(\frac{P^c_{j,t}}{P^c_{j,t-1}} - 1\right)^2 P_t$$

subject to (3.31), (3.32), (3.34) and (3.35).

From the first order conditions, and assuming that $\gamma^*_c$ is the Lagrangian multiplier for the output condition and $\phi_t$ is the Lagrangian multiplier of the collateral constraint, the following optimality conditions are obtained:

$$w_t \left(1 + r^c_{j,t}\right) (1 + \phi_t) = (1 - \alpha) z_t \left(\frac{K^c_{t+1}}{H^c_{t}}\right)^{\alpha} \gamma^*_c$$

(3.36)

$$\left(1 + r^c_{j,t}\right) (1 + \phi_t) = \mathbb{E}_t \left(1 + \pi_{t+1}\right) Q_t \left((1 - \delta) \psi_{t+1} + \kappa \phi_{t+1}\right) + \alpha z_{t+1} \left(\frac{H^c_{t+1}}{K^c_{t}}\right)^{1-\alpha} \gamma^*_c$$

(3.37)

$$\left(1 - \theta_p\right) \left(\frac{P^c}{P^c_t}\right)^{1-\theta} \psi_t = \psi_p \left(1 + r^c_{t+1}\right) (1 + \phi_t) (1 + \pi^c_{t+1}) \pi^c_t$$

(3.38)

$$+ \theta_p \left(\frac{P^c}{P^c_t}\right)^{-\theta_p} \gamma^*_c$$

$$\left(1 + r^c_{j,t}\right) (1 + \phi_t) = \left(1 - \psi_t \left(\frac{L^c_t}{L^c_{t-1}} - 1\right) \left(\frac{L^c_t}{L^c_{t-1}} - 1\right)^2 \psi_t \left(\frac{L^c_t}{L^c_{t-1}} - 1\right)^2 Q_{t+1} \psi_{t+1}$$

(3.39)

The optimality conditions (3.36) and (3.37) are the same as the ones obtained for the unconstrained firms except that now it appears the interest rate on bank loans and the Lagrangian multiplier of the collateral constraint, $\phi_t$, appears modifying them.

Assuming that the constraint is always binding, then $\phi_t$ is always positive. Equation (3.36) implies that the marginal productivity of labor of constrained firms must always be higher than that of unconstrained firms. A similar effect can be found on the optimality condition of capital, a positive $\phi_t$ increases the required marginal productivity of capital due to the fact that capital must be financed with loans, which leads to a reduc-
tion in the optimal level of capital. However, an increase in capital reduces the effect of the collateral constraint, so forward looking firms trying to achieve their optimal level of production will want to increase investment as much as possible.

As with the unconstrained firms, condition (3.38) can be restated as

\[ P_t^c = \left( \frac{\theta_p}{\theta_p - 1} \right) (\gamma_t^c + \Omega_t^c) P_t \]  

(3.40)

where

\[ \Omega_t^c = \frac{\psi_p}{(\theta_p - 1) \theta_p Y_t^c} \left\{ \left( 1 + r_{t+1}^l \right) (1 + \pi_{t+1}^c) (1 + \pi_{t+1}^c) Q_{t+1} - \left( 1 + r_t^l \right) (1 + \pi_t^c) \pi_t^c \right\} \left( \frac{P_t^c}{F_t} \right)^{\theta_p}. \]

Similarly to what is seen for unconstrained firms, \( \Omega_t^c \) acts as a second source of cost for the firm coming since for a firm is costly to change prices. This condition states that a constrained firm will choose to charge higher prices if it expects growing inflation or if it expects higher interest rates in the future. In other words, constrained firms will charge a higher price if

\[ \left( 1 + r_{t+1}^l \right) (1 + \pi_{t+1}^c) (1 + \pi_{t+1}^c) Q_{t+1} - \left( 1 + r_t^l \right) (1 + \pi_t^c) \pi_t^c. \]

If prices are totally flexible then \( \psi = 0 \), condition (3.40) reduces to the usual condition on New Keynesian models. Condition (3.40) also shows that there is a wedge between marginal costs and firm prices due to the markup, \( \theta_p/(\theta_p - 1) \), introduced by the monopolistic competition. From this condition can be seen that the price of constrained goods is not only increased by the marginal cost, \( \gamma_t^c \), but also by the variable \( \Omega_t^c \).
Banks

Financial intermediaries only lend to constrained firms using funds that are obtained from households’ deposits, $D_t$, and through monetary injections made by the central bank, $X_t$. On the asset side of the balance sheet banks only have loans made to constrained firms, $L_t$. Then the balance sheet at the beginning of period $t$ is given by

$$L_t = D_t + X_t$$ \hspace{1cm} (3.41)

Banks’ income is determined by the interest rate they charge on loans, $r^l_t$, and by the amount of loans provided to firms, $L_t$, so every period the banks receive $(1 + r^l_t) L_t$. On the other hand, the costs that banks face come in the form of an administration cost equal to $\xi L_t$ and of payments for household deposits. Then their profits are given by

$$\Pi_t^{Bank} = \left(1 + r^l_t - \xi \right) L_t - \left(1 + r^d_t \right) D_t$$

Profit maximization and perfect competition in the banking sector leads to the following condition

$$r^d_t + \xi = r^l_t$$

This condition states that the interest rate charged by banks to constrained firms is higher than the one paid for deposits.
Central Bank

It is assumed that the central bank follows a simple Taylor rule in the form of

\[ 1 + r_t^d = \frac{1}{\beta} \left( 1 + \pi_t \right)^{\tau_{\pi}} \left( 1 + \frac{Y_t}{Y_{t-1}} \right)^{\tau_g} (1 + u_t) \]  

(3.42)

where \( u_t \) are exogenous monetary policy shocks, \( \tau_{\pi} \) is a parameter that measures the response of the central bank to an increase in inflation, which is assumed to be greater than one, and \( \tau_g \) is a parameter that measures the response of the central bank to changes in growth.

Equilibrium

The equilibrium of the model is defined by the optimality conditions from households, unconstrained firms, constrained firms, and banks, the goods market equilibrium, the labor market equilibrium, loans market equilibrium and the asset market equilibrium. To solve the model it is necessary to choose a numeraire good; in this case the composite good is chosen. The price of the composite good, \( P_t \), is chosen to be 1 at steady state.

The goods market equilibrium is defined by the following equations:

\[ Y_t^u = C_t^u + I_t^u \]  

(3.43)

\[ Y_t^c = C_t^c + I_t^c \]  

(3.44)

\[ P_t Y_t = (1 - \omega) \left( P_t^s c_t^s + P_t^s I_t^s \right) + \omega \left( P_t^b c_t^b + P_t^b I_t^b \right) \]  

(3.45)
The equilibrium in the loans market require that

\[ X_t = M_{t+1} - M_t \]

The endogenous variables in this model are: \( Y_t, Y^c_t, Y^u_t, C_t, C^a_t, C^b_t, H_t, H^c_t, H^u_t, K^c_t, K^u_t, I^c_t, I^u_t, \gamma^c_t, \gamma^u_t, m_t, \pi_t, r^b_t, r^d_t, b_t, d_t, l_t, \pi_t, \pi^c_t, \pi^u_t, R_t, w_t, P_t, P^c_t, P^u_t \) and \( \phi_t \). The exogenous variables are \( u_t, z_t \), which are assumed to follow AR(1) processes:

\[ u_t = \rho_u u_{t-1} + \varepsilon_{u,t} \quad (3.46) \]
\[ \ln(z_t) = \rho_z \ln(z_{t-1}) + \varepsilon_{z,t} \quad (3.47) \]

Equation (3.46) is the process for monetary injection surprises and equation (3.47) is the process for aggregate productivity shocks. The model is solved with the optimality conditions together with the conditions and constraints shown in equations (3.15) through (3.45) and two exogenous processes detailed in equations (3.46) and (3.47).

