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UNIVERSIDADE TÉCNICA DE LISBOA

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DISSERTATION

ON THE WELFARE EFFECTS OF FINANCIAL DEVELOPMENT

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All errors are mine.

ABSTRACT

The aim of this paper is to show how the evolution of financial technology affects the welfare in the economy. On the empirical side, I construct a time series for the costs of financial services, and I find that the evolution shows a decreasing trend in the period analyzed. In addition, the new statistical tool goes a long way to explaining US M1 money demand. I find that the financial costs became significantly lower after major financial innovation events had taken place. Then I study how financial innovation, understood as a decrease in portfolio adjustment costs, affects macro variables and welfare.

JEL Codes: E3, E4, E5.

Keywords: financial costs, market segmentation, money demand, welfare

CONTENTS

1. Introduction

The traditional monetary theory that links interest rates, money supply and inflation rate has been called into question over the last 30 years. One explanation for this is the large increase in technology in financial markets. In fact, over these past decades, financial markets have been characterized by a surge in technology[1], with the introduction of new products and instruments[2] by banks and in financial markets with, ATMs, venture capital, credit cards, interest rate swaps, CDS, e-banking and electronic payments. Technology and the structure of the financial system are constantly changing, affecting the way in which money is held.

Empirical evidence shows that financial innovations have an impact on the money demand function, a process that started in the 1970s. This problem with the stability of money demand began in the 1970s with Goldfeld (1973). He found that a traditional money demand equation enabled an accurate characterization of quarterly U.S. data during the period 1952-1972. As a result of this work, the M1 money demand function became the conventional money demand function used by policy makers. However, Goldfeld (1976), extends the sample period to 1976 and reports a significant reduction in the performance of the money demand equation. This phenomenon of instability in the money demand function was labeled as the "case of missing money" and the most commonly accepted explanation for this is that money demand declined as the result of financial innovations. After this, as far as the importance of the effects of financial innovation on understanding the relation between money demand, income and interest

[1] Lerner and Tufano (2011) provide useful reviews of the literature about financial innovation.
[2] For a longer description of new financial instruments see Foster et al. (2011).

rate elasticity is concerned, a large volume of research has been undertaken and several proxies have been used in order to capture these effects.

The research on instability of money demand has followed several directions. One direction is that financial innovations have to some degree blurred the distinctions between the different components of the monetary aggregates to some degree. As a consequence, there has been a discussion about whether M1 is the best aggregate to use in the study of money demand. For instance, Teles and Zhou (2005) argued that M1 is the relevant measure of money since the major technological developments that have taken place in financial markets. They focused on a monetary aggregate Money Zero Maturity (MZM)[3], which measures balances available immediately for transactions at zero cost.

Another implication for the study of money demand is that financial innovation affects both the extensive margin (the decision whether to hold interest-earning assets) and the intensive margin (the decision on how to allocate wealth between money and interest-earning assets). Mulligan and Sala-i-Martin (2000) reported that the fixed costs of adopting financial innovation introduce frictions into the participation decision as a way of explaining the reason why only 41 percent of US agents in 1989 have an interest bearing banking account. In addition, Vissing-Jorgensen (2002) reports that these costs, faced by households in rebalancing a portfolio, motivate the holding of money and less participation in the financial markets.

In a model with cash-in-advance constraints faced by households, these latter seek to

[3] Federal Reserve Bank defined MZM as M2 less small-denomination time deposits plus money funds.

hold only money enough to liquidate their consumption expenses at a constant rate over some interval of time and hold the remaining wealth in the form of non-monetary assets. As households need to visit financial markets to transfer wealth from the bonds to money and pay a real cost to make these transfer, it is costly for them to go to the financial markets to adjust the composition of portfolio, but, at the same time, it is also costly to hold money because it is an asset with no earned interest. As documented by Edmond and Weill (2008), this (high) cost is normally required in models of market segmentation and implies that households visit financial markets very low infrequently.

I will give special attention to the role of these financial costs (γ). My interpretation for γ will be the real costs of visit financial markets to exchange assets with less liquidity for money - for instance, costs associated with time spent for information meeting, decision making, negotiation and communication or price of financial intermediation. As suggested by Reynard (2004), a stable money demand can be obtained by a decreasing γ combined with increasing financial market participation. However, as the components of γ are difficult to account for, the analysis of monetary models in literature is simplified by making them constant.

The first aim of this Dissertation is to verify if γ has been lower over the last century. To analyze the previous point, I explain it through a general equilibrium model with calibration of parameters at steady state values and construct the time series for γ. Concerning the choice of a model, I construct a Baumol-Tobin model with market segmentation, similar to the model developed by Silva (2012). In the model households can choose freely the timing for their use of financial services, and γ, which appears in budget constraint of households, influences this choice, and, thus, the money demand.

Because the model has been constructed to study the long-run money demand when the economy is at steady state, the series constructed can be seen as a proxy of the real values of γ. I found that, in general, γ has followed a decreasing trend, and this evolution goes a long way to explain the aggregate money demand over the century, with elasticity of 1/2, and with the interest rate elasticity of money demand of –1/2.

I also confirm that the decreasing of γ is higher after major financial innovations and financial regulations have been introduced. Thus, a reduction of γ in the model can be a good proxy in order to catch developments in the US financial sector.

Finally, I also study how financial innovation, understood as a decrease in γ, affects macro variables and welfare. For this, I made an experiment with the model and I find that, because markets are segmented, a reduction in γ is beneficial for welfare because it more than offsets the welfare costs of higher interest rates.

The structure of this paper will be organized in the following way: In Section 2, I introduce the model used in this study, explaining the behavior of the agents in the model (households, firms, and the government) and defining the competitive equilibrium and steady state of the model. In Section 3, I explain the experiment that I use to create a γ time series and I also present my money demand specification, in order to explain the U.S. money income ratio. In Section 4, I introduce the social welfare definition and study the welfare effects of the evolution of γ a proxy for financial development. Finally, in Section 5, I present my conclusions.

2. Model

Typically in the standard macro models, the moments at which households can readjust their portfolios are exogenous. I follow a general equilibrium model where the markets are endogenously and households manage money holdings by solving a Baumol (1952) and Tobin (1956) problem of money as inventory segmented. Time is continuous and denoted by $t \in [0, \infty)$.

At any moment, there are markets for assets, consumption goods, and labor. The markets for assets and the market for consumption goods are physically separated. There are two assets: money and nominal bonds. As in Alvarez et al. (2002, 2009) households owns two financial accounts, a brokerage account and a bank account. They choose how often to transfer funds deposited in the account at the investment bank into the money in commercial bank account. For make this transfer is involved a financial costs γ. As result, households accumulate bonds for a certain time and visit infrequently the bond market as in the models of Grossman and Weis (1983), Rotemberg (1984) and Alvarez, Atekson and Edmond (2009).

The model also can be seen as standard cash in advance model with decision on capital and labor like Cooley and Hansen (1989) and Cooley (1995). I follow closer the model of Silva (2012). The difference between the model of Silva (2012) to the others referred above is that the decision on timing to visit financial markets, that is endougnousely chosen by households.

2.1. Firms

At time t, individual firm i hires labor $h(t,i)$ and capital $k(t,i)$ to produce the consumption goods with a Cobb-Douglas technology. With the aggregate capital $K(t)$ and the aggregate labor $H(t)$, the production function $Y(t)$ is given by:

$$Y(t) = AK(t)^{\theta}H(t)^{1-\theta} \tag{1}$$

where $Y(t)$ is the output produced by firms, A is the level of general technology taken as given by firms and a parameter $\theta \epsilon (0\ 1)$ is capital income share of total income. The problem of perfectly competitive firms is choice the optimal mix of aggregate capital and aggregate labor to maximize the following profit function:

$$V \equiv \int_{0}^{\infty} \left[P(t)AK(t)^{\theta}H(t)^{1-\theta} - w(t)P(t)H(t) - r(t)^{k}P(t)K(t)\right]dt$$

where $P(t)$ is the price of consumption good produced by firms, $w(t)$ is the nominal wage received by the worker and ${r_t}^{K}$ is the real rental price of capital. From the first order conditions, profit maximization implies that firms hire capital and labor to equate the rental rates to the respective marginal products, i.e., at $t \in [0\ \infty)$ the demand for labor and the demand for capital are, respectively, given by:

$$w(t) = (1-\theta)A\left(\frac{K(t)}{H(t)}\right)^{\theta} \tag{2}$$

$$r^{K}(t) = A\theta\left(\frac{K(t)}{H(t)}\right)^{-(1-\theta)} \tag{3}$$

Assuming perfect mobility of production factors implies that $w(t)$ and $r^{k}(t)$ are the same for all firms.

