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FINANCIAL FRICTIONS AND WEALTH DISTRIBUTION: A THEORETIC APPROACH

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For my mom.

For my dad.

Special thanks to my patient and encouraging advisor, Dr. Alexander Dentler

Abstract

The purpose of the thesis is to show the implications of a specific financial friction, the lending-deposit spread rate, on the distribution of liquid wealth and on welfare. The lending-deposit spread rate is just the difference between the lending rate and the deposit rate. Liquid wealth is defined as the total set of tangible and intangible assets that are accepted as a mean of payment (e.g. cash, checks, credit cards, properties, reputation). The base model used to achieve that is a search-theoretic monetary one, in which individuals exchange money for consumption goods in a decentralized market structure. Bargaining takes place during bilateral meetings where agents sell or buy consumption goods between each other in return for a monetary transfer. The assumptions of the model allow to study lending-borrowing patterns over the quantity of money held by the individuals. A high lending rate forces agents to consume less while low level of the interest rate will generate more consumption. In this economy, there exist individuals that borrow or lend money. Borrowers are considered debtors only if their money holdings are below a certain monetary threshold. They will borrow from lenders paying the correspondent lending interest rate in order to acquire a unit of consumption. The results suggest that when the lending interest rate is too high, the Gini coefficient of wealth tend approximately to equality while the level of welfare diminishes. Likewise, a high lending interest rate will decrease the amount of good traded as well as the amount of money paid for the good. On the contrary, when individuals face a lower lending interest rate, they will be more likely to increase consumption by issuing debt. A theoretic exploration is developed to analyze the relation between the marginal utility function and the buyer and seller's value of money. In addition, a numerical simulation is provided to address the effect of a high lending rate, given a fixed deposit rate, on the Gini index and welfare.

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Chapter 1

Introduction

The 2008-09 global financial crisis showed how vulnerable the financial sector was to uninsured financial friction shocks. The contraction in macroeconomic activity of developed and developing economies through financial channels, such as credit conditions, provided an opportunity to study how financial constraints affect macroeconomic output. The issue of financial friction shocks over macro and microeconomic variables has been a controversial and much disputed subject within the field of macro and micro theory. While some researches have taken search theory as a more convenient approach no single study exist which demonstrates a quantitative analysis between exogenous changes in the lending-deposit spread rate and the income distribution. So far monetary search methods have only been applied to explain money as a mean of exchange. Therefore, it is pertinent to ask in what manner do credit frictions distort wealth accumulation and what approach is well suited to address exogenous financial frictions issues? What approaches are being considered to measure financial frictions effects on income distribution in the economy? And finally, what is the main framework that economists and policymakers have taken to examine the implications of high lending rates on underdeveloped economies?

In the last three decades, a monetary framework concerning search theory has provided rigorous and useful models to discuss some important monetary and fiscal policy issues such as money as a medium of exchange and changes in the level of money supply. These models are characterized by using random bilateral matching to represent the trading process of bargaining for either a centralized and/or a decentralized market structure. Referring to the usefulness of the search theory of money, authors like Nobuhiro Kiyotaki (1989,1993), Randall Wright (1989,1993), Ricardo Lagos (2005) and Miguel Molico (2006) have been implementing search-based models of money in support of broadening the process of monetary exchange by making explicit the frictions that can lead to an efficient exchange arrangement during trading.

Despite the theoretic framework developed so far, currently adopted models are partially suitable to formalize the role of fiat money as a medium of exchange due to their reduced-form and simplified assumptions. This means that severe restrictions are imposed in these models in order to make them tractable for monetary policy analysis. In addition, by not specifying the frictions (e.g. explicit market exchange mechanisms, informational asymmetries and financial frictions) that make monetary exchange useful, reduced-form models may be too limited to describe possible determinants of monetary shocks in the economy.

Restrictive classic monetary search models are not well-suited *per se* to address specific financial friction issues on wealth inequality distribution. Numerous financial studies have extrapolated search theory to modeling the financial frictions that are characteristic in credit markets as well as in over-the-counter markets (Lagos, Rocheteau, 2009).However, there is no theoretical model that directly links the interest rate spread friction with wealth inequality under bilateral trading. That being said, this thesis intends to determine the extent to which the lending-deposit interest rate spread[1] affects wealth distribution as well as the distribution of prices under a decentralized market exchange configuration.

The search-theory literature on financial markets have provided an approach that emphasizes the effects of trading frictions, idiosyncratic shocks, measures of liquidity, credit market constraints on asset price distribution and on macroeconomic stability. As a specific case, it has pointed out to financial intermediaries as a key determinant to overcome credit financial frictions reaching price and monetary stability. Hence, allowing credit frictions to be incorporated into search-based monetary analysis helps understanding some implications of exogenous financial elements like the interest rate spread on aggregate welfare for the conduct of monetary policy.

The thesis extends the work developed by Miguel Molico (2006), where I present a special form of financial friction in a particular monetary environment with a search-based model approach. I take into account three main points: the first, changes on the welfare distribution as a result of a higher lending rate; second, a standard measure of income inequality (Gini index) and its interaction with respect to exogenous variations in the lending rate; third,

[1] The interest rate spread is an economic development indicator defined as the difference between the lending interest rate charged by banks on loans and the deposit interest rate paid by saving depositors (public and private customers including commercial banks). The rates differ by country and measure financial sector efficiency in intermediation.

changes in the amount of goods traded and monetary transfers under different levels of the lending rate. In general terms, Molico developed a search-theoretic model stressing the relation between monetary distribution, price distribution and idiosyncratic income shocks. This particular model takes into account the dynamic of agents holding a positive quantity of money every period of time and the bargaining processes carried out over the monetary transfers and the quantity of consumption goods, both exchanged during bilateral meetings. Under such a framework, the distributions of money holdings and of prices are determined endogenously.

Sketching preliminary results, the main insights from the theoretical exploration indicate that when the marginal value of money of a seller increases, his marginal utility will decrease since the monetary transfer he will receive by selling goods to someone will be spent in buying an addition unit of a consumption good, so it is possible that in the long term the marginal utility of a seller could decrease. This insight seems reasonable, considering that individuals sell or buy goods during bargaining. We can think about middle and middle-high income people as an example for this case. Another result illustrates that when the marginal value of money of a buyer raises, so will the marginal utility. The intuition behind this is that when the agent is more concerned about buying a unit of good in order to survive (e.g. like poor and extremely poor people), increases in his marginal value of money of buying will cause his marginal utility to be boosted. Similar results are found with the quantity of the good traded and with the monetary transfer paid by the buyer during bargaining. Here, it is much more easy to perceive why increases on the quantity traded induces reductions in the marginal utility. It follows the Law of Diminishing Marginal Utility, which states that for an additional unit of consumption, the change in utility will be lower.