### 3.4 Calibration

In this section, I discuss the calibrated parameters used in the model. For the most part, the values of these parameters, which are now standard in the literature, were taken from Christiano et al. [2005] and Christiano et al. [2010b]. The discount rate of households in both countries, \( \beta \), is set equal to 0.99, with this value, the level of the annual interest rate of deposits and bonds is set to 4% at steady state, while the habit formation parameter, \( \tau \), is 0.77. Capital share in the production function is 0.36, depreciation is set to 1.9% and the investment adjustment cost, \( \psi_I \) is set to 0.3. Tis
last parameter had to be set considerably lower than the values used in the previously mentioned papers due to the fact that higher values induce a sawtooth dynamic in the impulse response functions.

In terms of the parameters related to the goods market, the parameter that measures the elasticity of substitution among goods, \( \theta_p \), is set to 6 with the objective to obtain a markup of 1.2. The parameter that measures the cost of adjusting prices, \( \psi_P \), is set to 2. The papers that were used as a model for both the basic model and the parameter values do not use a quadratic cost of adjustment as a way to model price stickiness and instead use Calvo prices, so they do not have a parameter value to use as a base. Instead, other papers in the literature were used to find a sensible value for \( \psi_P \), which include Gavin et al. [2013], Niemann et al. [2013] and Leith and Liu [2016], the range of values used was wide as it went from 2 to 116. Several parameter values were tried in the model, and the results did not seem much affected by the changes, so a low value was used.

With regards to the parameters related to the labor market and wage setting, the relative disutility of labor, \( \chi \), is chosen to ensure that in the steady state households allocation time to work is close to 0.32; this yields \( \chi = 20 \). The inverse of Frisch elasticity parameter, \( \eta \), is assumed to be equal to 1, which implies that the utility is quadratic in leisure and a labor supply elasticity of 1. The price elasticity of substitution among different types of labor, \( \theta_w \), is 8, which implies a markup value in the labor market of 1.14. This markup value lies in between of the 1.05 used in Christiano et al. [2005] and the 1.5 used in Smets and Wouters [2007]. The fraction of households that are given
the opportunity to re-optimize their wages is 0.2, which implies a value of $\omega_w$ of 0.8. This value is in the range of the values used in Christiano et al. [2005] and in Smets and Wouters [2007]. The rate of wage indexation, $\nu$, is 0.4, which is lower than the values used normally in the literature which go from 0.7 to 1. This parameter had to be kept low due to fact that higher numbers changed the response of output to monetary policy shocks.

Table 3.1: Parameter Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>0.99</td>
<td>Household discount factor</td>
</tr>
<tr>
<td>$\chi$</td>
<td>20</td>
<td>Labor relative disutility factor</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.019</td>
<td>Depreciation rate</td>
</tr>
<tr>
<td>$\eta$</td>
<td>1</td>
<td>Inverse Frisch elasticity</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.36</td>
<td>Capital share</td>
</tr>
<tr>
<td>$\tau$</td>
<td>0.77</td>
<td>Habit formation parameter</td>
</tr>
<tr>
<td>$\theta_p$</td>
<td>6</td>
<td>Price elasticity of demand for individual good</td>
</tr>
<tr>
<td>$\theta_w$</td>
<td>8</td>
<td>Price elasticity of demand for individual labor</td>
</tr>
<tr>
<td>$\nu$</td>
<td>0.4</td>
<td>Wage indexation to $\pi_{t-1}$</td>
</tr>
<tr>
<td>$\psi_p$</td>
<td>2</td>
<td>Price adjustment cost parameter</td>
</tr>
<tr>
<td>$\psi_I$</td>
<td>0.01</td>
<td>Investment adjustment cost parameter</td>
</tr>
<tr>
<td>$\tau_\pi$</td>
<td>1.5</td>
<td>Interest rate sensitivity to inflation</td>
</tr>
<tr>
<td>$\tau_g$</td>
<td>0</td>
<td>Interest rate sensitivity to growth</td>
</tr>
<tr>
<td>$\omega_{cu}$</td>
<td>0.2</td>
<td>Percentage of unconstrained firms</td>
</tr>
<tr>
<td>$\omega_w$</td>
<td>0.8</td>
<td>Wage stickiness</td>
</tr>
<tr>
<td>$\xi$</td>
<td>0.015</td>
<td>Banks cost parameters</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>0.01</td>
<td>Collateral constraint parameter</td>
</tr>
<tr>
<td>$\rho_z$</td>
<td>0.95</td>
<td>Autoregressive coefficient of productivity shock</td>
</tr>
<tr>
<td>$\rho_u$</td>
<td>0.65</td>
<td>Autoregressive coefficient of monetary shock</td>
</tr>
</tbody>
</table>

Finally, in terms of the financial variables, a value 0.015 was used as a variable cost for the banking industry. This parameter is in line with the findings of Kovner et al. [2014] who find that noninterest expenses are around 1.22 percent of risk-weighted assets.
in the banking industry in the US. Regarding the collateral constraint of small firms, the value chosen was the biggest parameter value that would always allow having a binding collateral constraint. The value of the sensitivity of the monetary policy to changes in inflation, $\zeta_\pi$ is set to 1.5, the size of monetary policy shock is set to 0.0025, to account for surprise changes of 25 basis points and the autocorrelation coefficient of monetary policy shocks is set to 0.65. Lastly, the sensitivity of the interest rate to changes in output growth is set to 0.

3.5 Results

In this section, I study the transmission of monetary policy by analyzing the model impulse responses to an unanticipated 25 basis points decrease in the deposits rate, which in this case is the policy rate. The transmission mechanism of monetary policy shocks in this model takes place through its effect on the real and nominal interest rates, on investment and on the labor market equilibrium.

In the following section, I will present an analysis of the consequences of having heterogenous firms in the same model. The results show that financially constrained firms have a subdued response to monetary policy shocks, so the main effect of monetary policy is transmitted to unconstrained firms. In the second section, I will compare the model with heterogenous firms with two other versions of the model, a version with only constrained firms and another with no firms constrained.
Response to Monetary Shocks in the Heterogenous Firm Model

On impact, an expansionary monetary shock decreases the real rate on deposits which is transmitted to the interest rate on corporate bonds by conditions (3.9) and (3.10). On the other hand, as can be seen in Figure 3.1, this effect is not transmitted immediately to the nominal rate, because of the effect on expected inflation. However, the effect is seen later and reaches a peak effect after 8 quarters. In terms of financial assets, after the first period, households substitute their intraperiod savings from deposits to bonds. On the other hand, loans see a minimal response to a monetary policy shock. In terms of these variables, almost all of the effect is diluted after around 25 quarters.

Figure 3.1: Effects of Monetary Policy Shock on Financial Variables

Source: Author’s Calculations
In terms of real variables, Figure 3.2 shows the effect on output, consumption, labor, wages, capital and inflation. The blue lines with triangles show the effect the impulse response of a monetary policy shock on the variables related to unconstrained firms, the impulse response of the variables related to constrained firms are shown in red lines with circles, and black lines show the effects on the economy as a whole. The effect over the variables of the aggregate economy is consistent to what has been found in the literature that studies monetary policy shocks, Christiano et al. [2010b], but the effect of a monetary policy shock varies on firms with different levels of financial constraints.

In terms of output consumption and labor hours, the effect on constrained firms follows the same pattern of unconstrained firms, but the effect is stronger on unconstrained firms. The impact on these variables is completely reversed after around 30 periods.

The effect on investment shows completely different patterns in three cases analyzed. In unconstrained firms, although there is an initial decrease in investment this is then reversed as the nominal interest rate decreases and bond financing increases. On the other hand, investment in the constrained firms remains negative after the monetary policy shock, in spite of the fact that, for these firms, capital not only is used as for production but it also acts as collateral for their loans.
Figure 3.2: Effects of Monetary Policy Shock on Real Variables and Inflation

Overall the effect of a monetary policy shock in an economy with heterogenous firms works in the following way: on impact, financially constrained firms have a weaker reaction to an unanticipated change in monetary policy than unconstrained firms, due to the fact that the former firms cannot increase their borrowing as they are already hitting the collateral constraint. This weaker increase in production for constrained firms relative to unconstrained firms leads to an increase in its price relative to that of unconstrained good, this, in turn, leads to a substitution of consumption from constrained
firm goods to unconstrained firm goods. This shows that the effect of monetary policy on constrained firms is limited and that unconstrained firms receive the bulk of the effect. The effect of the monetary policy shock will depend on the proportion of firms in the constrained sector, the intensity of the collateral constraint and the constrained firms levels of capital.