2.2. Government

At moment t, government issues nominal bonds, $B^G(t)$, that pay a nominal interest rate $r(t)$ and prints money, $M^G(t)$, makes consumption expenditures $G(t)$ and receives a Lump-sum tax $\tau(t)$ paid by the households[4]. The financial responsibility is given by total public debt $D^G(t) = B^G(t) + M^G(t)$.

Let $Q(t) = e^{-\int_0^t r(\tau)d\tau}$ denotes the price at time zero of a bond that pays one dollar at time t. At moment $t + v$, for very small v, the financial responsibility is given by total public debt,

$$D^G(t+v) \equiv M^G(t+v) + B^G(t+v) = M^G(t) + Q(v)B^G(t) - P(t)G(t) + P(t)\tau(t).$$

At moment $t + 2v$:

$$D^G(t+2v) = M^G(t+v) + Q(v)B^G(t+v) - P(t+v)G(t) + P(t+v)\tau(t).$$

By multiplying both sides of $t + sv$ constraint by $Q(sv)$ and add all of them, the present value of all budget constraint:

$$\sum_{s=0}^{S}(Q((s+1)v) - Q((s+2)v))M^G(t+(s+1)v) + Q(Sv)D^G(t+Sv)$$

$$= \sum_{s=0}^{S} M^G(t)Q(v) + B^G(t) - Q((s+1)v)P(t+v)(G(t) - \tau(t))$$

Because government cannot accumulate debt infinitively, imposing the No Ponzi Games condition, $\lim_{S\to\infty} Q(sv)D^G(t+Sv) = 0$, then

[4] In General case we can consider the revenues from tax capital and labor.

$$\sum_{s=0}^{S}(Q((s+1)v) - Q((s+2)v))M^G(t+(s+1)v)$$

$$= \sum_{s=0}^{S} M^G(t)Q(v) + B^G(t) - Q((s+1)v)P(t+v)(G(t) - \tau(t))$$

Due to the government be continuously in the asset markets exchanging bonds for money, and v is very small, $v \to 0$, thus the present value of intertemporal budget constraint of government is given by:

$$D_0^G = \int_0^\infty Q(t)[rM^G(t) - P(t)G(t) + P(t)\tau(t)]dt,$$

where $D_0^G = M_0^G + B_0^G$ is the initial public debt of government. Dividing both sides by $P(t) = P_0 e^{\pi t}$, where π is the inflation rate, we have the budget constraint of government in real terms:

$$d_0^G = \int_0^\infty e^{\pi t} Q(t)[rm^G(t) - G(t) + \tau(t)]dt, \tag{4}$$

where $d_0^G = D_0^G/P(t)$, and $m^G(t) = M^G(t)/P(t)$.

2.3. Households

There is a unit mass of infinitely-lived households with preferences over consumption and leisure. Each household sells hours of labor $h(t,i)$ and rents capital $k(t,i)$, to the firms. The problem is written assuming both the labor income, $P(t)w(t)h(t,i)$, and the rental income, $r^k(t)P(t)k(t,i)$ are deposited in brokerage account[5].

Household $i \in [0\ 1]$ decides on consumption $c(t,i)$, labor supply $h(t,i)$, capital $k(t,i)$, the dates when transfers to the bank are made $T_j(i)$, money holdings in the bank account $M(t,i)$ and bond holdings in the brokerage account $B(t,i)$. She has an initial endowment of wealth divided between initial monetary assets $M_0(i)$ in the bank account, initial bonds $B_0(i)$ in the brokerage account and the initial dividends from rents capital to the firms in the brokerage account, $P_0 k_0(i)$. The holding period between any two consecutive transfer times is the interval $(T_j(i), T_{j+1}(i))$, for $j = 1,2, \ldots$.

In order to describe de model, it will be used the notation $x^-\left(T_j(i), i\right)$ for denotes the position of variable x just before the transfer time at $T_j(i)$, and $x^+\left(T_j(i), i\right)$ for denote the position at transfer time $T_j(i)$. The net transfer from the brokerage account to the bank account is given by $M^+(T_j(i), i) - M^-(T_j(i), i)$, where $M^+\left(T_j(i), i\right) \equiv \lim_{t \to T_j(i), t > T_j(i)} M(t,i)$ and $M^-\left(T_j(i), i\right) \equiv \lim_{t \to T_j(i), t < T_j(i)} M(t,\mathrm{i})$ shows, respectively, the monetary assets holding just after and before a transfer at $t = T_j(i)$. The definitions of dynamic of bonds holding in brokerage account and quantities of capital are similar. When a household i readjust portfolio at $T_j(i)$, $j = 1,2 \ldots$, it face a constraint on the brokerage account which imposes the portfolio chosen plus costs of adjustment $P\left(T_j(i)\right)\gamma$ must be equal or smaller to the current wealth, i.e.,

[5] Alvarez et al. (2009) and Khan and Thomas (2010) write the problem of households assuming that firms pays 60% of total income received from households in money. Silva (2012), in the model without decision in capital and labor by households, compare the money demand with the assumption of these works, and with the assumption that all income is paid in non-monetary assets.

$$M^{+}\left(T_j(i),i\right)+B^{+}\left(T_j(i),i\right)+P\left(T_j(i)\right)k^{+}\left(T_j(i),i\right)+P\left(T_j(i)\right)\gamma$$
$$\leq M^{-}\left(T_j(i),i\right)+B^{-}\left(T_j(i),i\right)+P\left(T_j(i)\right)k^{-}\left(T_j(i),i\right)$$

During holding periods $t \in \left\{\left[T_j(i),T_{j+1}(i)\right)\right\}_{j=1}^{\infty}$, bonds and capital follow respectively $\dot{B}(t,i)=r(t)B(t,i)+P(t)w(t)h(t,i)-P(t)\tau(t)$ and $\dot{k}(t)=(r^{K}(t)-\delta)k(t,i)$. With this, and multiplying the restriction in each holding period by $Q\left(T_{j+1}(i)\right)\equiv e^{\int_0^{T_{j+1}(i)} r(\tau)d\tau}$, where $Q\left(T_{j+1}(i)\right)$ denotes the price in $t=0$ of a bond which pays one dollar in $T_{j+1}(i)$, substituting the restriction recursively for the different holdings period constraint, and after sum up all them we have

$$\sum_{j=1}^{\infty} Q\left(T_j(i)\right)\left[M^{+}\left(T_j(i),i\right)+B^{+}\left(T_j(i),i\right)+P\left(T_j\right)k^{+}\left(T_j(i),i\right)+P\left(T_j\right)\gamma\right]\leq$$
$$\sum_{j=1}^{\infty} Q\left(T_j(i)\right)M^{-}\left(T_j\right)+B_0(i)+P_0k_0(i)+\int_0^{\infty} Q(t)\,P(t)w(t)h(t,i)dt-$$
$$\int_0^{\infty} Q(t)\tau(t)dt.$$

Using the Non Ponzi Games conditions, $\lim_{j\to+\infty} Q(T_j)B^{+}(T_j)=0$ and $\lim_{j\to+\infty} Q(T_j)P(T_j)k^{+}(T_j)=0$, the present value of intertemporal budget constraint becomes:

$$\sum_{j=1}^{\infty} Q\left(T_j(i)\right)\left[M^{+}\left(T_j(i),i\right)+P\left(T_j(i)\right)\gamma\right]\leq\sum_{j=1}^{\infty} Q\left(T_j(i)\right)M^{-}\left(T_j(i),i\right)+B_0(i)+$$
$$P_0k_0(i)+\int_0^{\infty} Q(t)\,P(t)w(t)h(t,i)dt-\int_0^{\infty} Q(t)\tau(t)dt \qquad (5)$$