Turning now to the numerical simulation outcomes, these suggest that when the interest rate charged on loans is too high, the Gini coefficient, welfare, the average quantity traded and the average amount of money traded will decrease. It should be clarified that with a high lending rate, the wealth distribution approximately converges to equality: this is what the Gini coefficient estimations show. However, the welfare level diminishes marginally. An implication of this is the possibility that most agents suffer a general reduction on both their consumption levels and wealth holdings as a result of a higher lending rate. Specifically, some agents won't have sufficient money holdings to acquire an additional unit of the consumption good because they won't be able to pay for it and also to pay, in case of being a debtor, the corresponding debt payment. In consequence, the amount of quantity traded, together with the monetary transfer, will be lower during bargaining.

The overall structure of this thesis takes the form of four chapters, including this introductory chapter. Chapter two begins by laying out the motivation section where, using empirical data provided by the World Bank database, an OLS and a fixed-effect regression illustrate the negative impact of the deposit-lending spreads on the Gini coefficient for a set of OECD countries. The third chapter is concerned with the methodology used in this thesis. There, I set out the fundamentals of the model which includes the description of the environment, the steady-state equilibrium conditions, a theoretical exploration and a numerical exercise. In these two last subsections, I extend the Molico's (2006) numerical exercise by including an exogenous lending rate and a fixed deposit interest rate variable in the numerical solution. In addition, the theoretical exploration provides an examination about the marginal consumption dependency on a bunch of variables: the quantity of the good traded, the monetary transfers and the marginal value function. Both exercises will allow me to derive insights on two main topics: lending-deposit spread, aggregate value for money and wealth inequality distribution. Finally, in the conclusion I give a brief summary of these findings.

Chapter 2

Motivation

The economic ravages caused by the historic great recession and the 2008-09 commodity financial crisis are a stark reminder that financial frictions are a key driver of systematic crisis to the economic stability. Classic economic literature has highlighted the importance of those frictions and its macroeconomic implications on the financial system during business cycles. Clearly, understanding financial-economic disruptions for policy responses entails adopting an adequate theoretic framework that allows to examine credit frictions and their interactions with monetary variables, as well as aggregate variables such as real GDP and income equality. By doing this, enriching and extending the macroeconomic analysis for such phenomena.

Assume a frictionless economic environment where aggregate output is studied as a representative agent paradigm; money holdings and capital flow from one hand to other and funding does not cause any issues. Under this context, it seems worthless to examining wealth distribution due to the limitations imposed by the representative agent paradigm which undercuts the analysis of credit frictions' dynamics on welfare, capital and income misallocation. On the contrary, allowing financial frictions to be integrated as part of the basis of monetary search theory, liquidity considerations become important and the wealth distribution, along with debt funding claims, does matter (Brunnermeier *et. al*., 2013). Fortunately, spurred by the surge in the blowout of credit market, together with a large decline in labor and output at a micro- and macro-level, after the 2007-2009 credit-commodity crisis an emerging literature has been aiming at financial frictions as an alternative source through which volatility fluctuations along with certain credit disruptions can affect macroeconomic outcomes (Arrellano *et al*., 2012; Christiano *et al*., 2014). For instance, inducing a significant tightening on the credit spread rate along with high levels of uncertainty and risky debt, leads to a decline in real GDP. This negative effect is driven by a drop in the investment component of aggregate spending (Simon, Jae and Egon, 2011). To illustrate that financial frictions are a disturbance source of economic activity, mainly on wealth inequality, evidence has to be shown.

Recent studies have outlined the causes for the economic development stagnation among Latin America countries. Notably, Gordon Hanson (2010) points out to some features of credit markets that may continue to inhibit Mexico's economic growth. After overcoming the 1994-95 banking crisis, Mexico has overhauled its financial regulations.

Despite Mexico's domestic credit reforms, there has not been any improvements relative to other Latin American countries. For example, Chile has enjoyed higher productivity and income growth than Mexico even though both countries have liberalized trade and privatized state companies. Hanson presents evidence relating to weak protections for creditors as the causal factor for limited credit access to credit in Mexico.

From a cross country approach, it has been well-documented (Gropp *et al.*, 1997) that, at least in the United States, providing high bankruptcy protections for debtors and low protections for creditors diverts lending away from borrowers. However, higher exemptions for personal bankruptcy could be seen as a form of partial wealth insurance for risk-averse borrowers as long as their marginal utility of wealth increase. Therefore, diverting credit away from the poorest does not necessarily translate into low productivity growth. Empirical evidence illustrates that impeding firms in obtaining finance either by terms of collateral requirements or interest rates, have had an indirect impact on Mexico's economic growth, as they relate to firm sales rather than productivity.

To evaluate the interaction of credit frictions on wealth inequality it is necessary to identify variables that ideally model this relation. Data for this thesis' section were provided by the World Bank's World Development Indicators available database for the period 1997-2015. This database covers the 34 OECD member countries[2] with annual data periodicity. For the purpose of analysis, an ordinary least squares (OLS) and a fixed effects estimation method are used on a pair of economic indicator variables for OECD countries. The OLS estimation analysis is problematic since further data collection is required to determine exactly the relationship among variables. Thus, the OLS regression is likely to give inaccurate estimations since there is missing data for a subset of selected countries[3]. The fixed-effects

[2] Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

[3] Australia, Turkey and the United Stated are the only three countries that don't have any deposit-lending spread data for the period 1997-2015.

estimation method is one of the more practical ways to overcome that difficulty. Hence, we would expect a reasonable estimation of the effects by running the fixed-effect regressions.

The measure of credit friction used as the independent variable is the interest rate spread (lending rate minus deposit rate). The dependent variable for the analysis is the Gini index (World Bank) which is a widely used measure of income or consumption inequality laying from 0 to 100, where 0 means perfectly equal. I also include a time trend control variable for each country in the sample.

As stated above, the way that the lending-deposit spread is correlated with the Gini index is estimated with an OLS and a Fixed-Effect linear regression models. Table 1, column 1, reports the OLS estimation results from regressing the Gini index on the lending-deposit spread. Note that the sign of the interest spread rate variable on the Gini index is positively significant, although the predicted value is quite problematic since its R-square coefficient is low (0.0315), meaning that high levels of variability affect the precision of the estimation which could possibly be attributed to the lack of data mentioned above. Columns (2)-(4) provide a glimpse of the fixed effect estimates with and without the time trend variable. As seen in column (2) the deposit-lending spread is significantly and negatively related to Gini index with a high r-squared coefficient. Barely significant and without the time trend variable, column (4) reveals a negative effect on Gini with a minimal r-squared value. Looking at the r-squared coefficient values presented in columns (1)-(4), the third column shows that when we exclude the deposit-lending spread variable from the fixed-effect regression, the model explains more than fifty percent of the data. Column (2) repeats this regression but including the spread rate variable and the interaction time-trend variables. The results are quite different, the r-squared is greater than column (3), which may reflect a more adequate model. After excluding the time-trend interaction variable from the model in column (4), the r-square coefficient appears to be the smallest, which may indicate that the excluded variable overestimate the model results.

