Intermediation Costs and Welfare*

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Abstract

This paper studies quantitatively how intermediation costs affect the ability of agents to smooth consumption over time and the consequent welfare implications. Agents face uninsurable idiosyncratic shocks to labor productivity in a production economy with costly financial intermediation and endogenous borrowing constraints. Reducing intermediation costs leads to two effects: First, for a given interest rate, borrowing costs decrease and net borrowers’ consumption possibility frontiers expand. Households with positive current net wealth may also borrow in the future to smooth consumption since they face a positive probability of bad productivity shocks. Second, the demand for loans increases, which increases the interest rate. Decomposing the two effects shows that intermediation costs have large welfare implications relative to other policy changes, such as moderate inflation. The aggregate welfare gain of reducing intermediation costs from 3.9 percent (US level) to 1 percent is about 3.5 percent of equivalent consumption in the baseline economy, with the gains distributed unevenly: the bottom wealth decile gains about 11 percent of equivalent consumption.

JEL Classification: E60; G38

Keywords: Intermediation costs; Distribution; Welfare

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1 Introduction

The wedge between loan and deposit interest rates (i.e., the spread) varies significantly across countries and is high even in some developed countries. Data from the World Development Indicators show that while the spread is about 1.06 percentage points in the Netherlands, it is roughly 40 percentage points in Brazil. A careful empirical investigation by Díaz-Giménez, Prescott, Fitzgerald, and Alvarez (1992) shows that for collateralized loans the average interest rate is nearly 4 percentage points higher than the return on bank deposits in the United States and for uncollateralized loans the spread exceeds 10 percentage points. Using operational efficiency to measure financial intermediation cost, this paper asks two positive questions. What are the welfare implications of intermediation costs? Are the welfare effects evenly distributed across individuals with different levels of wealth?

In order to answer these questions, we construct a standard neoclassical growth model where individuals face uninsurable idiosyncratic shocks to labor productivity, an endogenous borrowing limit, and costly intermediation.1 Households smooth consumption over time by making deposits at a financial intermediary in good times and by running down credit balances or getting loans in bad times. The intermediation cost generates a wedge between loan and deposit rates, with interest payments on loans higher than the return on deposits. Figure 1a graphs intermediation costs versus per capita GDP for selected countries and figure 1b plots the costs over time for three countries. The figure shows that costs are about 8 percent in Brazil, almost 4 percent in the United States, and less than 1 percent in Ireland.2

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1 We consider both a Kehoe and Levine (1993) endogenous borrowing constraint and an Aiyagari (1994) natural borrowing limit.

2 Section 3.1 measures intermediation costs by overhead plus taxes as a percent of total assets, using Demirgüç-Kunt and Levine’s (2000) data set. All data in Figure 1 are in 2004 US dollars.
We calibrate the model to match key statistics of the United States economy and perform counter-factual experiments. Reducing intermediation costs leads to two effects. First, for a given interest rate, decreasing borrowing costs expands net borrowers’ consumption possibility frontiers and even current savers may benefit (with positive probability they may need to borrow to smooth consumption in the future due to bad labor productivity shocks). Second, there is an indirect effect: lower intermediation costs imply an increase in the demand for loans, which raises the interest rate. This offsets part of the decrease in borrowing costs and also increases interest income, improving the welfare of net savers. Clearly, the net impact of these effects requires a quantitative analysis.

We find two important quantitative results: intermediation costs have a large and differential effect on welfare. The aggregate welfare gain of all agents from reducing intermediation costs from 3.9 percent (United States level) to 1 percent (level observed in the 10th percentile of countries with the lowest overhead costs) is about a 3.5 percent consumption equivalent increase in the baseline economy. This is at least 3.5 times larger
than previous estimates of:³ (i) reducing the capital income tax rate from 36 to 0 percent; (ii) reducing inflation from 10 to 0 percent; and (iii) eliminating all business cycle fluctuations. And welfare gains are not evenly distributed across agents. The lowest wealth decile has an average welfare gain of 11 percent of their baseline consumption, while the highest decile has an average welfare gain of roughly 1.1 percent. The welfare analysis focuses on stationary equilibria and transitional dynamics. The transition is slow, and abstracting from it can lead to misleading welfare calculations. Also, mobility in wealth means that comparing, for instance, the agent with median wealth in two stationary equilibria may not involve the same household.