The restrictions (5) states that the present value of money transfers and transfers fees must be less or equal to the present value of deposits in the brokerage account, including initials holdings of bonds and income from capital and labor. Households also have a cash-in-advance constraint with varying holding periods $(T_j(i),T_{j+1}(i))$, which imposes that households need enough money on their bank account to be able to visit goods markets during the whole holding period, $\dot{M}(t,i) = -P(t)c(t,i), t \geq 0, t \neq T_j(i), j = 1,2, \ldots$, The cash in advance constraints that household i faces can be written as:

$$M^{+}\left(T_j(i), i\right) \geq \int_{T_j(i)}^{T_j+1(i)} P(t)c(t,i)dt \qquad (6)$$

In this economy without uncertainty is never optimal to set $M^{-}(T_{j+1}) > 0,\ j \geq 1$, because it means that the agents maintained money holdings in the bank, during the holding period $(T_j(i), T_{j+1}(i))$ without receiving interest. The agent is always better off if transfer money from their brokerage account to their bank account and reducing the amount transferred at T_j for transactions during the holding period until $M^{-}(T_{j+1}) = 0$. However, as M_0 is given by households, it can still be the case that $M^{-}(T_{j+1}) > 0$, for $j = 0$.

The household i take a King, Plosser and Rebelo (1988) utility function[6]:

$$U\left(c(t,i), h(t,i)\right) = \frac{1}{\left(1 - \frac{1}{\eta}\right)}\left[c(t,i)\left(1 - h(t,i)\right)^{\propto}\right]^{1-\frac{1}{\eta}}$$

Where η is the elasticity of inter-temporal substitution, $1/\eta$ is the relative risk aversion and $\alpha > 0$ is the relative preference parameter for leisure $l(t,i) = 1 - h(t,i)$. Preferences are a function of consumption goods and labor, the financial costs do not enter directly in utility function. At $t = 0$, given prices and $i = (M_0, B_0, K_0)$, agents make their decisions in choice the vector $\mathfrak{I} = \left\{c(t,i); h(t,i); M^{+}(t,i); T_j(t,i)\right\}$ by solving the following problem:

---

[6] King et. al (1988) shows that this kind of preferences have properties consistent with steady state equilibrium.

$$\max_{\mathfrak{I}} \sum_{j=0}^{\infty} \int_{T_j}^{T_{j+1}} e^{-\rho t} U[c(t,i), h(t,i)] dt$$

subject to inter-temporal budget constraint (4) and cash in advance constraint (5).

Let $\lambda(i)$ to be lagrange multiplier of budget constraint and $\mu\left(T_j(i)\right)$ the lagrange multiplier of cash in advance constraint, the Lagrangean of problem stated above is:

$$\mathcal{L}\left(\mathfrak{I}; \lambda(i); \mu\left(T_j(i)\right)\right) = \sum_{j=0}^{\infty} \int_{T_j(s)}^{T_{j+1}(s)} e^{-\rho t} \frac{1}{\left(1-\frac{1}{\eta}\right)} \left[c(t,i)\big(1-h(t,i)\big)^{\alpha}\right]^{1-\frac{1}{\eta}} dt +$$

$$\lambda(i) \left\{ \sum_{j=1}^{\infty} Q\left(T_j(i)\right) M^-\big(T_j(i), i\big) + B_0(i) + P_0 k_0(i) + \int_0^{\infty} Q(t) P(t) w(t) h(t,i) dt - \right.$$

$$\left. \int_0^{\infty} Q(t)\, \tau(t) dt \; - \; \sum_{j=1}^{\infty} Q\big(T_j(i), i\big) \left[M^+\big(T_j(i), i\big) + P\left(T_j(s)\right)\gamma\right] \right\} +$$

$$\mu\left(T_j(i)\right)\left\{M^+\big(T_j(i), i\big) \; - \int_{T_j(i)}^{T_j+1(i)} P(t) c(t,i) dt\right\}$$

For $\left\{\left[T_j(i), T_{j+1}(i)\right)\right\}_{j=1}^{\infty}$ the first order condition with respect to consumption $c(t,i)$, leisure $l(t,i) = 1 - h(t,i)$, money holdings after a transfer $M^+\big(T_j(i), i\big)$ and timing for make transfer at $T_j(i)$ becomes respectively:

$$|c(t,i)|: e^{-\rho t} l(\mathrm{t}, i)^{\alpha} (c(t,i) l(\mathrm{t}, i)^{\alpha})^{-1/\eta} - \mu\left(T_j(i)\right) P(t) = 0 \tag{7}$$

$$|l(t,i)|: e^{-\rho t} \alpha l(\mathrm{t}, i)^{\alpha-1} c(\mathrm{t}, i) (c(t,i) l(\mathrm{t}, i)^{\alpha})^{-1/\eta} - \lambda(i) Q(t) P(t) w(t) = 0 \tag{8}$$

$$\left|M^+\big(T_j(i), i\big)\right|: -\lambda(i)\, Q\big(T_j(i), i\big) + \mu\left(T_j(i)\right) = 0 \tag{9}$$

$$\left|T_j(i)\right|: e^{-\rho\left(T_{j(i)}\right)} \left(\frac{1}{\left(1-\frac{1}{\eta}\right)} \left[c^-\big(T_j(i), i\big) \left(1 - h^-\big(T_j(i), i\big)\right)^{\alpha}\right]^{1-\frac{1}{\eta}} \right) -$$

$$e^{-\rho\left(T_{j(i)}\right)} \left(\frac{1}{\left(1-\frac{1}{\eta}\right)} \left[c^+\big(T_j(i), i\big) \left(1 - h^+\big(T_j(i), i\big)\right)^{\alpha}\right]^{1-\frac{1}{\eta}} \right) -$$

$$\lambda(i)\; \left\{ \dot{Q}\big(T_j(i), i\big) M^+\big(T_j(i), i\big) + Q\big(T_j(i), i\big) \dot{M}^+\big(T_j(i), i\big) + \gamma \left[\dot{Q}\big(T_j(i), i\big) P\left(T_j(i)\right) + \right.\right.$$

$$\dot{P}\left(T_j(i)\right)Q\left(T_j(i),i\right)\Big] - P\left(T_j(i)\right)Q\left(T_j(i)\right)w\left(T_j(i)\right)\left[h^+\left(T_j(i),i\right) - h^-\left(T_j(i),i\right)\right] -$$

$$Q(T_j(i))\tau(T_j(i))\Big\} + \mu\left(T_j(i)\right)\left[M^+\left(T_j(i),i\right) + P\left(T_j(i)\right)c^+\left(T_j(i),i\right)\right] -$$

$$\mu\left(T_{j-1}(i)\right)\left[P\left(T_j(i)\right)c^-\left(T_j(i),i\right)\right] = 0 \quad (10)$$

Inserting condition (7) in the ratio between (5) and (6) we have the intratemporal condition between leisure and consumption, which is $\frac{l(t,i)}{\alpha c(t,i)} = \frac{Q(T_j(i),i)}{Q(t)w(t)}$. Using (5), we get the growth rates of leisure and consumption during the holding periods, which are respectively, $\varkappa_c = \frac{\dot{c}}{c} = \frac{\alpha(\eta-1)-\eta}{1-\alpha(\eta-1)}r$ and $\varkappa_l = \frac{\dot{l}}{l} = \frac{1-\eta}{1-\alpha(\eta-1)}r$.[7] Thus consumption and leisure at moment t follow $c(t,i) = c_0(i)e^{\varkappa_c(t-T_j(i))}$ and $l(t,i) = l_0(i)e^{\varkappa_l(t-T_j(i))}$, with $c_0(i)$ and $l_0(i)$ are the positions of initial artificial consumption and leisure respectively in holding period. With this behavior of $c(t,i)$ and $l(t,i)$, and since $\frac{Q(T_j(i),i)}{Q(t)} = e^{r(t-T_{j(i)})}$, the intra-temporal condition between leisure and consumption, becomes:

$$\frac{c_0(i)e^{\varkappa_c(t-T_j(i))}}{l_0(i)e^{\varkappa_l(t-T_j(i))}} = \frac{e^{-r\left(t-T_{j(i)}\right)}w(t)}{\alpha}, \text{ for } j = 0,1,2,... \quad (11)$$