Table 2.1: OLS & Fixed Effects Estimations
Ordinary Least Square (OLS) and Fixed-Effects (FE) estimation results.

	(1)	(2)	(3)	(4)
	OLS	FE	FE	FE
Time-trend interaction	No	Yes	Yes	No
Deposit-lending spread	Yes	Yes	No	Yes
Regressors	Gini_Coeff	Gini_Coeff	Gini_Coeff	Gini_Coeff
DLSpread	0.6446**	-0.3152***	-	-0.2879*
	(0.2772)	(0.1057)	-	(0.1486)
Constant	31.1651***	-120.7244**	-28.6102	34.5816***
	(1.1595)	(60.0748)	(39.3046)	(0.5771)
Observations	168	168	363	168
Number of country	-	25	34	25
R-squared	**0.0315**	**0.8058**	**0.5269**	**0.0258**

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Own table based on World Bank's World Development Indicators: Gini index series and Interest rate spread rate series.

Method: An OLS and a fixed-effects regression model are used. The independent variable (lending-deposit spread rate) is regressed on the dependent variable (Gini index). Additionally, a time trend variable for each country is used in the fixed-effects model.

From the data presented in Table 1, it is apparent that using a fixed-effects regression model, for columns (2) and (4), yields a negative deposit-lending spread coefficient. In other words, increases in this variable entails reductions in the Gini coefficient, which for our case, this might imply that a higher interest spread rate entails more income equality. However, the OLS estimation showed an opposite coefficient sign than the fixed-effects estimate. It seems possible that this is due to missing data. What is surprising is that when both the time-trend interaction and the deposit-lending spread are included in the fixed-effects model, the r-squared coefficient is relatively high. This is so, because the time-trend variable possibly carries more variation than the interest spread. This is verified by including just one of those variables in the regression. Interestingly, the variation explained by just the interaction variable is greater than the one explained by just including the interest spread. Overall, these results indicate that the deposit-lending spread coefficient have a little, but negative, impact on the Gini coefficient. It is important to bear in mind the possible bias in these estimations due to the lack of data.

Chapter 3

Literature review

Classic monetary models of money (the overlapping generations models, the cash-in-advance model and the money in the utility-function model) have been commonly criticized for their lack of describing endogenously the monetary exchange process in the economy. Attempts to formally modeling the medium of exchange role of money have been centered at a recent dominant framework, the search theory. Search theory has been used in a wide variety of applications such as finance, industrial organization, labor economics and monetary theory. It is in this last field where, since earliest 1990s, search-based models have been implemented what is considered “the driving force behind the use of money: specialization” (Kiyotaki, Wright, 1989). This notion has helped to reduce the double coincidence of wants problem by making fiat money an important element for bargaining, as well as, for trading strategies. Storability together with exchange and production costs are some of the intrinsic properties that accompanied the use of money in the exchange process.

In general, the basic structure of this class of models relies on the type of market structure which defines trading risks, as well as bilateral or multilateral bargaining processes among individuals. The first generation monetary model pioneered by Kiyotaki and Wright (1989) proposed a random bilateral matching model with divisible, nonstorable goods and costless currency storage. Equilibrium is constructed with valued commodity money and direct barter is allowed. The second generation of monetary search models improved on the theory of pricing by restraining the production and consumption holdings assumption and by using bargaining theory for measuring endogenous prices. As a result, Shi (1995) along with Trejos and Wright (1995b) have provided analytic results for heterogeneous exchange pattern and for price distribution but limiting their study by considering only a specific case.

General models like Green and Zhou (1998), Camera and Corbae (1999) and Molico (2006) relaxed the unit storage technology assumption; the distribution of money holdings can be tracked down; individuals can produce even if they hold money and meetings are not determined by the double coincidence of wants. Analytical, less restrictive-form and with explicit micro foundations is the model formulated by Lagos and Wright (2005) used for measuring the welfare cost of inflation. Central assumptions to achieve tractable results involve a degenerate distribution of money across agents in competitive markets and quasi linear preferences that offset wealth effects in the centralized market. Molico (2006), who computationally studies the effects of inflation and price dispersion under a decentralized market structure, considers a nondegenerate distribution of prices and money caused by search frictions. The steady-state equilibria analysis shows that as search frictions become smaller both distributions will tend to be less disperse causing improvements in welfare.

The present thesis contributes to existing knowledge of monetary search theory by providing a special form of financial friction, the lending-deposit rate spread in a particular monetary environment, namely a decentralize market structure with bilateral trading. Although extensive research models have been carried out to enrich the monetary search theory, no single model exists that incorporates the lending-deposit rate spread and explains its relationship between the wealth inequality distribution (Gini coefficient), the welfare and the value of money.

Up to this point, we can ask in what manner does exogenous financial frictions exert a causal influence on resources allocation, and more specifically, on income inequality? Theory suggest that financial institutions play a central role in mitigating financial disruptions, steering funds optimally, and preventing idiosyncratic shocks by diversifying aggregate risk, investing in long-term projects and providing liquidity to the markets. From a macroeconomic perspective, financial frictions operate through shocks in the demand or in the supply of credit that tight borrowing/lending constraints in credit markets resulting in capital misallocation, income inequality and low productivity. Investment is primarily affected through changes in credit spread caused by uncertainty shocks.

Greenwood, Sanchez and Weng (2010) presented a general equilibrium model with financial intermediation to quantify the impact of financial development on economic development. They proved that a decline in the interest-rate spread comes along with a lower cost of borrowing, redirecting capital to more productive sectors. Their model helps to understand why well-developed financial systems accounts for increases in capital-to-output ratio and welfare growth. In addition, Hugget (1990) discusses the importance of market imperfections to determining the risk-free rate in the economy using a pure exchange model where heterogeneous-agents experience idiosyncratic endowment shocks and are allowed to smooth consumption by holding credit balances. Despite its complexity, the model gives some insight about how financial frictions interact with market clearing: whenever agents face borrowing constraints, a low risk-free rate is required to persuade them to accumulate large credit balances, so that the credit market can clear.

Inquiring into the relationship between financial development and economic performance, it seems pretty obvious that financial systems set the pace for the stability of optimal saving rates, good investment decisions and long-run growth rates in the economy. Specific financial models that focus on the interactions between finance, aggregate growth and income distribution provide an important source to understand the impact between real and financial sectors. In this sense, Levine (2005a) claimed that inefficiencies in the financial intermediary development comes with a major economic impact on the poorest. Likewise, Galor and Zeira (1993) state that informational asymmetries produce credit constraints that are binding to the poor due to the lack of access to bank credit. Therefore, we can see how financial frictions determine wealth holdings through credit constraints. Restricting the poor from exploiting investment opportunities come with a negative social impact on wealth distribution, but allows one to measure on financial asymmetries, specially the interest rate spreads. Along with this, having a poorly functioning financial system will also produce higher income inequality by keeping capital away from entrepreneurs. However, alleviating credit constraints doesn't solve income inequalities issues. For example, income could possibly deviate to those rich and politically connected who might benefit from improvements in the financial system.