**Comparing Models with Different Number of Constrained Firms**

In this section I compare the heterogenous firms model against other two extreme versions of the same model. In the first, all firms face financial constraints, while in the second version there are no financial constraints. These versions of the model contain the same nominal and real rigidities as the heterogenous firms model, the main difference is that in the all-constrained version the whole section on the unconstrained firm part of the model is eliminated. On the other hand, in the all-unconstrained version the collateral constraint is eliminated. Note that in the all-unconstrained case firms are still financed by financial intermediaries, but these intermediaries do not demand any kind of collateral to provide funds. These versions of the model were developed this way, because it involved less manipulation of the original model, thus creating a closer version of that model. In order to make the models more comparable, some parameter values used in these models were changed in order to reach to a similar steady state.

This exercise is done to understand what is the effect of having varying degrees of financial constraints in a model. In general, it can be seen that the model without financial constraints shows a stronger response to monetary policy shocks and their
effects take longer to dissipate. In addition, although the heterogenous-firm version and the all-constrained version have different initial responses, the dynamics of both versions of the model tend to meet after 20 quarters.

The results of this exercise are presented in Figure 3.3. The black line shows the dynamics in which some firms are facing financial constraints, the blue line with triangles presents the version of the model in which all firms face financial constraints and the red line with circles shows the dynamics of the version in which there are no financial constraints. As before the responses show the effect of a 25 basis point decrease in the monetary policy rate.

On impact, the nominal rate decreases only in the model without financial constraints, while in the original version the interest rate increases, and in the constrained version it shows a minor response. In terms of the real interest rate, the no-constrained model presents an decrease in the real rate, which is greater than the initial monetary shock. A much softer response takes place in the model heterogenous-firms model, while in the all constrained model there the real rate increases in the first periods. Finally in terms of savings\textsuperscript{6}, the unconstrained model shows a greater increase in deposits, which shows that the income effect, caused by the fall in output, dominates the price effect, which would put pressure to a decrease in savings due to lower interest rate.

\textsuperscript{6}Savings in the heterogenous firms model consists of deposits and bonds, while on the other versions are just deposits.
In terms of real variables, there is an increase in output and labor which is much stronger in the unconstrained model than in the other two versions of the model, while the variables on the constrained model show a subdued response. This is later
reversed as output and labor turns negative in the unconstrained version of the model, while in the other two versions they remain positive. In terms of consumption, the response is, surprisingly, strongest in the original model and remains positive for the following periods. While the all-constrained version shows a similar, although weaker, response, the all-unconstrained version not only shows a weak response but it also becomes negative after 10 periods. These dynamics contrast with the response of capital, which is strong in the all-unconstrained model, while in the other versions it barely reacts.

Taking all into account, the variables in the unconstrained version of the model have a stronger response to monetary policy shocks. This comes together with greater uncertainty as a strong positive response is followed by strong negative dynamics. As such, in a country better represented by the unconstrained model the central bank will need to make smaller adjustments to the monetary policy rate. In contrast, the variables in the all-constrained version of the model have a weaker response to monetary policy shocks. As such, in a country better represented by the constrained version of the model the central bank will need to make stronger movements to the monetary policy rate.

3.6 Conclusions

In this paper I present a medium size DSGE model to analyze the effects of monetary policy shocks on the economy. The novel feature of the model is to abandon the representative firm assumption by identifying firms as either financially constrained
or unconstrained while keeping the model tractable. The financial constraints come from the fact that some firms do not release enough information to the public, so they need to guarantee the loans they take by using collateral.

The general equilibrium model I develop is populated by firms, constrained and unconstrained, households, capital producers, financial intermediaries and a central bank. Unconstrained firms are assumed to release enough information to the public, so households understand the company well and they are willing to lend resources directly to these firms. On the other hand, constrained firms need to rely on financial institutions for loans by not releasing information to the public. These loans are required to be secured by collateral. The model also include a number of rigidities that are now standard in monetary literature, which include: external habit formation, staggered wages, cost of investment, cost of adjusting prices and working capital.

The model is then used to study the transmission of monetary policy by analyzing the model’s impulse responses to an unanticipated 25 basis points decrease in the policy rate. The results show that financially constrained firms have a subdued response to monetary policy shocks, so the main effect of monetary policy is transmitted through unconstrained firms.

An exercise was performed comparing different versions of the model with varying the level of financial constraints. The results show that financially constrained models tend to have a weaker response to monetary policy shocks than unconstrained models. This stronger response comes together with greater uncertainty as a strong positive response is followed by strong negative dynamics. As such, in a country better
represented by the unconstrained model the central bank will need to make smaller adjustments to the monetary policy rate. In contrast, the variables in the all-constrained version of the model have a weaker response to monetary policy shocks. As such, in a country better represented by the constrained version of the model the central bank will need to make stronger movements to the monetary policy rate.
Chapter 4

Monetary Policy Effects on the Chilean Stock Market: An Automated Content Approach

4.1 Introduction

The latest financial crisis has increased the interest in understanding how monetary policy is developed and implemented, and how the implementation impacts the rest of the economy. One of the branches of the literature examining monetary policy effects analyzes the influence that regular policy announcements have on financial markets. This line of study has developed from the work of Cook and Hahn [1989], who measure the one-day response of bond rates to changes in the Fed Funds target rate. More recent studies include Kuttner [2001] and Bernanke and Kuttner [2005] who evaluate the effect of the unexpected component of the target rate changes on U.S. interest
rates and broad equity indices.

In recent years, this literature has developed beyond the analysis of the central bank target rate and has analyzed the qualitative information found in statements, minutes, speeches, and other types of policy documents, and has examined the effects of such information on financial markets. These market reactions depend on the type of information the documents contain and a nascent literature has turned to using Content Analysis, a common method used in other academic fields, to evaluate the qualitative information of the documents. In this paper, we look into the effects of the monetary policy decisions of the Central Bank of Chile on the returns of the Chilean Stock market between January 2003 and August 2016. We do this by evaluating the effects of monetary policy rate (MPR) surprises in conjunction with the qualitative content of the monetary policy statements.

Some of these studies which examine qualitative policy information have used a heuristic approach, which is conducted manually by the researcher. Specifically, the researcher analyzes each of the documents and, using his or her own judgment, quantifies the information content. An example of this approach is conducted by Rosa [2011]. He examines the impact of monetary policy statements - in conjunction with policy changes - on exchange rates. He finds that the statements have large and significant effects on the valuation of the U.S. dollar against other global currencies. The main issue with this approach is that it is subject to much of the bias of the evaluator.

In contrast, our paper uses the Automated Content Analysis approach, in which the evaluator creates a computer algorithm to extract the qualitative information
from policy statements. The main advantage of this method is that it is less susceptible
to the influence of the bias of the evaluator(s). An example comparing the differences
between the heuristic and automated approach can be found in the work of Lucca
and Trebbi [2009]. They conduct both a heuristic and an automated evaluation of
the statements and find that the automated approach seems to be more accurate in
depicting the information in the documents.

Using this methodology we study the information released in the monetary
policy statements regarding inflation outlook. We examine each statement and assess
if it leans toward decreasing large inflationary pressures, in what the literature calls
a *hawkish* tone or sentiment. The statements may instead lean towards promoting
growth, in what the literature represents as *dovish* sentiment. Using this evaluation,
we create an index that tracks the evolution of this sentiment. We then extract the
surprise sentiment component of this index and, in conjunction with monetary policy
rate surprises, we study its impact on the Chilean stock market.

The results show that the index we have created does a good job in tracking
the intention of the Chilean Central Bank Board. First, abrupt changes in the index
predict movements in the MPR. When we look at particular episodes, during the latest
financial crisis, the index shows that the communication of the Board leaned toward
promoting growth. After the crisis, our index indicates that the Board placed more
weight on inflation in Chile. However, the Board’s sentiment was not as hawkish as
what was seen prior to the financial crisis. In terms of monetary surprises, the results
show that prior to the financial crisis, the market reacted mainly to surprises in the
monetary policy rate (MPR), whereas after the financial crisis, the stock market also responds to the surprises in the information revealed in monetary policy statements.