The condition (11) gives the position on consumption and leisure by household i over the holding period, which depends on their growths rates, nominal wages, interest rates, the preference for leisure and the distance to the previous transfer time. Even if the size of the holding period $T_{j+1}(i) - T_j(i)$ is the same for all households, the hours of work supply decreases, and leisure increases within the holding period. The expression for the behavior of individual consumption and leisure of household (i) at moment t implies that aggregate consumption and aggregate leisure is respectively for $j = 1,2,3, \ldots$

[7] The setting that I will use implies $\varkappa_c < 0$ and $\varkappa_l \geq 0$.

$$C(t) = \left(T_{j+1}(i) - T_j(i)\right)^{-1} \int_0^{(T_{j+1}(i)-T_j(i))} c(t,i)dt,$$

and

$$L(t) = \left(T_{j+1}(i) - T_j(i)\right)^{-1} \int_0^{(T_{j+1}(i)-T_j(i))} l(t,i)dt.$$

As referred above, for a complete holding period, all households which make a transfer at $T_j(i)$ starts with c_0 for consumption and end with $c_0 e^{\varkappa_c (T_{j+1}(i)-T_j(i))}$. The heterogeneity of model is in the timing of when transfers are made by households. At any moment t, the money demand of household $i = s$ that make $j + s$ transfers is $M(t,i) = \int_t^{T_{j+s}(i)} P(z)c(z,i)dz$, for $i = s = 0,1, \ldots$. From now on, I will define the length of holding period as $N_j = T_{j+1}(i) - T_j(i)$, which is the same for all households. The aggregate money demand at date t is $M(t) = N_j^{-1} \int_0^{N_j} M(t,i)di$. As individual consumption for $i = s = 0,1, \ldots$, follows $c(z,i) = c_0 e^{\varkappa_c N_j} e^{-\varkappa_c T_{j+s}(i)} e^{\varkappa_c z}$, and $P(z) = P_0 e^{\pi z}$ for $z \in \left[t, T_{j+s}(i)\right)$, substituting in expression above of $M(t,i)$, the aggregate money demand at moment t is rewritten below:

$$m(t) \equiv \frac{M(t)}{P_0 e^{\pi t}} = \frac{c_0}{\varkappa_c(t) + \pi(t)} \left(e^{(\varkappa_c(t)+\pi(t))N_j} \frac{1 - e^{-(\pi(t))N_j}}{(\pi(t))N_j} - \frac{e^{\varkappa_c(t)N_j} - 1}{\varkappa_c(t)N_j} \right) \quad (12)$$

After rearranging (10), and using (11), the optimal interval between transfers, N_j yields from the positive root of

$$c_0 \left[\frac{1 - e^{(r(t)+\varkappa_c(t))N_j}}{\eta - 1} - r(t) \frac{e^{(\pi(t)+\varkappa_c(t))N_j}}{(\pi(t) + \varkappa_c(t))} \right] - w(t)l_0\left(1 - e^{\varkappa_l(t)N_j}\right) = \rho(t)\gamma \quad (13)$$

The left side of (11) is the marginal cost of delaying the transfer and the right side of (11) is the marginal benefit of increasing N_j. $\rho\gamma$ is the marginal benefit because households delays the payment of the transfer cost when N_j rises. When we divided (9) by $Q\big(T_j(i), i\big)P\left(T_j(i)\right)$ seems the term $\big[\dot{Q}\big(T_j(i), i\big) - \dot{P}(T_j(i), i)\big]\gamma$, which is the same as $\big[r\big(T_j\big) - \pi(T_j)\big]\gamma$ and means that the benefit of postponing the payment depends on the difference between nominal interest rate and inflation at T_j[8] and financial cost. Mulligan and Sala-i-Martin (2000) point out that a large fraction of households only hold money because the left side is lower than the right side.

2.4. Competitive equilibrium

A competitive equilibrium is a sequence of policies, allocations and prices such that (i) private agents (firms and households) solve their problems given the sequences of policies and prices, (ii) the budget constraints of the government is satisfied and (iii) all markets clear. Given a uniform distribution[9], with density $1/N_j$ the market clearing conditions implies that the money and bonds demanded by households is equal to the money and bounds supplied by government, i.e., ${N_j}^{-1}\int_0^{N_j} M(t,i)di = M^g(t)$ and ${N_j}^{-1}\int_0^{N_j} B(t,i)di = B^g(t)$. The labor and capital market clearing conditions are ${N_j}^{-1}\int_0^{N_j} h(t,i)di = H(t)$ and ${N_j}^{-1}\int_0^{N_j} k(t,i)di = K(t)$. Finally, the market clearing

[8] As we focus on steady state with constant nominal interest rate at r and inflation at π and with non-arbitrage condition $\rho = r - \pi$ an inter-temporal discount rate given by real interest rate in order to avoid the arbitrage opportunities between bonds and goods markets, i.e., $\rho = r - \pi$. With this appears $\rho\gamma$

[9] A proof that the uniform distribution is the only distribution of agents compatible with a steady state in which agents have the same consumption pattern is in Grossman (1985, appendix B).

conditions for goods implies that the sum of aggregate private consumption, public consumption, financial services and aggregate investment equal the output production:

$$G(t) + N_j^{-1}\int_0^{N_j} c(t,i)d(i) + \frac{\gamma}{N_j} + \dot{K}(t) + \delta K(t)$$
$$= A\left(N_j^{-1}\int_0^{N_j} k(t,i)di\right)^{\theta}\left(N_j^{-1}\int_0^{N_j} h(t,i)di\right)^{1-\theta} \equiv Y(t) \quad (14)$$

where the aggregate investment is the compensation of capital depreciated.

2.5. Economy in Steady State

The steady state is interpreted as the allocations and prices of an economy that has not been exposed to shocks for a long time, and so the evolution of inflation rate, nominal interest rate, aggregate consumption, aggregate capital and aggregate labor are independent of time. I also concentrated in a steady state equilibrium where the initial distribution of bonds, money and capital among the households is such that the economy of the model has properties that all holding periods, have the same duration, N, and all households behave similarly during their holding periods. Thus, all households readjust their portfolio in the same way, being equal the fraction of households that readjust their portfolio at any moment in this interval. This means, for example, the initially portfolio adjust is at date $n(i) \in [0, N)$, and the posteriors readjusts are at dates $n(i) + jN$, for $j = 1,2, \ldots$. However, the proprieties of market segmentation are in the moment of transfer times, which are made at different times.

To ensure the existence of a competitive equilibrium in steady state with bounded budget sets, there are two conditions that must be held in order to avoid arbitrage opportunities. The non-arbitrage condition between goods markets and asset markets which states the inter-temporal discount factor is such that compensates the returns of bounds and the growth rate of the single good price, or, in other , must be equal to the real interest rate, i.e., $\rho = r - \pi$. Because only one asset is needed to accomplish all inter-temporal trades in a world without uncertainty, the second arbitrage condition ensures that capital and bonds have the equivalent rate of real return, i.e., $r^k - \delta = r - \pi$. If the left side of the last condition is higher than the right side, the household can make its budget set unbounded by either buying an arbitrarily large capital, or in opposite case, selling capital short with an arbitrarily negative capital.

At steady state equilibrium, the economy can be described by eight independent equilibrium static equations (1), (2), (3), (4), (9), (10), (11) and (12)[10], which can be used to determine eight steady state equilibrium variables. For the experiments that I want to do, I choice as endogenous variables, the vector $ב = [c_o \;\; N \;\; m \;\; h_0 \;\; H \;\; Y \;\; K \, w]$, and the remaining variables of the model are parameters attributing it fixed values[11].

[10] In appendix I rewrite the steady state equations.

[11] In order to achieve the solution of the system of nonlinear equations, I build a program in MATLAB and use the function *fmincon*. The method[11] adopted is generally referred to as constrained nonlinear optimization and, given an initial allocation for endogenous variables, it consists on minimizing an objective function subject to a system of nonlinear restrictions identified above. The objective function is a scalar function of the endogenous variables, and as the number on restrictions is equal to a number of variables to be determined, the objective function can be any constant, because it does not influence the values of ב at steady state. Thus without loss consistency, I fix the objective function $f(ב) = 100$.