Authors like Greenwood and Jovanovic (1990) have tried to model a non-linear relationship between finance and income distribution. They show that the distributional effects of financial deepening are adverse for the poor at early stages, but positive after economic growth. Gelos (2009) assesses the role of bank and country-specific factors in determining banking spreads using micro data for 2,200 banks from 85 countries, including 12 Latin American economies. Gelos found that one of the determinants of banking spread is the macroeconomic volatility and inflation shocks. Theory predicts that the riskiness of borrowers is likely to rise with the level of interest rate. The higher the inflation rate, the higher the banking spread; that's why banks typically want to be compensated for taking higher risks, meaning a positive relation between the interest rate and spreads.

The cost of financial intermediation constitutes an important component for financial and economic activity since it measures the degree of development the banking sector address. Low-income countries face high banks interest margins which are translated into a set of systemic problems such as: lack of competition, high volatility in credit markets, credit constraints and high operating costs. Their implications on welfare distribution across individuals are address by Cavalcanti and Villamil (2005) whose model described an economy where individuals are allowed to smooth consumption by making loans or accepting deposits from households. Uninsurable idiosyncratic shocks are presented on household labor productivity and financial intermediation results costly.

Quantitative results show that with high interest spreads, lending becomes more expensive, deposits increase and, wealth decreases. Both poor and rich individuals experience persistent bad shocks on labor productivity and smoothing consumption results costly over time for individuals at the bottom 1 percent of the wealth distribution, those (low productivity individuals). One general equilibrium effect stresses income increments on bonds holders (rich households) whenever average consumption and average wealth decreases. An opposite general effect accounts for higher savings and increases in deposits as lending interest rate become more expensive.

Overall, welfare distribution of the lending-deposit spread level depend on the magnitude of the two effects mentioned above. Important wealth distributional results indicate a positive effect between a high banking interest rate spread and welfare gains for those at the top of the wealth distribution who commonly are assets holders. In short, an increasing deposit-lending spreads cause more consumption inequality dispersion. As for the wealth distribution, the effects of increasing intermediation costs are concentrated on households on the low tail of the distribution.

While increasing intermediary costs tends to lower consumption and heading wealth to those rich individuals, considering the counterfactual leads to opposite effects: expansion of net borrowers' consumption and an increasing demand for loans. Apparently, when individuals rely on holding debt to smooth consumption, the scope for welfare gains will improve or fall depending on the interest rate differentials. Antunes, Cavalcanti and Villamil (2013) compare welfare levels in the United States using both Mexico and Brazil lending-deposit spread. Unsurprisingly, when the wedge between those spread is large, the welfare effects are small, and that’s because households hold little debt when the wedge is large. As the spread decreases and more households rely on debt to smooth consumption, the scope for welfare gains increases.

Chapter 4

Environment

Time is continuous, starts at t=0, and goes on forever. There is a continuum $[0,1]$ of infinitely lived agents named buyers and sellers who can produce or consume and trading between them occurs in a decentralized market structure characterized by random, anonymous and bilateral matchings. There is never a double coincidence of needs meaning that agents won't buy or sell the product that they want. Agents derive utility $u(q)$ from consuming q units of a good, and disutility $c(q)$ from producing the good. The utility function $u(q)$ and the cost function $c(q)$, both are twice continuously differentiable with $u' > 0$, $c' > 0$, $u'' < 0$ and $c'' > 0$. Also, $u(0) = c(0) = 0$, and suppose that when $q = 0$, the marginal utility is greater than the marginal cost

$$c'(0) < u'(0)$$

$$\lim_{q \to \overline{q}} c(q) = \infty$$

for some $\overline{q} < \infty$

Let $r > 0$ denote the rate of time preference (the discount factor). The lending and deposit rates are denoted as $l > 0$ and $d > 0$, respectively. Suppose further that agents face random debt payments given by the lending rate l. In this economy, it is assumed the existence of a perfectly divisible and costless storable object called fiat money. Money is intrinsically valueless but it has value as a medium of exchange. Agents can hold any nonnegative amount of money $m \in \mathbb{R}_+$, and it cannot be produced or consumed by anyone. As discussed in He, Huang and Wrigth (2005) and in Telyukova and Wright (2008), these studies provide important insights into the role of money as medium of exchange: assuming alternative means of payment like debits cards, checks, and so on, maintains an essential role for money plus analytic tractability. Let $F(m)$ denote the distribution of liquid money holdings. In general, $F(m)$ is the probability distribution function in terms of fiat money $\widehat{m}$. The total amount of fiat money in the economy is denoted by M

$$F(\widehat{m}) = Pr(m \leq \widehat{m})$$

$$m \epsilon R_{+}$$

And the total liquid money stock is fixed, $\int m dF(m) = M$

Unlike other monetary search models, the present model is noted by making explicit the inclusion of the lending-deposit spread rate in the form of an instantaneous return variable. As it will be shown, this variable is composed by the liquid wealth holdings of each agent and by the debt and deposit payments made/given by them. Intuitively, the instantaneous return variable is similar like a banking system but without transaction costs like intermediation fees. It is a financial intermediation variable that helps maintaining an essential role for credit and money during trading. Consequently, debtors are those whose liquid wealth holdings are below a certain threshold (e.g. less than 100 units of fiat money) and are charged, in case of trading, with the lending rate l. On the other hand, depositors have high levels of liquid wealth (e.g. more or equal than 100 units of fiat money), they lend to debtors and are paid with the deposit rate d.

As mentioned above, the instantaneous return variable works as follows: First, for each agent the amount of liquid wealth they hold is m. During trading, either buyers and sellers can hold less than or greater than an exogenous amount of liquid wealth denoted by m_0. Second, depositors (lenders) will receive a monetary return $(m - m_0) \cdot d$ given the deposit rate d, respectively. On the contrary, the debtors (borrowers) will have wealth holdings below the amount m_0, in which case they will have to issue debt and pay $(m < m_0) \cdot (m - m_0) \cdot l$ in order to buy a consumption unit during the bargaining process. For simplification, we assume away all enforcement problems with credit. The next expression displays the instantaneous return for each agent.

$$R(m) = (m - m_0) \cdot d + (m - m_0) \cdot l$$

4.1 The value function

During trading, agents meet a potential trading partner with probability α. Likewise, with probability x, agents can consume but cannot produce and with probability x, agents want to produce but do not want to consume. With the remaining $1-2x$ probability, the agent simply prefers not to sell or buy any good. In summary, during randomly bilateral meetings, with a certain probability the individuals will buy a consumption good offered by his trading partner, the seller. With the same probability, the agent will produce and sell the consumption good to the buyer, in which case he will receive a monetary transfer. At each meeting, individuals will bargain over both, the amount of output $q(m_b, m_s) \geq 0$ and the amount of money transfer $t(m_b, m_s) \geq 0$. This last one is determined by the bargaining process between a buyer with liquid money holdings m_b and a seller with m_s. Preferences, technology and the cost of borrowing are the main determinants of the number of transactions in equilibrium.