To the best of our knowledge, the only paper that has examined the impact of Chilean monetary policy shocks while accounting for the information provided in the statements is the work by Garcia-Herrero et al. [2016]. Using a heuristic approach, the authors assess whether the Chilean interest rates of futures reacted to the information revealed by the Central Bank of Chile. Using the information from monetary statements, minutes, and inflation reports, they create an index that measures the communication sentiment of each of the documents. Using this index, they evaluate how the communication of the Central Bank affects the interest rates of futures. In contrast, we use an automated approach to analyze the complete document. In addition, the index that we built is a continuous variable from -100 to 100, which states the degree of hawkishness (or dovishness) of the documents, while theirs is a discrete index that takes integer values between -2 and 2, going from very dovish to very hawkish. Finally, we analyze the impact of sentiment surprises and monetary policy shocks on the stock market, while they focus on the interest rate futures market.

The rest of the paper is structured as follows. Section 4.2 reviews the relevant literature. Section 4.3 discusses the evolution of monetary policy implementation in Chile. Section 4.4 explains the data, the sources from which they are obtained, and some issues that we faced when analyzing them. Section 4.5 describes the methodology for building the sentiment index. Section 4.6 provides the results from regression analyses.

\footnote{García-Herrero et al. [2016] focus only on some sections of the texts whereas we consider all discussions relevant to the economic outlook.}
Finally, section 4.7 conducts some robustness and extensions while section 4.8 concludes with a few remarks.

4.2 Related Literature

Much of the literature evaluating the impact of policy documents are those that relate to the Federal Reserve (Fed). A significant number of these studies examine the short-term effects of Fed monetary policy announcements on financial markets. In his seminal work, Kuttner [2001] uses data from the federal funds futures market to estimate the impact of monetary policy actions on Treasury bills, notes, and bonds yields. Consistent with the expectations hypothesis, the results show that only unanticipated changes lead to large and significant responses. Bernanke and Kuttner [2005] add to these discussions by evaluating the impact of the unexpected component of the target rate changes on equity prices. They find that the unexpected component causes very large equity market reactions.

Along the same lines, Kiley [2014] analyzes the movements in long-term rates that are attributed to FOMC statements using the first-principal component of short-term interest rates. He then evaluates how these movements impact equity markets before and during the period when the fed funds target rate is set at its Zero Lower Bound (ZLB) value. He finds that equity prices are much more sensitive to the changes in long-term rates prior to 2009 compared to the period during the ZLB. Additionally, Gürkaynak et al. [2005] evaluate the impact of FOMC statements on financial markets.
They observe that much of the reactions of the markets are due to the information about the future path of policy as conveyed by the statements.

Other papers have also studied the effects of the information released in Federal Open Market Committee (FOMC) statements, speeches and minutes on international financial markets. For instance, Aizenman et al. [2014] examine FOMC member speeches during the ‘tapering tantrum’ period. They find that during this period, tapering news, particularly those relayed by the chairmen, have a large and adverse impact on exchange rates. The observed effect is largest among those countries with a combination of low external debt, current account surpluses, and large amounts of international reserves.

Studies that analyze the content of documents released by different central banks have also been done at the international level. Reeves and Sawicki [2007] study how financial markets react to the minutes and inflation reports from the Bank of England. The authors find that the publication of these documents affects near-term interest rate expectations in England. Hendry and Madeley [2010] extract information from Bank of Canada statements to find the type of information that affects returns and volatility of interest rate markets over the 2002-2008 period. For Brazil, Carvalho et al. [2013] use Google search queries to build a time series that measures whether each monetary policy statement is perceived as more hawkish or dovish. This time series is then used in regressions to explain changes in the term structure of interest rates.

For Chile, several papers that study the impact of monetary policy surprises on the financial markets have been written. The main differences among these papers are the way that monetary policy surprises are estimated. The earliest studies
are conducted by Larraín [2005, 2007] who use forward rates to estimate the surprise component of monetary policy decisions. The results show that the nominal yield curve reacts positively to monetary surprises, while the response of the real yield curve is subdued. In contrast, Meyer [2006] utilizes the answers from Bloomberg surveys to estimate the surprise component of monetary decisions between 2002 and 2006. In line with previous findings, the results show that monetary policy surprises have positive effects on nominal interest rates.

More recent papers include Ceballos [2014], who estimates the main components of the yield curve and analyzes the effects of macroeconomics news. He finds that monetary surprises have positive effects on the level of the yield curve, but have a negative impact on its slope. Acuña and Pinto [2015] use a low-frequency event study approach in measuring the effect of monetary surprises in a broad number of Chilean stock market indices. Contrary to what has been found in the literature, the results of their paper indicate that anticipated changes in monetary policy have negative effects on stock market returns, while non-anticipated changes do not seem to have any impact.

4.3 Monetary Policy in Chile

4.3.1 Monetary Policy before the 2008 Crisis

Monetary policy in Chile is currently conducted using an inflation targeting regime and is the result of a transitional process that has taken about fifteen years. In 1989, the Basic Constitutional Act of the Central Bank of Chile established that the
objectives of the Central Bank would be the stability in the value of the currency and
the normal functioning of the internal and external payment system. This means that
contrary to the objectives of the Federal Reserve, the Central Bank of Chile only has
to make sure that inflation is low and that the central bank is not mandated to target
maximum employment levels.

The main tool in the implementation of monetary policy in Chile is the Monetary Policy Rate (MPR). The level of this rate is decided monthly in monetary policy meetings, whose schedule is publicized six months in advance.\(^2\) The decisions made at these meetings are made public through statements, one-page documents released at 6 PM on the same day the policy meeting is held. In these documents, the board explains its decision based on current inflation forecasts, economic shocks, and international developments that could have an impact on the inflation level in Chile. Although unemployment and growth are not part of the mandate of the Central Bank of Chile, those are referenced in the statements because of their impact on inflation.\(^3,4\)

Although monetary policy in Chile finished its transition process in 1999, important changes in its implementation had taken place since, notably the nominalization of the reference rate and the fixation of the inflation rate target band. Until August 2001, the reference rate used in conducting monetary policy was an inflation-adjusted interest rate. In order to decrease inflation inertia, economic indexation was reduced by

\(^2\)Monetary policy meetings usually take place after the 10th day of each month.
\(^3\)Longer documents that contain more details, the meeting minutes, are released around two weeks after the policy meeting.
\(^4\)For more information about the conduction of monetary policy in Chile refer to Banco Central de Chile [2007].
switching the MPR target to a nominal interest rate level. Another important change that occurred in 2001 was the definition of the inflation rate target to a band between 2 percent and 4 percent and aimed at the center of 3 percent. This objective was set for an undefined period of time.\(^5\)

### 4.3.2 Monetary Policy around the Crisis Period

The situation in Chile was slightly different to that of the rest of the world prior to the Great Recession. This is because Chile was affected by a strong drought, which impacted food and energy production, among other things. Referring to figure 4.1, the effects of the drought on production led inflation to rise from 2.8 percent at the beginning of 2005 to 9.9 percent by October 2008. Although the crisis was well on its way to becoming a major event, the board decided to maintain the monetary policy rate at 8.25 percent until inflation subsided.

Once inflation began to decrease and economic activity showed signs of weakening, the central bank took several measures to counteract the effects of the financial crisis. These measures included the reduction of the monetary policy rate from 8.25 percent to 0.5 percent between January and July 2009. In addition, the Central Bank of Chile implemented a number of measures to ease the management of liquidity in the financial market and the enactment of complementary monetary policy measures starting in July 2009.\(^6\)

\(^5\)For more information about this transition period and the nominalization of the MPR, refer to Banco Central de Chile [2000], Morande [2002] and Massad [2003].