3. Money Demand Instability and Financial Costs

3.1. A Time-Series Construct for Financial Costs

Since empirically it is extremely difficult to construct a direct measure of γ, I will use indirect measures to create a time-series for γ this will make it possible to posit the evolution. I construct a time-series for γ through calibrating the model explained in the previous section, with annual time-series data of m/Y and r for the period 1900 to 2006. M1 is used for the monetary aggregate, m, the nominal GDP for output, Y, and short-term commercial paper rate for the nominal interest rate[12], r, as in Lucas (2000) and Wright (2005). For each annual period, the method adopted to achieve γ consists in calibrating the nominal interest rate (r) with the values taken from the data, and γ is calibrated in such a way that, in the general solution of the model, money-income ratio matches these values.

In this exercise, for convenience, I assume there is no government and $\eta \to 1$. With this setting for η, the King, Plosser and Rebelo (1989) utility function turns in logarithmic function $U\big(c(t,i),h(t,i)\big) = \log\big(c(t,i)\big) + \alpha\log(1 - h(t,i))$, and has the propriety of separable leisure and consumption, and $\varkappa_c = -r$ and $\varkappa_l = 0$ on each holding period, i.e., consumption decreases at the nominal interest rate and leisure is constant. Moreover, in goods markets clearing condition (10) government expenditure term does not appear. I use a similar parameterization to that used by Silva (2012). In addition to calibration of parameters explained above, I calibrate the model for ρ = 3%, α = 2.065, δ = 10% and A = 1. One important note is that the values of γ that will be obtained are

[12] Data sources are described in appendix.

not the real values of γ because the model is constructed to explain the long-run money demand, when the economy is at its steady state. However, as we will see in the next subsection, the γ created in this exercise can be seen as a very good proxy for real quantitative values of this variable, if we consider the financial costs as being the unexplained part of the money-income ratio.

Figure 1plots the time series of financial costs and its trend retired by the Holdrick and Prescott (1997) filter. In general, as can be easily verified, the financial costs have followed a downward trend.

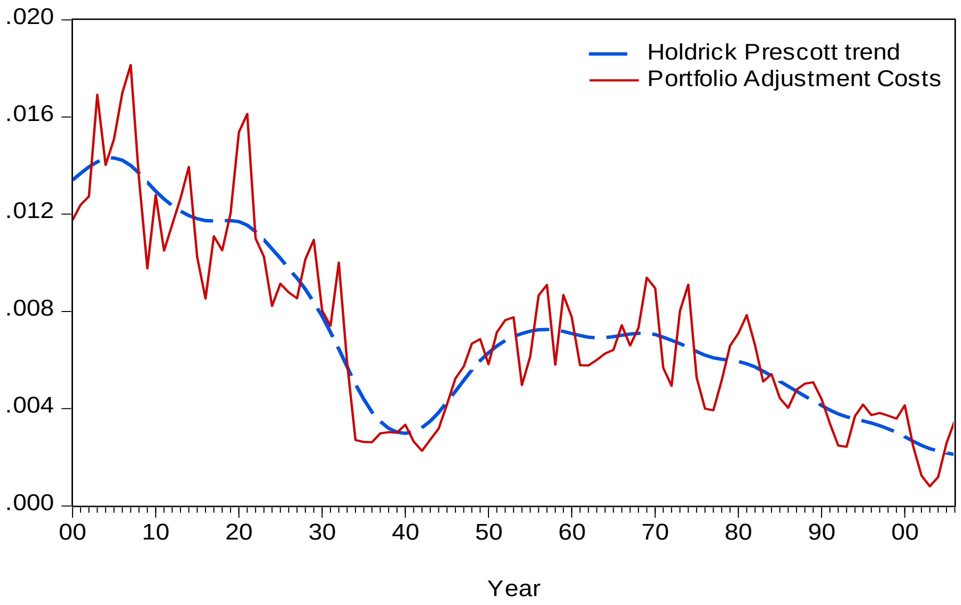

Figure 1: Evolution of Portfolio Adjustment Cost

The evolution has a minimum of 0.0008, a maximum of 0.018 and a mean of 0.007. We can interpret γ as a fraction of income or as a cost per transfer. With per capita income of 35,000 dollars in 2000, that statistics means that the evolution of cost per transfer has a minimum of 28 dollars, a maximum of 630 dollars and a mean of 245 dollars. If I made the exercise dividing the annual rates by 365 would imply evolution of γ in days per transfer with a minimum of 0.292, a maximum of 6.57 and a mean of 2.56.[13] And so have a minimum of about one third of day per transfer, a maximum of 6.57 days per transfer and a mean of about 2.56 days per transfer.

An important observation needs to be made about the 1930s, which were characterized by the Great Depression and during which financial costs were very low. However, money demand was high due to an interest rate close to zero, making households feel less attracted to invest their income with very low return.

3.2. Money Demand Function with Financial Costs

Using data from 1900 to 1994, Lucas (2000) relates the money-income ratio to the nominal interest rate, using

$$m/Y = Zr^{\emptyset} \tag{15}$$

where Z>0 is a constant, and $\emptyset$ measures the value of interest rate elasticity of money demand. Lucas (2000) preferred specifications set $\emptyset$ = - 1/2, consistent with a shopping time model for money demand, and Z is such that m/Y matches the geometrical mean when r takes its geometrical mean.

Teles and Zhou (2005) argue that M1 was a good measure of money before the development of the financial sector which started in the early 1980s. After that, they focus on MZM as the most appropriate measure for money demand, and the opportunity cost of holding money as the difference between the nominal interest rate and the interest for some components of MZM, like NOWs, MMDAs or MMMFS. The

[13] With this we can compare the values obtained with the values of Silva (2012).

statistical used for this interest is the Three-month T-bill rate for secondary market. Hence they propose the following specification:

$$m/Y = Z(r - r^m)^{\emptyset} \quad (16)$$

Now, I will estimate the determinants of the money demand equation in (15) and (16) using ordinary least squares (OLS). The equations estimated are denoted by (15') and (16') respectively[14]

$$\log\left(\frac{\widehat{M1}}{Y}\right) = -0.313\log(r) - 1 \quad (15')$$

$$\log\left(\frac{\widehat{MZM}}{Y}\right) = -0.13\log(r - r^m) - 0.87 \quad (16')$$

Thus the estimated interest rate elasticity for (15') is ∅= - 0.31, and the estimated opportunity cost elasticity for (16') is ∅ = -0.29. The estimation of MZM/Y only began in the 1959 because sufficient was only then available. Figures 2 and 3 plot the logarithm of M1/Y and MZM/Y with the parameters showed above.

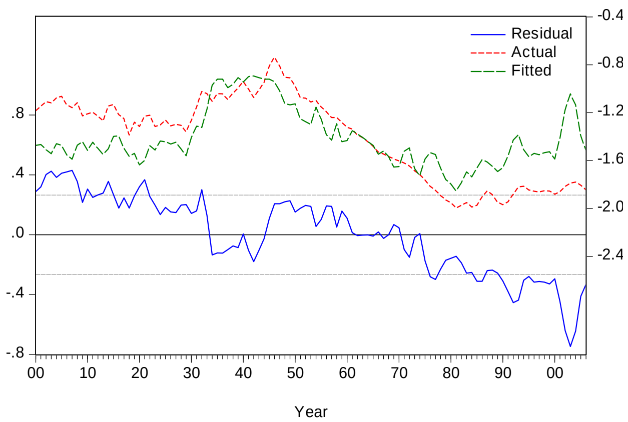

Figure 2: Actual and Estimated M1/Y for 1900-2006

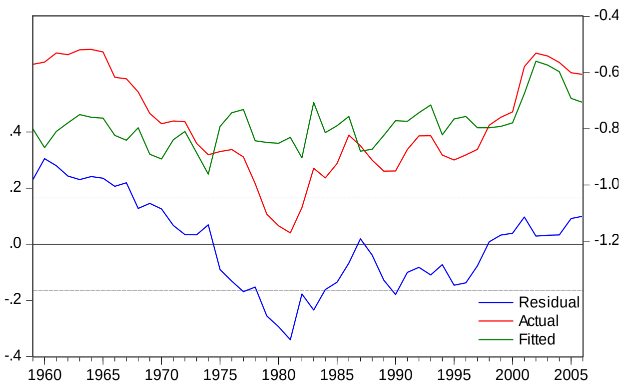

Figure 3: Actual and Estimated MZM/Y for 1959-2006

[14] If I estimate the MZM demand, only after 1980, the parameters will be the same as in Teles and Zhou (2005).