Let $V(m)$ be the value function of each agent with liquid money holdings equal to m. The value function accounts for the expected lifetime utility of every individual who trade during meetings. As in Molico (2006), we only consider stationary (steady-state) equilibria where $V(m)$, $F(m)$, $q(m_b, m_s)$ and $t(m_b, m_s)$ are all constant. That being said, the value function satisfies the next flow version of Bellman's equation

$$rV(m) = R(m) + \alpha x \int \{u[q(m_b, m)] + V[m - t(m, m_s)] - V(m)\} dF(m_s)$$

$$+\alpha x \int \{-c[q(m_b, m)] + V[m + t(m_b, m)] - V(m)\} dF(m_b) \qquad (1)$$

This expression states that the expected value of holding liquid money is equal to the instantaneous return (the lending-deposit spread rate) plus the total net expected surplus of buying and selling, weighted by their respected probabilities. The left term is the flow value of holding m units of liquid money weighted by the discounted interest rate r.

4.2 The bargaining solution

It has been suggested that a strategic sequential model of bargaining is advantageous to determine the terms of trade $q(m_b, m_s)$ and $t(m_b, m_s)$ for bilateral meetings (Osborne and

Rubinstein, 1990). Therefore, finding a sequential Nash equilibrium to the bargaining problem (q,t) requires assuming that agents play a strategic sequential bargaining game with alternating offers. Under a stationary market structure, the Nash equilibrium converges to a unique subgame perfect equilibrium. Following Molico (2006), we use the next generalized Nash solution expression:

$$(S_b - T_b)^{\theta}(S_s - T_s)^{1-\theta}$$

Where S_b and S_s represents the buyer's and seller's payoffs from each bilateral trading. T_b and T_s are the Nash bargaining solution threat points which account for the expected utility $V(m)$. The parameter $\theta > 0$ measures the buyer's bargaining power and $1-\theta$ is the seller's bargaining power. An equilibrium condition is imposed where both, the consumption good $q(m_b, m_s)$ and the money transfer $t(m_b, m_s)$, solve the following optimization problem

$$\max_{\{q,t\}}\left[S_b(t,q)^{\theta} S_s(t,q)^{1-\theta}\right] \qquad (2)$$

Rewriting (2) in terms of the utility function and the production cost results in

$$\max_{q,t}[u(q) + V(m_b - t) - T_b]^{\theta}[-c(q) + V(m_s + t) - T_s]^{1-\theta} \qquad (3)$$

subject to

$$q \geq 0$$

$$t \leq m_b$$

$$u(q) + V(m_b - t) \geq V(m_b) \qquad (A)$$

$$V(m_s + t) - c(q) \geq V(m_s) \qquad (B)$$

$$\theta \epsilon [0,1]$$

The last two constraints state the incentive compatibility constraints, saying that during bargaining both parts cannot be worse off. These two constraints exhibit the instantaneous payoffs from the utility of consuming and the disutility of producing plus the flow of money holdings from further trading. Depending on how one sets up the bargaining game, the threat points satisfy $T_b = T_s = 0$ or $T_b = V(m_b)$ and $T_s = V(m_s)$. For simplicity, we assume the latter.

4.3 The distribution of money holdings

When time runs indefinitely, each agent's state is defined accordingly to their money holdings $m \leq \hat{m}$. Money holdings are defined by an heterogeneous distribution function across individuals and is denoted by $F(m)$. Given a stationary bargaining solution, $q(m_b, m_s)$ and $t(m_b, m_s)$ the conditions that a steady-state money distribution must satisfy are derived as follows:

4.4 Equilibrium

There is a stationary equilibrium and a monetary equilibrium. The conditions that should be satisfied in order to reach those are the following:

For the stationary equilibrium

1. $F^*, (q^*, t^*), V^*$ satisfy (1)
2. V^*, (q^*, t^*) solve (2)
3. t^*, $F^*(m)$ is invariant

For the monetary equilibrium

$$q(m_b, m_s) > 0$$

Chapter 5

Theoretical exercise

The purpose of this section is to provide an expression that directly links the marginal utility function with four variables: the marginal valuation of liquid wealth of the seller $V'(m_s)$ and of the buyer $V'(m_b)$, the quantity of the good consumed q, and the monetary transfer t. By doing this theoretical exploration, it is expected to offer some important insights about the interactions between the agents' marginal utility, the value for money, the quantity traded and the monetary transfer.

From (3), we assume $T_b = V(m_b)$, $T_s = V(m_s)$ and suppose that x is the total amount of liquid wealth for each agent. The next system of equations displays the agent's surplus for consumption and producing:

$$S_b = [V(x-t) + u(q) - V(x)] \quad (i)$$

$$S_s = [V(x'+t) - c(q) - V(x')] \quad (ii)$$

Note that we have replaced m for x and x'. The former denotes the buyer's level of liquid wealth and the latter the seller's liquid wealth. Intuitively, one can think of x as the most liquid portion of money supply in an economy, like the M1 money supply metric, which includes credit, debit, liquid financial assets or cash. Recalling that $\mathrm{V}(m)$ is continuous and hence, so is $V(x)$, we propose using the Taylor-series approximation method on $V(x)$ to get a linear expression for some value function $\mathrm{V}(\tilde{x})$. In an analysis of Taylor-series, Hlawitschka (1994) found that when linear approximations converge or diverge, two-moment expansions may provide excellent approximations to expected utility. Therefore, using Taylor-series helps us constructing a functional expression that bring together the marginal utility function and the marginal value function. The next steps demonstrate this.

We first start by showing the Taylor expansion for a kth-order polynomial continuation value function $V(\tilde{x})$

$$V(\tilde{x}) \approx V(x) + \frac{V'(x)}{1!} \cdot (\tilde{x} - x) + \frac{V''(x)}{2!} \cdot (\tilde{x} - x)^2 + \ldots + \frac{V^{(k)}(x)}{k!} \cdot (\tilde{x} - x)^k \qquad (iii)$$

$$k \epsilon \mathbb{R}_{++}$$

By taking the first-order expansion we have the next linear functional form

$$V(\tilde{x}) \approx V(x) + V'(x) \cdot (\tilde{x} - x) \qquad (iv)$$

Now, assuming $\tilde{x} \approx x - t$, substituting into (iv) and solving for $V(x - t)$ we have

$$V(\tilde{x}) \approx V(x) + V'(x) \cdot [(x - t) - x]$$

$$V(\tilde{x}) \approx V(x) - V'(x) \cdot t$$

$$V(x - t) \approx V(x) - V'(x) \cdot t \qquad (v)$$

(v) presents a linear proxy for the buyer's flow of money. It is formed by the monetary transfers t, the buyer's value function $V(x)$ and its marginal value $V'(x)$. Substituting (v) into (i), we get an equation in terms of the utility and of the price of the good traded p.