\(^6\)The measures aimed at managing financial market liquidity were announced on October 10th, December 3rd and December 10th of 2008.
As shown in figure 4.1, the Central Bank of Chile decided to keep the MPR at a minimum of 0.5 percent for eleven months starting in July 2009. During 2010, inflation began to show signs of acceleration so the Board decided in June of that year to increase the MPR to one percent. This decision was followed by a number of increases that quickly raised the rate to 5.25 percent. Finally, the Central Bank of Chile decided to make a sterilized intervention of the foreign exchange rate market in January 2011. Beginning on the 5th of that same month, the central bank implemented daily asset purchases of $50 million until December 2011. This measure was taken with the intention to increase the amount of reserves by $12 billion during 2011.

![Figure 4.1: Chilean Monetary Policy and Inflation Rates](image)

Source: Central Bank of Chile
Note: The vertical line marks the Lehman Brothers bankruptcy

### 4.4 Data

In the literature that examines the effect of monetary policy surprises on financial markets in the United States, during a very small period of time, it is assumed that
when the Federal Reserve release its policy statements, everything else is constant and there is no other relevant information that could affect the markets. This is because the FOMC meeting statements and minutes are released while the markets are still open. The case is different with Chile. The statements are released after the closing of the markets, so the effect on prices and returns are observed the following morning. It is reasonable to assume that after the release of the statements and before the opening of the markets, there is new information that affects prices and returns.

To account for this possibility, in our analysis, we include a measure that would capture relevant events in the foreign markets. The measures that we examine have to satisfy two criteria. First, important events in the international markets must affect the measure before, or at the same time, as the Chilean stock market. Second, the direction of causality must be that the changes in this measure impact the Chilean stock market and not the other way around. Otherwise, our estimated effect will not be capturing the influence of foreign events in the Chilean markets.

Following this criterion, we use the return of a US stock market index to capture the effect of foreign news on the Chilean stock. The measures we test include the S&P 500 and the Dow Jones Industrial average, the main broad equity indices of the U.S., as well as the Exchange Traded Funds (ETF) that follow these indices. We also incorporate the VIX index, which is the implied measure of risk of the S&P 500, as a measure to capture risk in U.S. equity markets. Stock market indices from other countries, such as European or Asian indexes, do not qualify for our criteria given that they leave too much time without trading so there are long periods of time when foreign
information reflected by these markets is not captured.\textsuperscript{7}

To measure the return of the Chilean stock market, we consider the IPSA index, which is the main stock market index in Chile.\textsuperscript{8} Since the release of the statements occur after the closing of the financial markets, we find that the proper return is the one that is obtained by comparing the closing level of the IPSA on the same day as the policy meeting with the opening level of the following day. However, we found that in roughly the first half of the sample, the opening level of the index is the same as the closing level on the previous day. Interestingly, in the second half of the sample, the opening level is generally different to the closing level of the previous day. We assume that there must have been a change in the methodology in calculating the index.\textsuperscript{9}

In light of the issues surrounding the calculation of the return of the stock market indices, we have decided to compare the closing level on the day after the policy meeting with the closing level on the release day. By including a measure of the US stock market, we expect to capture the new information released outside Chile. Since Chile is mainly a copper exporter, we include the change in the copper price. Lastly, we also include the price of WTI oil since oil is the main import of the country.

The data used for the analysis ranges from January 2003 to August 2016. In total, the dataset accounts for 164 policy meetings. Removing the meetings that

\textsuperscript{7}We also focus on the U.S. stock index given that much of the financial market activity within the same timeline as Chile occurs in U.S. markets.

\textsuperscript{8}Other stock market indexes either have a more limited number of stocks (inter-10 only measures the return of 10 stocks) or are simply a disaggregation of the IPSA.

\textsuperscript{9}We called the department in charge of producing the index, The Chilean Exchange, and they could not provide an answer to explain this characteristic of the data. We also tried obtaining intraday data to use as an alternative; however, records of this type are not kept by the exchange, and Bloomberg only keeps data for the last 200 days.
coincide with a holiday in the US leaves a total of 151 observations. Data for financial variables are obtained from Bloomberg. We have also procured the expected level of the MPR from the Bloomberg survey. Finally, the effective level of MPR, as well as the policy statements, are acquired directly from the website of the Central Bank of Chile. With the exception of the policy statements issued in January, February, and March 2003, all of the other statements are obtained in English. The statements that are not available in English are translated by the authors following the style of the statements.

4.5 Sentiment Analysis

4.5.1 The Dictionary Method

Monetary policy statements include information not only about policy decisions but also discussions regarding economic outlook. These statements update the beliefs regarding Chile’s current economic fundamentals as well as the expectations regarding future policies. In order to assess the type of information in these documents, we conduct the Dictionary Method of Automated Content Analysis using the Python programming language.

In order to conduct this methodology, we follow Tadle [2016] and create a compilation of key terms and modifiers based on the content of the policy statements. We account for two categories, referenced as sentiments, which represent the policy tilt based on the overall economic discussion. Those terms that relate to higher inflationary

\footnote{Due to the construction of available data, we could not create a distinction between which of the expectations are driving the effect. The results we obtain are the aggregate effect of these changes in expectations.}
pressures and are contractionary policy leaning are denoted as *Hawkish*, while those that convey a more subdued inflation outlook and show expansionary policy leaning discussions are referred to as *Dovish*. Table 4.1 shows the collection of key terms considered in the analysis.

In addition, we compile a set of modifiers that are widely used in the policy statements. These modifiers can be either positive or negative, as shown in table 4.2 and table 4.3, respectively. They can be nouns, adjectives, verbs, or adverbs, and have their unique conjugations.\textsuperscript{11}

<table>
<thead>
<tr>
<th>Table 4.1: Key Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hawkish Keys</strong></td>
</tr>
<tr>
<td>accounts</td>
</tr>
<tr>
<td>demand</td>
</tr>
<tr>
<td>expenditure</td>
</tr>
<tr>
<td>inflation</td>
</tr>
<tr>
<td>lending</td>
</tr>
<tr>
<td>yen</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Dovish Keys</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>exchange</td>
</tr>
<tr>
<td>turbulence</td>
</tr>
</tbody>
</table>

The keys are categorized as either *hawkish* or *dovish*. In order for a key term to be classified as *hawkish*, it must be true that when it is used in conjunction with a positive modifier, it conveys a contractionary policy leaning sentiment. If the same *hawkish* term is used together with a negative modifier, it signals a stronger sentiment towards expansionary monetary policies. For example, the combination of the key term

\textsuperscript{11}Taking the roots of the terms changes the context of the examined information. For this reason, their conjugations are maintained.
‘prices’ and the modifier ‘high’ results to the phrase ‘high prices’, which indicates a hawkish sentiment. On the other hand, replacing the term ‘high’ with ‘low’, which is categorized as a negative modifier, results in the dovish phrase ‘low prices’. Following this classification method, we categorize the keyword ‘prices’ as hawkish.

Table 4.2: Positive Modifiers

<table>
<thead>
<tr>
<th>above</th>
<th>accelerated</th>
<th>acceleration</th>
<th>active</th>
<th>advantageous</th>
</tr>
</thead>
<tbody>
<tr>
<td>appreciate</td>
<td>appreciated</td>
<td>appreciation</td>
<td>aggravated</td>
<td>better</td>
</tr>
<tr>
<td>dynamic</td>
<td>elevated</td>
<td>exceed</td>
<td>exceeded</td>
<td>expand</td>
</tr>
<tr>
<td>expanded</td>
<td>expanding</td>
<td>expansionary</td>
<td>favorable</td>
<td>gained</td>
</tr>
<tr>
<td>good</td>
<td>grow</td>
<td>high</td>
<td>higher</td>
<td>highs</td>
</tr>
<tr>
<td>improve</td>
<td>improved</td>
<td>improvement</td>
<td>improvements</td>
<td>increase</td>
</tr>
<tr>
<td>increased</td>
<td>increasing</td>
<td>normalize</td>
<td>normalizing</td>
<td>optimistic</td>
</tr>
<tr>
<td>outpacing</td>
<td>outperformed</td>
<td>over</td>
<td>positive</td>
<td>progressing</td>
</tr>
<tr>
<td>propitious</td>
<td>raise</td>
<td>rapidly</td>
<td>rebound</td>
<td>recover</td>
</tr>
<tr>
<td>recovered</td>
<td>regained</td>
<td>rise</td>
<td>risen</td>
<td>rising</td>
</tr>
<tr>
<td>robust</td>
<td>rose</td>
<td>significant</td>
<td>solvency</td>
<td>sound</td>
</tr>
<tr>
<td>stabilization</td>
<td>steadily</td>
<td>stirring</td>
<td>strengthening</td>
<td>strengthened</td>
</tr>
<tr>
<td>strong</td>
<td>stronger</td>
<td>strongly</td>
<td>up</td>
<td>upturn</td>
</tr>
<tr>
<td>vigor</td>
<td>vigorous</td>
<td>vigorously</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: ‘intensification’ is denoted as negative since it is only used with ‘downside risk’.