In the money demand specification that I propose, I add to the counterpart money demand specification by Lucas (2000) the evolution created for γ. Therefore, the money demand proposed in this study can be represented by

$$m/Y = Zr^{\emptyset}\gamma^{\varphi} \quad (17)$$

where φ is the financial costs elasticity of money demand. The OLS estimators of (17) are in (17'), and imply that $\emptyset$ = - 1/2 and φ = 1/2. So, as reported by Silva (2012), the money demand in this model is similar to a Baumol-Tobin money demand, i.e., $m/Y = A\sqrt{\gamma/r}$. According to Lucas (2000), this specification has a good fit to the U.S. data.

$$\log\left(\frac{\widehat{M1}}{Y}\right) = -0{,}5\log(r) + 0{,}5\log(\gamma) + 1.8 \quad (17')$$

In figure 4, it can easily be seen that with the time-series created for γ, the money demand estimated gives a very good explanation of the logarithmic of M1-income ratio. It describes the general pattern of the data much better than the other specifications of money demand.

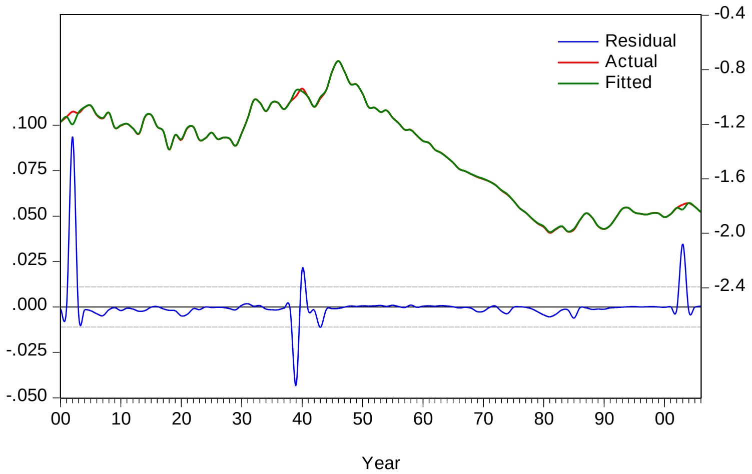

Figure 4: Actual and Estimated M1/Y with financial costs for 1900-2006

This research suggests that γ may be important in explaining the instability of money demand. This way, it is important to identify the determinants of γ, and, in particular, if changes in γ match the alterations in US financial laws.

In the next chapter, I will provide a brief review of post 1980 development in the financial sector of the United States, and check, with a new calibration of the model, if γ is lower since that date, and I will quantify the welfare effects. With this I also provide robustness to the exercise make in this chapter.

4. Welfare Effects of Financial Innovation and Financial Deregulation

Have financial innovation and financial deregulation make lower γ? As in the previous section, this question is examined trough calibrating the model with time-series data of m/Y and r for the period 1900 to 2006. However, the method adopted to achieve γ is different and consists in the following steps. In the first place, the available data is divided into two samples. The first sample takes in the period between 1900 and 1979 and the second sample goes from 1980 to 2006. The second sample has the particularity to covers the period of financial deregulation and the occurrence of major financial innovations. For both periods, the data used is the same as the previous exercise in this Dissertation. In the second place, for each sample, is computed the US historical geometrical mean for money-income ratio (*m/Y*), along with nominal interest rate (*r*). Finally, for each sample, I assume the US historical geometrical mean to calibrate the nominal interest rate (*r*), and γ is determined in such a way that in a general solution of the model, money-income ratio (*m/Y*) taken US historical geometrical mean. In the first subsection, I will provide a brief review of the post 1980 era in the financial sector of the United States.

4.1. Financial Innovation and Financial Deregulation in the USA (post 1980)

The beginning of financial deregulation started with enactment of the Depository Institutions Deregulation and Monetary Control Act of 1980, which abolished most of the interest ceilings imposed on deposit accounts. From then on, a number of major deregulation acts have been passed. They included: the Federal Deposit Insurance Improvement Act of 1991, which introduced some risk sensitivity to deposit insurance premiums, and the Neal-Riegle Interstate Banking Act of 1994, which created financial holding companies, and ended the artificial separation of insurance companies and commercial and investment banks.

Along with numerous financial innovations, powered by the rapid improvements in data processing and telecommunications, the deregulation of the financial sector also created an increasing competition in the banking industry. The development of Internet banking, electronic payments, and information exchanges appear as the biggest financial innovations. ATMs, for instance, grew steadily during the early- to mid-1980's. The adoption of new cash management techniques, along with increasing competition among commercial banks is likely to have brought about considerable benefits to consumers and reduced the costs of money transactions.

4.2. Welfare

The Welfare of this kind of economy is given by the steady state aggregate intertemporal utility from all households, each with equal weight, for the steady state nominal interest rate, and for financial costs of participation. Formally, we have:

$$U^W(r,\gamma) = \frac{1}{N}\frac{1}{\rho}\frac{1}{1-\frac{1}{\eta}}\int_0^N \left[c_0 e^{\varkappa^c t} l_0 e^{\varkappa^l t^{\alpha}}\right]^{1-\frac{1}{\eta}} dt,$$

which can be rewritten as:

$$U^W(r,\gamma) = \frac{1}{\rho}\frac{c_0(N(r,\gamma))^{1-\frac{1}{\eta}}(l_0)^{\alpha\left(1-\frac{1}{\eta}\right)}}{1-\frac{1}{\eta}}\frac{e^{(\varkappa^c+\alpha\varkappa^l)N(r,\gamma)\left(1-\frac{1}{\eta}\right)}}{(\varkappa^c(r)+\alpha\varkappa^l(r))N(r,\gamma)\left(1-\frac{1}{\eta}\right)} \quad (17)$$

In (17), I write $N(r,\gamma)$ to emphasize the role of most important factors that influence the holding period. In this experiment, the effects on welfare are present in N. Silva (2009) proves that $\frac{\partial N}{\partial r} < 0$ and $\frac{\partial N}{\partial \gamma} > 0$.

The welfare compensation is defined as the amount of additional income that households should receive in a given situation to ensure the same level of aggregate utility in another situation. Let $U^W(\gamma, r, \varepsilon)$ denote the steady state intertemporal utility for all households when each household receives compensation ε and all remaining equilibrium variables are set at their steady state values under the fixed cost γ and r. Let $\bar{\gamma}$ and $\bar{r}$ be respectively the higher financial costs and the lower interest rate and what needs to be found is I need to know how much consumers would need to be compensated to be as well as after the financial costs decrease to γ and increase $\bar{r}$ to r. If compensation is negative, thus the second situation provides benefits in welfare in the economy of this model. The compensation that makes the households indifferent between (γ, r) and $(\bar{\gamma}, \bar{r})$ is an exogenous transfer $\varepsilon_{\gamma,r}$ to each household, of an extra flow of real income such that it solves $U(\bar{\gamma}, \bar{r}, \varepsilon_{\gamma,r}) = U(\gamma, r, 0)$, i.e.,

$$\varepsilon_{\gamma,r} = \frac{c_0\left(N_{(\gamma,r)}\right)^{1-\frac{1}{\eta}} l_0\left(N_{(\gamma,r)}\right)^{\alpha\left(1-\frac{1}{\eta}\right)} N_{(\bar{\gamma},\bar{r})} e^{(\varkappa^c(r)+\alpha\varkappa^l(r))N_{(\gamma,r)}\left(1-\frac{1}{\eta}\right)}}{c_0\left(N_{(\bar{\gamma},\bar{r})}\right)^{1-\frac{1}{\eta}} l_0\left(N_{(\gamma,r)}\right)^{\alpha\left(1-\frac{1}{\eta}\right)} N_{(\gamma,r)} e^{(\varkappa^c(r)+\alpha\varkappa^l(r))N_{(\bar{\gamma},\bar{r})}\left(1-\frac{1}{\eta}\right)}} - 1 \qquad (18)$$

In the economy with variables $(\bar{\gamma}; \bar{r}; \varepsilon_{\gamma,r})$ the market clearing condition is

$$G + C + \frac{\bar{\gamma}}{N} + \frac{\delta\theta}{p+\delta} Y = Y + \varepsilon_{\gamma,r} \qquad (19)$$

Now I have a new system of equilibrium allocations, where I add one more variable $\varepsilon_{\gamma,r}$, one more equation (18) and the equation (14) exchanged by (19) to the previous system of equations. As the number of equations is equal to the number of endogenous variables, the new system of equations can be solved and the value of $\varepsilon_{\gamma,r}$ associated with the sample characterized by financial innovation and deregulation can be determined.