By taking (v) into (i) we obtain

$$S_b = \{[V(x) - V'(x) \cdot t] + u(q) - V(x)\}$$

$$S_b = V(x) - V'(x) \cdot t + u(q) - V(x)$$

$$S_b = V(x) - V'(x) \cdot t + u(q) - V(x)$$

$$S_b = u(q) - V'(x) \cdot t \qquad (vi)$$

Now, we have an expression in terms of the agent's utility, his marginal value function and the monetary transfers. This will allow us to examine the interaction of the marginal value on changes in the money holdings. We now repeat the same steps for the seller's surplus S_s. The resulting equations from applying the linear approximation to (ii) is:

$$S_s = V(x + t) - c(q) - V(x')$$

$$S_s \approx V'(x') \cdot (t) - c(q) \qquad (vii)$$

Without loss of generality, we assume a linear cost of production c and also that the buyer's bargaining power is equal to $\theta = 1$. This last parameter implies that the buyer has all the bargaining power. In consequence, the seller's surplus would be $S_s = 0$. Solving for t in (vii), we have

$$V'(x') \cdot (t) - c(q) = 0$$

$$V'(x') \cdot (t) = c(q)$$

$$t = \frac{c(q)}{V'(x')} \quad (viii)$$

Substituting $(viii)$ in the buyer's surplus (vi) results in an expression in terms of the utility, the value function of the seller and the buyer, and the cost of producing. We can solve the resulting expression as an optimization problem to find an equation composed by the marginal values of liquid wealth of both parts. Hopefully, we would get some insights by examining the connection between the marginal utility and the marginal values for money.

$$S_b = u(q) - V'(x) \cdot \left[\frac{c(q)}{V'(x')}\right]$$

$$\max_{\{q\}} \left\{u(q) - \frac{V'(x)}{V'(x')} \cdot c(q)\right\} \quad (ix)$$

Solving FOC results in

$$\frac{dS_b}{dq} = u'(q) - \frac{V'(x)}{V'(x')} \cdot c'(q) = 0$$

Rearranging

$$u'(q) = \frac{V'(x)}{V'(x')} \cdot c'(q) \qquad (x)$$

What is interesting about expression (x) is that it shows a direct relation between the marginal utility and the marginal value function of selling and buying. We can get some insight about this expression by observing that, *ceteris paribus,* increases in the marginal value of money for the seller $V'(x')$, leads to lower levels of marginal utility $u'(q)$. It can be suggested that if an individual mostly prefers to sell rather than buying, his marginal valuation of money will be greater. In consequence, as the money transfer received by selling goods goes up, the agent won't be restricted to consume, so it is possible that in the long-term his marginal utility for consuming an additional good will be lower. Intuitively, we can think of middle or middle-to-high income people who are more interesting in expanding their individual wealth by selling goods than expanding their consumption. For example, comparing the change in utility of an addition unit of consumption between a poor and a middle-income individual, it is clear who will have a bigger marginal utility of consumption and who a greater value for money. On the other hand, what expression (x) also shows is a direct link between the marginal value function of money for the buyer $V'(x)$ and the marginal utility. It seems that when the former goes up, so does the latter.

The intuition is as follows: poor and extremely poor people are more interested in buying a consumption good, even if they have to issue debt. Hence, as their marginal value of money for buying increases, their marginal utility will also increase. Figure 1 below illustrates an overview of what the functional form between $u'(q), V'(x')$ and $V'(x')$ might look like. For simplicity, we characterize $u'(q)$ as a function $F[\cdot]$ of $V'(x')$ in panel A and also as a function $G[\cdot]$ of $V'(x)$ in panel B. Remember that we are only considering two independent cases of expression (x): one in which the marginal utility is affected by changes on the seller's marginal value function, and the other when the marginal utility is influenced by the buyer's marginal value function. For each case, we are assuming that the marginal cost of production and either $V'(x')$ or $V'(x)$stay fixed.

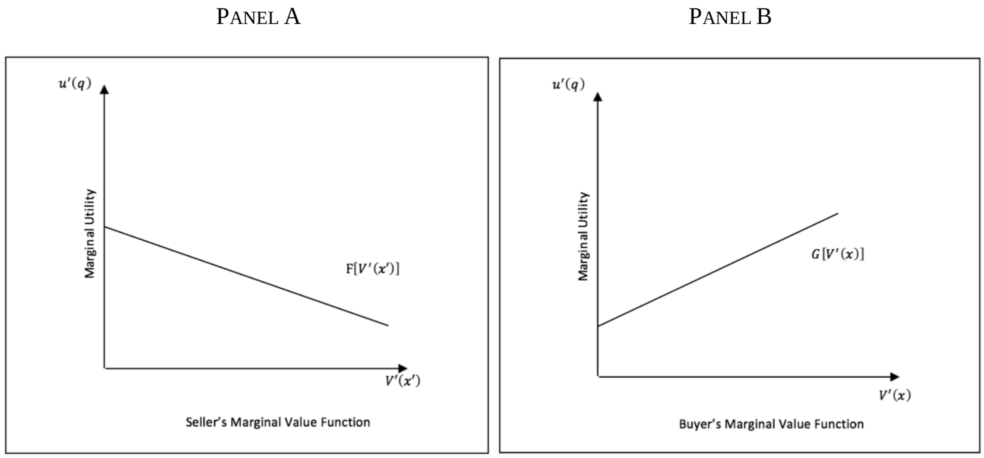

FIGURE 5.1: Marginal utility and marginal value function of liquid wealth
Source: Own figures.

On the basis of equation (x), we now proceed to derive an expression that relates the marginal utility with the quantity of the good traded q and also with the amount of money traded t. Without loss of generality we assume a linear production cost $c(q) = c \cdot q$, which gives us a functional linear expression that depends on the consumption good. From $(viii)$ we solve for the seller's marginal value function $V'(x')$ to obtain the following.

$$V'(x') = \frac{c(q)}{t}$$

where $c(q) = c \cdot q$

Given that the marginal cost of production is $c'(q) = \mathrm{c} > 0$, and substituting into (x) we have an expression in terms of the buyer's marginal value function, the quantity of the good traded and the monetary transfer.

$$u'(q) = \frac{V'(x)}{V'(x')} \cdot \mathrm{c}$$

$$u'(q) = \frac{V'(x)}{\frac{c \cdot q}{t}} \cdot \mathrm{c}$$

Rearranging, we obtain the following

$$u'(q) = \frac{V'(x) \cdot t}{q} \qquad (xi)$$

Clearly, we derive an expression that exhibits the marginal utility, the money transfer, the quantity consumed and the buyer's marginal value function. We give interpretation to the equality (xi) by stating that all else equal the individual's marginal utility goes down when the quantity of the consumption good grows up. This finding may be supported by the notion behind the Law of Diminishing Marginal Utility, which says that as consumption increases, the marginal utility derived from an additional unit declines. Interesting enough is to note the direct proportional relation between the marginal utility and the amount of monetary transfer. When this last one increases, so does the marginal utility. Figure 2 below shows the interaction between the quantity of the good traded, the monetary transfer and the marginal utility. Note that, as before, we defined the marginal utility as a function $F[\cdot]$ of the monetary transfer t as well as a function $G[\cdot]$ of the quantity traded q.