An analogous process is used to select Dovish key terms. In order for a key term to be classified as Dovish, it must be true that when it is used in conjunction with a positive modifier, it conveys an expansionary policy sentiment. If the same Dovish term is used together with a negative modifier, it relays a contractionary leaning sentiment. For example, the combination of the key term ‘recession’ and the modifier ‘significant’ results to the phrase ‘significant recession’, which indicates a dovish sentiment. On the other hand, replacing the term ‘significant’ with ‘subdued’, which is categorized as a negative modifier, results in the dovish phrase ‘subdued recession’. Following this
classification method, we categorize the keyword ‘recession’ as dovish.

The Dictionary Method is then implemented by keeping all those sentences that contain any of the key terms and eliminating the rest of the sentences. These sentences that are removed do not incorporate information related to the economic outlook, particularly regarding inflation. Those that are kept are evaluated based on the number of modifiers they contain and the types of keywords they have.

Sentences with hawkish keywords that have more positive than negative key terms are given a score of ‘+1’. On the other hand, sentences with hawkish key terms that have more negative than positive modifiers are scored a ‘-1’. The opposite scoring strategy is conducted for sentences with dovish key terms. If a sentence with a dovish term has relatively more positive modifiers,

<table>
<thead>
<tr>
<th>Table 4.3: Negative Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>adverse</td>
</tr>
<tr>
<td>decelerating</td>
</tr>
<tr>
<td>depreciated</td>
</tr>
<tr>
<td>deterioration</td>
</tr>
<tr>
<td>down</td>
</tr>
<tr>
<td>dropping</td>
</tr>
<tr>
<td>fallen</td>
</tr>
<tr>
<td>fragility</td>
</tr>
<tr>
<td>lose</td>
</tr>
<tr>
<td>lowered</td>
</tr>
<tr>
<td>pause</td>
</tr>
<tr>
<td>receded</td>
</tr>
<tr>
<td>slow</td>
</tr>
<tr>
<td>sluggish</td>
</tr>
<tr>
<td>tension</td>
</tr>
<tr>
<td>undermined</td>
</tr>
<tr>
<td>weakness</td>
</tr>
</tbody>
</table>
Table 4.4: Example of Sentence Evaluations

**Sentence Example 1**
‘copper and oil prices have posted substantial reductions in recent weeks’
- Source: August 2011 Policy Statement
- Sentence Score: -1 (hawkish keyword and more negative than positive modifiers)

**Sentence Example 2**
‘annual inflation dropped but it remains above 5% and core indicators are above 4%’
- Source: December 2014 Policy Statement
- Sentence score: +1 (hawkish keywords and more positive than negative modifiers)

it is given a score of ‘-1’. However, if it has relatively more negative modifiers, it is scored a ‘+1’. For sentences with equal numbers of positive and negative modifiers, we give a score of ‘0’. We do not differentiate among the degree of hawkishness within sentence for two reasons. We want to avoid exposing the scoring metric to additional subjectivity. Moreover, the addition of within-sentence variation in scoring creates ambiguity that makes the categorization much more difficult to quantify.

We present some examples of the sentence evaluations in Table 4.4. In the first example taken from the August 2011 policy statement, the sentence has a hawkish keyword and only has one modifier, which is negative. Following the scoring metric, this sentence is given a score of ‘-1’, implying that it conveys a dovish sentiment. On the other hand, the second sentence, extracted from the December 2014 policy statement, has hawkish keywords and two positive and one negative modifier. Based on the described scoring procedure, this sentence has a score of ‘+1’, which reflects its hawkish information.
The next step we take is aggregating the scores of individual sentences by policy statement. We then divide the aggregate score by the number of evaluated sentences in each document. After scaling by 100, we create a continuous document sentiment measure that ranges from -100 to 100.

4.5.2 Applying the Dictionary Method to the Policy Statements

We apply the Dictionary Method on the monthly policy statements released since January 2003 to August 2016. This period covers both the extreme drought, the international financial crisis of 2008-2009, and the occurrence of the effective monetary policy rate lower bound in Chile. Figure 4.2 shows the corresponding series. Although we observe that the statements reflect a more dovish trend overall, the sentiment score series shows movements that are closely related to the movements of the monetary policy rate. After a period of great volatility in 2003, the sentiment index increases rapidly during 2004 and leads the rapid increase of the monetary policy rate. The index then moved to a period of low dovishness during 2007 in line with the drought. It is worth noting that the index does not decrease much during the financial crisis. This fact is explained by the high level of inflation that existed at the end of 2009.

After the spike in inflation in 2008 and the short period of deflation that followed, the inflation rate returned to levels close to that of the target. During the subsequent recovery period, the sentiment index stabilized within the range of ‘-10’ and ‘-20’ points. However, an important change occurred between June 2012 and August 2012 when the index dropped from -15 points to -31 points. This reflects the concern
regarding the growth prospects about the economy. Since then the index has mostly moved within a band -30 points and -40 points, in line with a slower economy.

Figure 4.2 demonstrates the pattern in which movements in the statement sentiment index shortly before similar changes in the MPR, particularly in the increases of the MPR in 2005 and 2010, as well as its decreases in 2009 and 2014. These observations suggest that sharp changes in the index signal changes in monetary policy implementation. This may well be due to the fact that risks to growth and inflation are highlighted in the statements well before actual changes in the MPR and that these documents reflect information that affect future decisions about the MPR.
4.6 Empirical Analysis

4.6.1 The Surprise Component of Document Sentiments

Figure 4.2 shows that the statement sentiment scores have fluctuated over time, and beginning in 2005, changes in the sentiment have only occurred gradually. Rosa [2011] finds a similar observation with the FOMC statements, and he argues that this follows from the small changes in fundamentals that are reflected by the wording in the meeting documents. Given that there seems to be some persistence in the sentiments, there may be some expected component in the discussions of these documents. Therefore, we need to differentiate the unexpected component from the expectations since the surprise information is what causes financial market reactions.

To obtain the unexpected component, we use the specification\(^\text{12}\)

\[
PSS_t = \alpha_0 + \alpha_1 PSS_{t-1} + \alpha_2 PSS_{t-2} + \alpha_3 CPI_{t}^{ex} + \alpha_4 CPI_{t-1}^{ex} \\
+ \alpha_5 CPI_{t-2}^{ex} + \alpha_6 Y_t^{ex} + \alpha_7 Y_{t-1}^{ex} + \alpha_8 Y_{t-2}^{ex} + u_t
\]  

(4.1)

where $PSS_t$ is the policy statement sentiment for period $t$, $CPI_t^{ex}$ is the one year ahead expected CPI inflation rate, and $Y_t^{ex}$ is the one year ahead expected monthly GDP growth as measured by the growth rate of the IMACEC index.\(^\text{13}\) These forecasts are obtained from the *Encuesta de Expectativas Economicas*.\(^\text{14}\)

Table 4.5 show the results of two versions of regression 4.1. In the first version,

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\(^\text{12}\)Using the Maximum Likelihood Estimation gives similar results.

\(^\text{13}\)The IMACEC index is an estimation that summarizes activity in different sectors of the economy. It is published monthly and its yearly change is an approximation of the evolution of the GDP.