4.3. Calibration

The most important variable in this experiment is γ, which is determined in such a way that $m(r)/Y = \bar{m}(\bar{r})$ is verified for each sample, where $\bar{m}$ and $\bar{r}$ are the US historical geometrical means of money income ratio and nominal interest rate respectively. This method is similar to that followed by Lucas (2000) and Silva (2012) for M1, and Alvarez et al. (2009) and Khan and Thomas (2007) for the average of M2 velocity. The mean interest rate during the first sample $\bar{r}$ is 3.13% percent per year and the mean of money income ratio $\bar{m}/Y$ is 0.28. For the second sample $\bar{r}$ = 5.54% and $\bar{m}/Y$ = 0.15.

The parameterization adopted for the two samples in this experiment is shown in the table below:

Table I: Parameter values

	η	A	G	α	δ	θ	r	π	ρ
First Sample	3	1.5	0.189	2.9195	10%	0.33	3.13%	-0.5%	3.64%
Second Sample	-	-	-	2.9198	-	-	6.36%	2.72%	-

The relative risk aversion parameter was set equal to 3. This assumption is consistent with the empirical evidence presented by Hall (1988), who suggests that the inverse of the intertemporal elasticity of substitution, $1/\eta$, is much less than one. In addition, the seminal work of Mehra and Prescott (1985) states that the estimates of the elasticity of intertemporal substitution are usually below 10. Silva (2012) also argues that the values of η above 10 only match the data with exogenous segmentation. Cooley and Hansen (1989) and Cooley and Hansen (1991) set $\eta = 1$.

The depreciation rate δ is set to 10% so that the investment share in total output is close to 30%. I set D_0^G=0 because it is not optimal for the government to have initial debt higher than zero in steady state. Government expenditure was set close to 22% of the total output in each sample. The Lump Sum Tax is set so that it compensates seignoriage in financing government expenditures.

For convenience, the preference for leisure α was left to be determined in the model and the equilibrium value of h was set to be close to 30% of the total time available for hours of work. In this way, I let varying the growth rate for consumption and leisure with an additional parameter in each sample. For the share of capital income in total income I set θ=1/3, the same value used by Cooley and Hansen (1989), and Cooley and Hansen (1989). It was also assumed that A=1.5. Finally, I set ρ = 3.64%, and the inflation rate π is given by non-arbitrage condition between goods market and bonds market[15], $r - \rho$.

4.4. Results and Comments

The results from the first experiment are summarized in Table 2. The lower γ in the second sample suggests that γ is a good measure of the financial development in the second sample. With a higher interest rate, which implies higher inflation (π increases about 3.23% in the second sample), the results are surprising due to lower financial costs in second sample. In general a situation with higher interest rate is worse for welfare. For instance the interest rate can be seen as a "tax of holding money". Additionally, a situation with lower γ, also can be worse to welfare. As we assume that over the century only two parameters change, these results occur because in the model, households can choose the timing for when to use financial services. The change in γ is relatively higher than the change in r, and then γ/N decreases.

For 1900-1979, γ which makes $m(3.13) = 0.28$ is 0.0117 and the optimal time interval between visits to financial markets is 1.3 per year, which means that households spend about 20 minutes per week on financial transactions. For 1980-2006, then γ which

[15] I could let π takes its geometrical mean, and ρ is given by the difference between r and π. However this would imply a ρ very low. Typically, annual ρ assumes values close to three.

makes $m(6.36) = 0{,}15$ is 0.0057 and the optimal N = 0.68 year, and so the time devoted to financial transfers is about 19 minutes per week.[16]

Table II: Steady State Values in each Sample for first experiment

	1900-1979	1980-2006
c_0	0.4508	0.4511
N	1.2932	0.68
γ	0.0117	0.0057
H	0.3	0.3
Y	0.849	0.849
K	2.0541	2.0541
h	0.3058	0.3053
m/Y	0.28	0.15
$\varkappa^l$	0.0129	0.0225
$\varkappa^c$	-0.0183	-0.0319
C	0.4456	0.4623
$\varepsilon_{\gamma,r}$	-0.1%	

My interpretation for the results of this experiment is that financial innovations, not only increases the participation in financial markets, but at the same time decrease the time that households devoted to financial services. As households can readjust, the timing to readjust their portfolio, and the net loss from making a transfer decreases with nominal interest rate and financial cost, households increase their participation in financial markets.

[16] According to the OECD, the average weekly hours of U workers from 1957 to 197 is equal to 36.5. So the time spent on financial services is given by $\frac{\gamma}{N} * 36.5 * 60$.

The results also show the empirical evidence found by McCandless and Weber (1995), in which inflation and output are not correlated in the long run.[17]

In the second sample, the initial consumption increases by 0.07%, and the negative growth rate of consumption within holding periods increases 74.16% and as referred, the length of the holding period decreases by 47.4%. As a result, aggregate consumption increases by 3.74%. As the increase in frequency of transfers is lower than the decrease in financial costs, under market clearing conditions of goods and for the same output, this situation requires a transfer in the use of resources in the financial services γ/N to aggregate consumption in output composition, i.e., the share of financial service is lower in output and the share of aggregate consumption is higher in output composition for the second sample, which is illustrated in table 3.

Table III: Composition of US GDP

	Consumption Expenditures	Financial Services	Government Expenditures	Investment
1900-79	52.47%	1,07%	22%	24.46%
1980-06	52.56%	0.98%	22%	24.46%

In addition, to compensate for the increase in resources available for consumption, households cut working hours. As households are working less, they have more time available for leisure and this increases utility. As aggregate consumption and aggregate leisure increase, there is a decrease in output produced by financial sector, which does not change the aggregate utility, the welfare is higher in the second sample. Figure 5 below illustrates the behavior of consumption in each steady state.

[17] On the other side, Cooley and Hansen (1989) report evidence of a negative correlation between inflation and output.

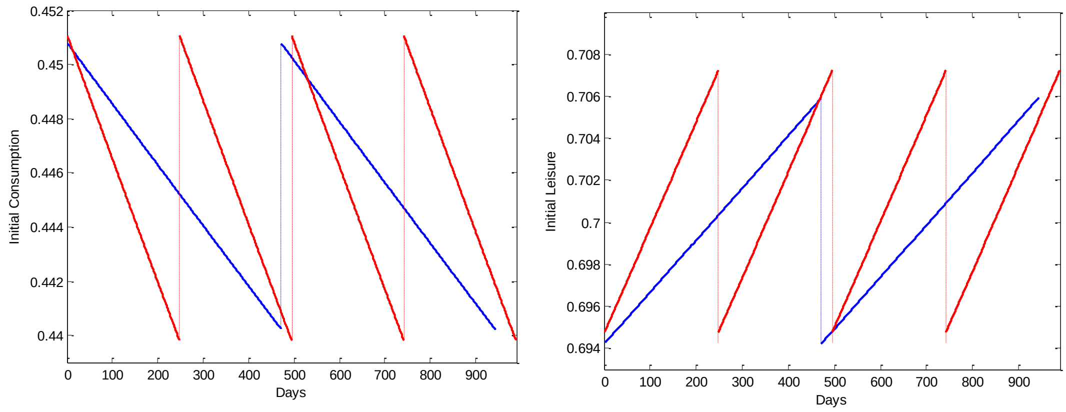

Figure 5 Artificial Consumption and leisure in each Steady State: x axes represents the periods, and y axes gives the position of artificial consumption for each period. I divide the annualized variables per 365 in order to obtain N in days. The evolution with color red is for first sample, and with color blue is for second sample. The discontinued line represents the end of holding period and the timing of households makes a transfer from brokerage account to bank account.