PANEL A PANEL B

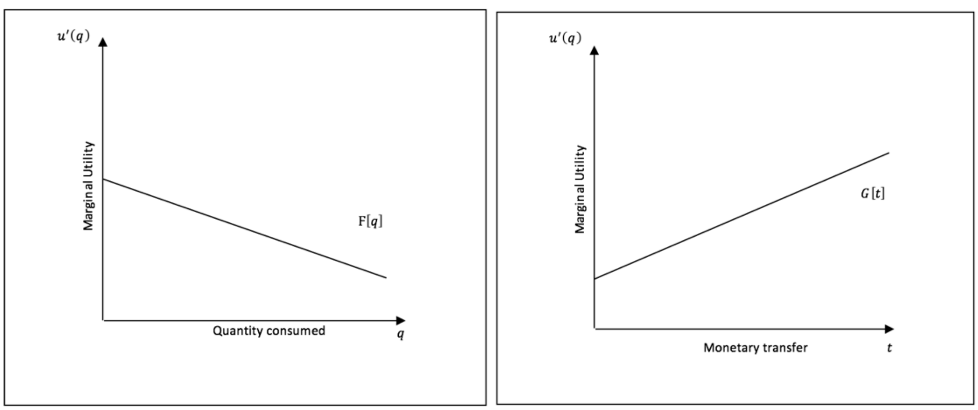

FIGURE 5.2: Marginal utility, quantity of good traded and monetary transfer
Source: Own Figure

Chapter 6

Numerical model

This part of the thesis evaluates, through a numerical simulation, the impact of different levels of the lending rate on welfare and the Gini coefficient estimates. In such exercises, the deposit rate is fixed. The welfare and the Gini coefficient are final statistical estimations calculated after reaching stationary convergence within the numerical solution. The former is computed as the difference between the dot product between the discounted value function and the stationary distribution of money and the dot product of the instantaneous return and the distribution of money. The latter is calculated using a given function that depends on the amount of money holdings per trader and on the population size. Due to the complexity and continuity of the value function computation, it is not feasible to characterize analytically a monetary stationary equilibria. Applying numerical methods allows one to obtain quantitative answers and get some insights about the mechanism of the lending-deposit spread and the wealth distribution.

For the numerical exercise, I follow Molico's (2006) work in which it is assumed a take-it-or-leave-it offer made by the buyer to the seller; the bargaining power still fulfills $\theta = 1$, and the agent's surplus is $(T_b, T_s) = (V(m_b), 0)$, respectively. The incentive compatibility constraint for the buyer (A) is omitted since any solution to the maximization problem satisfies this constraint. The bargaining problem is specified as

$$\max_{\{q,t\}}[u(q) + V(m_b - t)]$$

$$q \geq 0$$

$$0 \leq t \leq m_b$$

$$V(m_s + t) - c(q) = V(m_s)$$

And V must satisfy

$$rV(m) = R(m) + \alpha x \int \{u[q(m_b, m)] + V[m - t(m, m_s)] - V(m)\} dF(m_s)$$

$$\text{where } R(m) = (m - m_0) \cdot d + (m - m_0) \cdot l$$

The numerical equilibrium solution implies applying functional forms for preferences and technology as well as some function parameter values. The following is assumed:

$$u(q) = A \cdot \log(1 + q)$$

$$c(q) = B \cdot \frac{1}{\overline{q} - q} - \frac{1}{\overline{q}}$$

where A, B $\epsilon\mathfrak{R}^{+}$, and $\overline{q} > 0$, $A > \frac{B}{\overline{q}^{2}}$. The parameter values[4] imposed are: $A = 100$, $B = 1$, $\overline{q} = 1$, $\alpha = 1$, $r = 0.01$, $x = 0.1$, $d = 0.02$, $l = 0.2$, $m_0 = 100$, $N = 10000$ and $M = 100$.

During meetings, it could be possible that individuals with less than $m < m_0$ money holdings might not have enough money to convince a seller with $m \geq m_0$to produce. That being the case, the buyer will have to turn to debt in order to buy a consumption unit and paying the corresponding lending rate $(m - m_0)l$. Intuitively, the smaller the lending interest rate, the more willing the agents are to increase consumption through debt, whenever they have $m < m_0$, and thus the higher the value function of money. In contrast, as borrowing become costly the distribution of money across individuals will shrink, leading debtors to consume less and to refrain from bargaining until they can afford to pay. In this case, consumption and money will become more valuable for debtors.

What follows is a brief description of the numerical simulation results. After computing the stationary distribution which solves the bargaining problem, the Gini coefficient together with the welfare, among other estimations[5], are calculated. The process of stationary convergence is repeated several times during the simulation. This process starts by generating the first of four linearly spaced values from 0.01 to 0.2, which are in fact the range of values assigned to the exogenous lending rate (e.g. 0.01, 0.07, 0.13, 0.2). The deposit rate stays fixed at $d = 0.02$. Figure 3 presents the results obtained from plotting the range of values of the lending interest rate $l \in [0.01,0.2]$ over the Gini coefficient.

[4] The parameters m_0, N and M are defined in the simulation code as follows: the first is just the amount of money that determines if the individual issues debt or makes deposits; the second is the population size and the third parameter is the average fiat money in the economy.

[5] These are the expected price, the expected transfer, and the coefficient of variation for prices and transfers.

It is apparent from this figure that there is a clear trend of a decreasing Gini coefficient. Note that as the lending rate increases, the marginal change of the Gini coefficient will be lower[6]. This might suggest that the distribution of income (consumption expenditure) among individuals is less disperse. For example, after running the simulation a lending rate of 0.01 gives a Gini coefficient estimate of 0.4288 but for a rate of 0.2 the Gini is much lower 0.2078. These findings might indicate that increases in the lending rate could reduce the distribution of income between agents because, as this interest rate gets bigger (in our case $l = 0.2$), the Gini coefficient gets smaller (0.2078). These results could provide further support for the statement[7] that a wide lending-deposit spread rate enhance economic growth through a better financial sector in intermediation. Although, since in this model we are considering a special type of exogenous financial friction composed of the instantaneous return $R(x)$ variable, we can state that for a fixed deposit interest rate d, a wide lending rate generates a more equal distribution of liquid wealth and less dispersion among individuals. At least, this is what the numerical estimations show.

[6] A Gini coefficient of zero means perfectly equal

[7] According to the World Bank, the interest rate spread measures the financial sector efficiency in intermediation. Hence, a narrow-spread means low transaction costs which may reduce the cost of funds for investment (deposits), a crucial factor for economic growth.