\(^\text{14}\)This translates to ‘Economics Expectations Survey’. Every month, the Central Bank of Chile surveys a group of academics, consulting firms, and executives from financial institutions about a broad number of macroeconomic variables. The results from the responses are reported in the *Encuesta de Expectativas Economicas*. 

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the terms relating to the expected growth rate of the IMACEC index are omitted, while the second version presents the results of the full regression. The results show that the monetary policy sentiment is affected mainly by expected inflation and by lagged values of the sentiment itself, while expected growth does not seem to have effects on the sentiment score. Therefore, we take a parsimonious approach by selecting as our main specification the version of the regression that excludes growth terms.

The surprise component is the part of $PSS_t$ not explained by the first version.
of equation 4.1. We denote this surprise component as

\[ Sent_t^s = u_t \]

\( Sent_t^s \) provides a measure of the news shock, the unexpected component of the statements information that is unaccounted for by market asset prices.

### 4.6.2 Regression Analysis

Given the timing of the release of the policy statements, we use the IPSA daily returns as the main dependent variable. This way of measuring the impact of monetary policy on Chilean financial variables has been used by Meyer [2006], Larraín [2007], Ceballos [2014], and Garcia-Herrero et al. [2016].

Denoting the days with monetary policy meetings as \( t - 1 \), the return for some financial variable \( X \) is calculated as

\[
x_t = \frac{X_t - X_{t-1}}{X_{t-1}}
\]

(4.2)

where \( X_t \) represents the value for the financial variable at the end of day \( t \). To calculate the monetary surprise, \( MPR_t^s \), we compare the effective value of the MPR with the median value of the Bloomberg survey MPR forecast. In this case, the surprise element is of the form

\[
MPR_t^s = MPR_t - E_t(MPR_t^{BBG})
\]

(4.3)

where \( E_t(MPR_t^{BBG}) \) is the expected value of the monetary policy rate from Bloomberg and \( MPR_t \) is the effective value of the monetary policy rate.

\(^{15}\)Acuña and Pinto [2015] uses monthly returns instead.
To estimate the effect of monetary surprises on the financial variables of interest, we run the regression

\[ x_t = \beta_0 + \beta_1 r_t^{US} + \beta_2 MPR_t + \beta_3 Sent_t + \beta_4 WTI + \beta_5 Copper \]  

(4.4)

where \( x_t \) is the daily return of the financial variable, \( r_t^{US} \) is the daily return of SPY, the US stock market Exchange Traded Funds, \( Sent_t \) is the surprise component of the sentiment indicator, \( WTI \) is the daily return of the WTI oil commodity, and \( Copper \) is the daily return of the copper price.\(^{16}\)

We test for the possibility of a structural break in the relationship between monetary policy and the return of the stock market, since the sample period analyzed includes the financial crisis of 2007-2009. As explained in section 4.1, the types of policies that were implemented before the crisis were mainly movements of the MPR, whereas after the crisis a number of different policies were implemented.\(^{17}\) To test this hypothesis, we use the Cumulative Sum (CUSUM) of Squares Test for coefficient stability, following Brown et al. [1975]. This test is based on the cumulative sum of the quadratic values of the recursive residuals, which are the one step ahead forecast errors of the dependent variable. This test plots the cumulative sum alongside 5 percent critical lines. Any movement of the cumulative sum outside the critical values suggests coefficient instability.

The results of the test, as represented by figure 4.3, indicate that there is

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\(^{16}\)Similar results are obtained in the regression if we change the SPY for alternatives measures of the return of the US stock market. The measures we tested were the Dow Jones Industrial Average index (DJIA), the S&P500 index and the ETF that follow the DJIA.

\(^{17}\)The policies implemented after September 2008 are not quantifiable. Hence, we are not able to include those measures in our analysis.
reason to believe there is structural break around September 2008. To account for this structural break, we include a dummy variable which takes the a value of zero between the beginning of the sample and August 2008 and takes the value of 1 for the rest of the sample.\(^{18}\)

\[\text{Figure 4.3: Test of Stability}\]

\[\text{Table 4.6 shows the results for both of our regressions: the baseline regression and the one that accounts for a structural change in September 2008. The baseline regression shows that the Chilean stock exchange has a positive reaction to the US stock market. In addition, changes in the copper price have positive and significant effects on the Chilean stock market index, although the magnitudes of the effects are small. These reduced effects might be due to the fact that increases in the price of copper encourages economic growth in Chile. However, there is no copper producing}\]

\(^{18}\text{This approach of dividing the sample in two is also used by Garcia-Herrero et al. [2016].}\]
firm in the stock market so copper has an indirect effect over the stock market. On the other hand, the price of WTI has a strong and significant effect on the stock market. Contrary to what has been found in the literature, monetary surprises do not seem to have an effect on the equity market when using the whole sample. In the same token, the new information revealed by the surprise component of the statements do not seem to have any effect on the Chilean stock market index.

The results take a radical turn when the structural change is taken into account. The US stock market, copper price and the price of WTI oil continue to have positive and significant effects on the Chilean stock market. In contrast to what is found in the baseline regression, monetary surprises for the first half of the sample have a negative and significant impact on the stock market, in line with the economic intuition as well as the results of the literature. In this case, a monetary policy surprise rise of 25 bp decreases the return of the index by 47 bp.

Similarly, in the first half of the sample, the surprise component of the statements still indicates that the market does not seem to react to new information revealed in the statements. For the second half of the sample, the news shock has a positive impact on the stock market index. This is perhaps due to the fact that an unexpectedly more hawkish statement reveals a more positive economic forecast, thereby situating Chile’s economic outlook in a more positive light.

The differences between the baseline and the structural change regression results show that there has been a change in the way the market respond to monetary

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19 We have also considered examining assets whose value closely follow copper prices. However, there is no individual stock that is directly affected by the price of copper.
Table 4.6: Regression Results for Equation 4.4

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline</th>
<th>Structural Break</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.52 (6.70)</td>
<td>1.61 (6.46)</td>
</tr>
<tr>
<td>SPY</td>
<td>23.43** (10.12)</td>
<td>22.18** (9.04)</td>
</tr>
<tr>
<td>Monetary Surprise</td>
<td>-0.25 (0.39)</td>
<td>-1.88** (0.77)</td>
</tr>
<tr>
<td>Monetary Surprise × Dum</td>
<td></td>
<td>2.29** (0.89)</td>
</tr>
<tr>
<td>Sentiment Surprise</td>
<td>0.02 (0.68)</td>
<td>-0.32 (0.72)</td>
</tr>
<tr>
<td>Sentiment Surprise × Dummy</td>
<td></td>
<td>3.51** (1.63)</td>
</tr>
<tr>
<td>WTI</td>
<td>7.90** (3.66)</td>
<td>8.35*** (3.15)</td>
</tr>
<tr>
<td>Copper</td>
<td>10.88** (5.13)</td>
<td>10.15** (4.52)</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.2372</td>
<td>0.3004</td>
</tr>
<tr>
<td>F-test</td>
<td>0.0084</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Note: *, **, *** denote 10 percent, 5 percent and 1 percent level of significance.

Policy announcements. This could be explained by the diverse number of policies that were implemented after September 2008. In that sense, the results imply that before the crisis, the market focused almost exclusively in changes to the monetary policy rate. As the market observes signals about the downturn, it has begun to focus more on the information revealed in the statements.
4.7 Robustness and Extensions

4.7.1 Altering the Specification used for the News Shock

The estimation of the news shock may be subject to different specifications of equation 4.1. In order to evaluate the sensitivity of the results, we alter the specification. In one of the checks, we include an additional lag of the statement sentiment scores in the equation. This enables us to account for the sentiment of the policy statements for a whole quarter beforehand.

The results with the altered statement shocks are given in table 4.7. We again compare the results from the baseline regression to those obtained using the main specification. Comparing these values of table 4.6, we find that the results barely change and remain qualitatively the same.