We can conclude that, as γ decreases in the sample characterized by financial innovation and financial deregulation, γ in this model can be a good proxy for understanding financial development. In addition, a reduction in γ, or an increase in financial development, provides benefits to social welfare, and more than offsets the welfare cost of higher interest rate.

In order to quantify the benefits, $\varepsilon_{\gamma,r}$ = - 0.1% of income means that the benefits of financial development is already 10 billion dollars in US nominal GDP of 2000.

5. Conclusions

This Dissertation researched one empirical application of a Baumol-Tobin model with market segmentation. The financial costs (γ), faced by households when they use financial services, is important to explain the instability of money demand. I use the model with same particularities of Silva (2012), and I compute the time-series of these costs. I find that γ has seen a downward trend over the last century. Moreover, I add the new time series computed to the specification of money demand à la Lucas (2000), and the M1 money demand empowered a precise characterization of annual U.S. data during the period 1900-2006. The OLS estimates for elasticity of money demand counterpart that I propose are 0.5 for financial costs and -0.5 for interest rate. As my model is constructed to study the long run when economy is at steady state, the values of γ time-series are not the real values for γ, but is a very good proxy.

A stable estimate of money demand is an important tool for performing the objective of a monetary authority to provide elastic liquidity at stable prices (Teles and Zhou, 2005).

Finally, I divide the available data in to two samples, and I study the welfare effects on a sample characterized by a higher interest rate and substantially lower γ due to financial innovations and financial deregulation. Generally a higher nominal interest rate decreases the welfare. However, when the financial costs decrease, they provide benefits in such way that overcompensate the welfare costs of higher interest rates. A policy implication is that, as the fixed cost decreases over time, due to financial innovations, the welfare cost of inflation driven by a higher interest rate will can be affected.

This research suggests that γ can be important to explain the instability of money demand. This way, it will be important to identify the determinants of γ, and model it in order to have a stable estimate of γ. I leave this topic for future research.

Additionally, in this study, γ matches the alterations in the U.S financial laws with a decrease post 1980, and so γ can be used to be a good proxy of financial development.

A. Appendix

A.1.Data Description

From 1900 to 1997, all data series for M1, GDP and nominal interest rate is the same as used in Lucas (2000). After 1997 all the data are taken from the US Federal Reserve Bank's web-site: http://research.stlouisfed.org/fred2/

For M1 (billions of Dollars, December of each year):

- From 1900 to 1913: Historical Statistics of the United States (1960), Series X-267: Demand deposits adjusted plus currency outside banks;
- From 1924 to 1958: Friedman and Schwartz (1963), Table A-1, pp. 704-734, column 7 (sum of currency and demand deposits). December, Seasonally Adjusted;
- From 1959 to 2006: FRED M1 December, Seasonally Adjusted Series, M1SL (Billions of Dollars).

For income I use the nominal Gross Domestic Product (GDP):

- From 1900 to 1928: Historical Statistics of the United States: Colonial Times to 1970. Author: Bureau of the Census (1975). Series F1 (NGDP). (Billions of dollars)
- From 1929 to 1997: NIPA. Table 1.1.5. Gross Domestic Product. (Billions of dollars)

For the interest rate I use commercial paper rate expressed in annual percentage:

- From 1900to1975: Friedman and Schwartz 1982, Table 4.8, column 6, p. 122, "Monetary trends in the U.S. and the U.K., 1875-1975," University of Chicago Press.;
- From 1976 to 1997: Economic Report of the President (1996, Table B-73 "Bond Yields and Interest rates").

A.2. Steady State Equations Rewritten

Now it is dropped the index t and i from the notation for simplify. The equations of steady state are:

The production function

$$Y = AK^{\theta}H^{1-\theta}$$

The demand for capital

$$K = \frac{\theta Y}{(\rho + \delta)}$$

The aggregate supply of hours by households

$$1 - H = (1 - h_0) * \frac{e^{\varkappa_l N} - 1}{\varkappa_l N}$$

The government budget constraint

$$rm + \tau = G + \rho d_0^G$$

The market clearing conditions for goods

$$\frac{G}{Y} + \frac{c_0}{Y}\left(\frac{e^{\varkappa_c N} - 1}{\varkappa_c N}\right) + \frac{\gamma}{NY} + \frac{\delta\theta}{p + \delta} = 1$$

Equation for optimal length of transfer times

$$c_0\left[\frac{1-e^{(r+\varkappa_c)N_j}}{\eta-1}-r\frac{e^{(r-\rho+\varkappa_c)N_j}}{(r-\rho+\varkappa_c)}\right]-\frac{(1-\theta)Y}{H}(1-h_0)(1-e^{\varkappa_l N_j})=\rho\gamma$$

The real aggregate money demand

$$m=\frac{c_0}{\varkappa_c+r-\rho}\left(e^{(\varkappa_c+r-\rho)N_j}\frac{1-e^{-(r-\rho)N_j}}{(r-\rho)N_j}-\frac{e^{\varkappa_c N_j}-1}{\varkappa_c N_j}\right)$$

Labor demand

$$w=(1-\theta)A\left(\frac{K}{H}\right)^{\theta}$$

A.3. Time Series for Financial Costs

Year	γ	Year	γ	Year	γ	Year	γ
1900	0,011753	**1933**	0,005877	**1966**	0,007438	**1999**	0,003584
1901	0,012384	**1934**	0,00271	**1967**	0,006597	**2000**	0,004142
1902	0,012737	**1935**	0,002625	**1968**	0,007329	**2001**	0,00246
1903	0,016918	**1936**	0,002618	**1969**	0,009392	**2002**	0,001251
1904	0,014022	**1937**	0,002986	**1970**	0,008953	**2003**	0,000799
1905	0,015088	**1938**	0,003036	**1971**	0,005679	**2004**	0,001185
1906	0,017	**1939**	0,003017	**1972**	0,00494	**2005**	0,002584
1907	0,018137	**1940**	0,003336	**1973**	0,008014	**2006**	0,003521
1908	0,013447	**1941**	0,002651	**1974**	0,009104		
1909	0,009775	**1942**	0,002262	**1975**	0,005282		
1910	0,012795	**1943**	0,002727	**1976**	0,003997		

1911	0,010507	**1944**	0,003179	**1977**	0,003932
1912	0,01157	**1945**	0,004181	**1978**	0,005164
1913	0,012658	**1946**	0,005247	**1979**	0,006589
1914	0,013948	**1947**	0,00574	**1980**	0,007101
1915	0,010238	**1948**	0,006677	**1981**	0,007849
1916	0,008526	**1949**	0,00686	**1982**	0,006603
1917	0,011096	**1950**	0,005822	**1983**	0,005118
1918	0,01051	**1951**	0,007137	**1984**	0,005425
1919	0,012033	**1952**	0,007644	**1985**	0,004438
1920	0,015378	**1953**	0,007756	**1986**	0,004027
1921	0,016123	**1954**	0,004964	**1987**	0,004778
1922	0,011003	**1955**	0,006156	**1988**	0,005027
1923	0,010244	**1956**	0,008663	**1989**	0,005085
1924	0,008219	**1957**	0,009088	**1990**	0,0044
1925	0,009145	**1958**	0,005805	**1991**	0,003389
1926	0,008784	**1959**	0,008682	**1992**	0,002479
1927	0,00854	**1960**	0,007767	**1993**	0,00243
1928	0,010151	**1961**	0,005792	**1994**	0,003696
1929	0,010945	**1962**	0,005773	**1995**	0,004173
1930	0,008036	**1963**	0,006	**1996**	0,003737
1931	0,007405	**1964**	0,006274	**1997**	0,003827
1932	0,010008	**1965**	0,006416	**1998**	0,003712

Note: Years in Bold. If we multiply the values of financial costs by 365, we have familiar values that obtained by Silva (2012). With this is we can interpret the data as days per transfer.

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