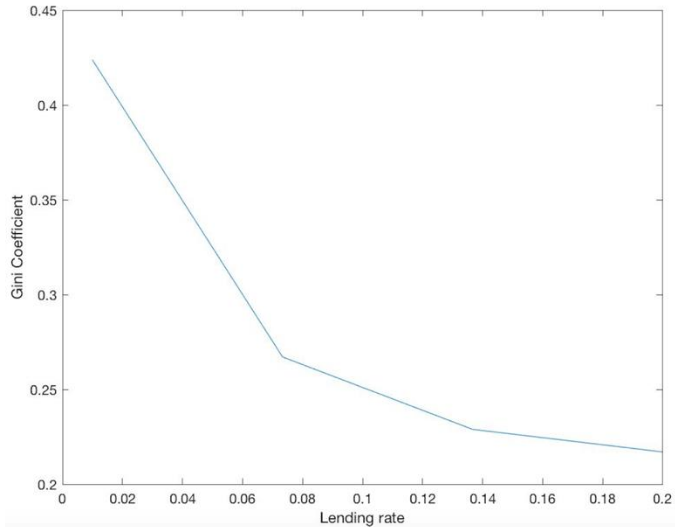

Figure 6.1: Lending rate and Gini coefficient
Source: Own figure

Turning now to analyze the effect of the lending rate on the welfare estimation, figure 4 provides an overview of the resulting chart obtained by plotting these two variables. As stated at the beginning of this section, the welfare is computed in terms of the value function of money $V(m)$, the instantaneous return $R(m)$ and of the distribution of money holdings $F(\widehat{m})$. Similar as figure 3, the chart below shows a negative relation between the welfare and the lending rate. Note that the higher the cost of borrowing, the lower the level of welfare. This finding might be supported by the notion of social welfare, measured as a function of individual welfare due to income alone (Schwartz, Winship, 1980). Under this approach, it is assumed that the social welfare, which may be a function of individual welfares (income and other resources), decreases as individual income decreases. A possible explanation to figure 4 might be that increases in the lending rate generates costly debt payments which refrain individuals to buy consumption goods. Because issuing debt is costly, individuals won't have enough money to pay for both a unit of the consumption good and the monetary transfer d of the seller.

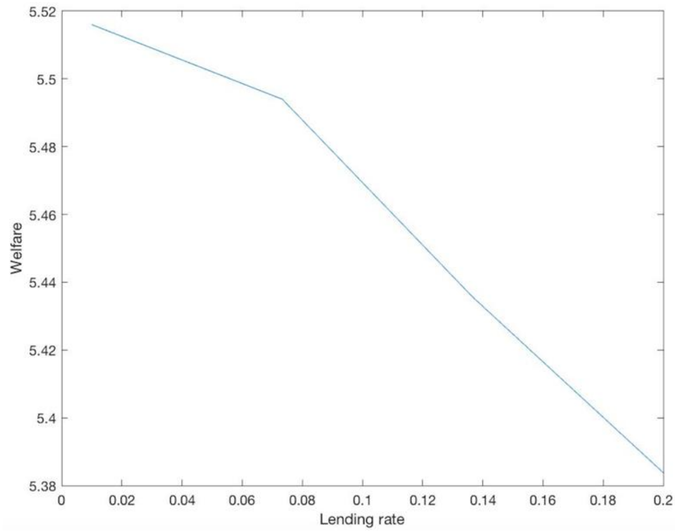

Figure 6.2: Lending rate and Welfare
Source: Own figure.

In the final part of this section, an analysis about the numerical results is offered. The table below reports the Gini coefficient of wealth, the welfare, the average quantity of good traded, and the average monetary transfer for different levels of the lending rate. First, note that the first two rows present the quantitative results obtained from previous discussion about the Gini coefficient and welfare. It is apparent from the third row that welfare barely decreases as the lending rate raises. This could mean that individuals whose money holdings are below $m < m_0$ might not suffer a significant reduction in consumption or in their money holdings. However, data observed from the average quantity traded implies a general decrease in consumption due to a higher lending rate. We see a similar result in the next row, where increasing the lending rate from 0.01 to 0.2 comes with a smaller amount of money traded from 3.4146 to 0.6531.

Table 6.1: Numerical results

Lending rate (l)	0.01	0.07	0.13	0.2
Gini coefficient of wealth	0.4288	0.2678	0.2167	0.2078
Welfare	5.5148	5.4939	5.4935	5.3845
Expected quantity	3.9693	0.8541	0.8471	0.8412
Expected transfer	3.4146	1.2424	0.8262	0.6531

Deposit rate = 0.02, m_0=100, M =100

Source: Own table

Chapter 7

Conclusions

This thesis was undertaken to analyze the implications of the deposit-lending rate spread on wealth distribution. Particularly, the thesis extends our knowledge of monetary search-theoretic models by broadening Miguel Molico's (2006) search-theoretic model. We provide an examination between the lending interest rate interaction, given a fixed deposit rate, on two measurements: the Gini coefficient of wealth and the welfare.

Our first approach to this was presented in the motivation section, where it was used two estimation methods, an OLS and a fixed-effects model to provide some insights about the effect of the deposit-lending spread on the Gini index. Unfortunately, the findings obtained from the regressions were subject to certain limitations: first, only the fixed-effect estimations gave positive results. Second, there was missing data for some OECD countries in the World Bank's deposit-lending dataset that might prevent from getting more accurate estimations. Finally, the r-squared coefficients resulted from the fixed-effect estimations may suggest that including a time-trend variable explains more variation than just the deposit-lending spread along. Without those constrains we would have got better, and more accurate, estimation results.

The main finding of using the fixed-effects estimation model was that running the Gini coefficient variable on the deposit-lending spread variable resulted in a negative coefficient, suggesting that increases in the latter generates decreases in the former, which was the intended outcome.

Throughout this thesis, a theoretical exploration was provided with the aim of deriving an expression which, in some manner, captures the relation between the agent's marginal utility, the marginal value function of selling and buying, the quantity traded and the monetary transfer. Figures 1 and 2 show the possible effect of raising the marginal value of money of a seller on the marginal utility. The higher the marginal value function of selling, the higher the quantity of the good traded, the smaller the marginal utility. Opposite results are found with increases in the marginal value of a buyer and the monetary transfer.

The final subsection features the solution to the bargaining problem throughout a numerical simulation. We are able to see a negative effect between the lending rate and the Gini coefficient. This may imply that the higher the lending rate, the more equal the wealth distribution among agents. A possible interpretation to figure 3 would be that most of the agents suffered a general reduction in their money holdings (liquid wealth) as a result of a high lending rate. In consequence, they won't be able to buy a consumption good to the seller. Similar results are observed with the welfare estimation, the average quantity traded and the average amount of money traded. A high lending rate generates low welfare, low quantity traded and a low monetary transfer. These findings are exhibit in table 2.

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