In order to also evaluate the robustness of the results when equation 4.1 is altered differently, we also take into account the forecasts for changes in the real GDP, as measured by the IMACEC index. We also incorporate other measures of inflation forecasts, particularly those that project the two year level of inflation. Even with these changes, we find that the results hold.
Table 4.7: Regression Results: Adjusted News Shocks

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline</th>
<th>Structural Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.54</td>
<td>1.16</td>
</tr>
<tr>
<td></td>
<td>(6.80)</td>
<td>(6.57)</td>
</tr>
<tr>
<td>SPY</td>
<td>23.45**</td>
<td>22.19**</td>
</tr>
<tr>
<td></td>
<td>(10.16)</td>
<td>(8.98)</td>
</tr>
<tr>
<td>Monetary Surprise</td>
<td>-0.25</td>
<td>-1.88**</td>
</tr>
<tr>
<td></td>
<td>(0.39)</td>
<td>(0.77)</td>
</tr>
<tr>
<td>Monetary Surprise×Dum</td>
<td></td>
<td>2.27**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.89)</td>
</tr>
<tr>
<td>Sentiment Surprise</td>
<td>-0.03</td>
<td>-0.34</td>
</tr>
<tr>
<td></td>
<td>(0.74)</td>
<td>(0.84)</td>
</tr>
<tr>
<td>Sentiment Surprise×Dummy</td>
<td>2.93*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.70)</td>
<td></td>
</tr>
<tr>
<td>WTI</td>
<td>7.87**</td>
<td>8.39***</td>
</tr>
<tr>
<td></td>
<td>(3.66)</td>
<td>(3.16)</td>
</tr>
<tr>
<td>Copper</td>
<td>10.88**</td>
<td>10.05**</td>
</tr>
<tr>
<td></td>
<td>(5.14)</td>
<td>(4.57)</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.2371</td>
<td>0.2939</td>
</tr>
<tr>
<td>F-test</td>
<td>0.0082</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

Note: *, **, *** denote 10 percent, 5 percent, 1 percent level of significance, respectively

4.7.2 Assymetric Effects of Monetary Policy Annoucements

We also test whether there are asymmetric effects in the response to surprises in the sentiment component of the monetary policy statements. For this, we create two dummy variables. The first is the variable \(INCREASE\), which takes the value of one when there are increases in the MPR, and 0 otherwise. The other dummy variable, \(DECREASE\), is set equal to one when there are decreases in the MPR, and 0 otherwise. Taking into account the results of the previous sections, we additionally test for changes in the asymmetric response to surprises in the sentiment component of the monetary policy statements.
The results of this test can be seen in Table 4.8, where the first column denotes the results of the analysis that assumes no structural change in the relationship of the variables. The lack of any significant coefficient indicates that there is no evidence that supports the idea of asymmetric responses to surprise in the statements. The results are similar when structural change are taken into account, as in the second column.\textsuperscript{20}

\textsuperscript{20}When the variable that captures the movements in the US market is replaced by the Dow Jones Index the coefficient that accompanies increases in MPR for the second half of the sample is marginally significant.
Table 4.8: Assymetric Effects

<table>
<thead>
<tr>
<th>Variable</th>
<th>W/o Break Dummy</th>
<th>W/ Break Dummy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>8.10 (7.40)</td>
<td>6.54 (7.31)</td>
</tr>
<tr>
<td>SPY</td>
<td>23.09** (10.18)</td>
<td>20.35** (8.78)</td>
</tr>
<tr>
<td>Monetary Surprise</td>
<td>-0.39 (0.47)</td>
<td>-2.43** (1.13)</td>
</tr>
<tr>
<td>Monetary Surprise×Dum</td>
<td>2.75** (1.32)</td>
<td></td>
</tr>
<tr>
<td>Sentiment Surprise</td>
<td>0.51 (0.79)</td>
<td>0.06 (0.81)</td>
</tr>
<tr>
<td>Sentiment Surprise×Dummy</td>
<td>3.19** (1.60)</td>
<td></td>
</tr>
<tr>
<td>WTI</td>
<td>8.38** (3.63)</td>
<td>9.30*** (3.20)</td>
</tr>
<tr>
<td>Copper</td>
<td>10.83** (5.13)</td>
<td>10.53** (4.56)</td>
</tr>
<tr>
<td>INCREASE</td>
<td>-18.03 (17.89)</td>
<td>-15.98 (18.93)</td>
</tr>
<tr>
<td>DECREASE</td>
<td>-29.99 (37.54)</td>
<td>-22.95 (35.16)</td>
</tr>
<tr>
<td>Sentiment Surprise×INCREASE</td>
<td>-0.44 (2.00)</td>
<td>-0.19 (1.95)</td>
</tr>
<tr>
<td>Sentiment Surprise×DECREASE</td>
<td>-4.11 (3.97)</td>
<td>18.06 (16.24)</td>
</tr>
<tr>
<td>Sentiment Surprise×INCREASE×Dummy</td>
<td>9.66 (6.92)</td>
<td></td>
</tr>
<tr>
<td>Sentiment Surprise×DECREASE×Dummy</td>
<td>-22.98 (14.44)</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.2530</td>
<td>0.3351</td>
</tr>
<tr>
<td>F-test</td>
<td>0.0043</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Note: *, **, *** denote 10 percent, 5 percent, 1 percent level of significance, respectively.
4.7.3 Sentiment Component Index: Domestic Indicators only

Figure 4.4: Full Statement vs Domestic Only Factors

Given that the policy statements of the Central Bank of Chile discuss economic indicators of other countries, we want to determine whether such discussions drive a significant portion of the results. In order to evaluate this possibility, we recalibrate the sentiment score of each policy statement while focusing only on discussions about domestic outlook.\textsuperscript{21} Referring to figure 4.4, we find that the sentiments calculated using only domestic factors follow a very similar pattern as the main measure.

We also evaluate the results using this measure. Our findings indicate that the news shock is still significant at the 95\% level after accounting for the structural break in the reactions of the stock market. Thus, much of the estimated impact of the discussions in the statements seem to result from the information related to domestic

4.8 Conclusion

In this paper, we present a study of the short term effects of monetary policy shock in the Chilean stock market. Although this types of studies have been done extensively for the US, there is only a small number of studies that have done this for Chile. The novelty of this study is that it also looks at surprises in the announcements in the policy meetings.

Using Automated Content Analysis, we measure the tone of each monetary policy statements released after each of the policy meeting between January 2003 and August 2016. With this information, we are able to build a series that tracks the evolution of the economic outlook of the monetary policy statements. We find that this series, which we refer to as sentiments, leads changes in the monetary policy rate. In particular, when the sentiment does not show relevant movements, there are no observed changes in the monetary policy rate.

Using regression analysis, we then extract the surprise component of the series using inflation forecasts and lagged values of the sentiment component. We use the surprise component along with surprises in changes of the monetary policy rate and other explanatory variables to find the overall effect of monetary policy shocks on the stock market. We find that from the beginning of the sample to August 2008, the stock markets seems to react to surprises in the monetary policy rate, while surprises in the
sentiment component are not significant. On the other hand, after August 2008 to the end of the sample, we find that surprises in the monetary policy rate are not relevant for the stock market, while surprises in the sentiment component shows significant effects on the stock market.

Future research agenda include using the surprise component to understand the effects of monetary policy surprises on the Chilean exchange rate and local interest rate market. In addition, future research might try to assess the reason why there is a structural break in the reaction of the stock market to monetary policy surprises.
Bibliography


Banco Central de Chile. La política monetaria del banco central de chile en el marco de metas de inflación. Technical report, Banco Central de Chile, 2007.


Carlos Carvalho, Fernando Cordeiro, and Juliana Vargas. Just words?: A quantitative analysis of the communication of the Central Bank of Brazil. *Revista Brasileira de*


Vasco Curdia and Michael Woodford. Credit frictions and optimal monetary policy.


Julio Garin, Robert Lester, and Eric Sims. Raise rates to raise inflation? neo-


Scott Hendry and Alison Madeley. Text mining and the information content of bank of canada communications. 2010.


Nobuhiro Kiyotaki and John Moore. Liquidity, business cycles, and monetary policy.

Anna Kovner, James I Vickery, and Lily Y Zhou. Do big banks have lower operating costs? 2014.


Franco Modigliani and Merton H. Miller. The cost of capital, corporation finance and


Joe Peek and Eric S Rosengren. Collateral damage: Effects of the japanese bank crisis