The goal is to evaluate how costly intermediation affects households’ ability to smooth consumption over time and the welfare effect on heterogenous agents. Thus, we assume a given costly intermediation technology and take regulation as given.⁴ The paper is related to a large literature on supply-side economics, such as Lucas’ (1990) article on the welfare effects of reducing capital income taxation.⁵ There is also a large literature that studies the impact of financial reform on long run productivity and economic growth (e.g., Amaral and Quintin, 2005; Castro, Clementi, and MacDonald, 2004; Erosa and Hidalgo-Cabrillana, 2007; Antunes, Cavalcanti, and Villamil, 2008).⁶ Our positive question is related to this literature, but we focus on the effects of intermediation costs on consumption smoothing and welfare, rather than on entrepreneurship and economic development. To our knowledge, we are the first to quantify the welfare implications of intermediation costs in a growth model with heterogenous agents and idiosyncratic uncertainty.

The paper proceeds as follows. Section 2 describes the model economy and defines the competitive equilibrium. Section 3 calibrates the model and performs policy experiments to evaluate the welfare effects of changes in intermediation costs. Section 4 concludes.

³See subsection 3.5 for details and discussion of the relevant literature.
⁴Townsend (1978) and Greenwood and Jovanovic (1990) build economies in which financial institutions arise endogenously to share risk and smooth consumption by collecting information, pooling risk and allocating resources to high return investments. See Diamond and Dybvig (1983) for a theoretical justification of bank regulation.
⁵See also Lucas (2000), who studies the welfare costs of inflation.
⁶For an important literature studying empirically the relationship between financial and economic development, see King and Levine (1993), Levine (1997), and Rajan and Zingales (1998).
2 The model

There are three sectors in the economy: households, banking, and production. A continuum of infinitely-lived households, who are *ex-ante* identical, face idiosyncratic shocks to their labor productivity but there is no aggregate uncertainty. Banks’ only role is to intermediate among households, and intermediation is costly. The production technology exhibits constant returns to scale. The produced good can be used for consumption or investment. Below we describe the economy in detail.

2.1 The banking sector

Banks lend to households that wish to borrow and accept deposits from those that wish to save. In period $t$, let $D^b_t$ be households’ deposits and $L^b_t$ be loans, with $i_{D,t}$ and $i_{L,t}$ the respective interest rates on deposits and loans. There is a cost $\tau$ per unit of value intermediated to the household sector. Financial intermediaries take the interest rates on deposits $i_{D,t}$ and loans $i_{L,t}$ as given and solve the following problem:

$$\max_{\{D^b_t, L^b_t\}_{t=0}^\infty} \{(1 + i_{L,t})L^b_t - (1 + i_{D,t})D^b_t - \tau L^b_t\},$$  

subject to:

$$L^b_t \leq D^b_t, \quad D^b_t, L^b_t \geq 0.$$  

Given that loans are restricted by the amount of deposits, the bank’s problem is static. Competition in the banking sector implies

$$i_{L,t} = i_{D,t} + \tau.$$  

Notice that there is no uncertainty at the aggregate level.
2.2 The production sector

In any time period \( t \), a production technology converts capital, \( K_t \), and labor, \( N_t \), into output \( Y_t \) according to:

\[
Y_t = K_t^\alpha N_t^{1-\alpha}.
\]

Parameter \( \alpha \in (0, 1) \) is the capital income share. Capital depreciates at rate \( \delta \in (0, 1) \). Households competitively rent units of efficient labor and capital to firms and input rental prices are given by their net marginal productivity:

\[
w_t = (1 - \alpha)K_t^\alpha N_t^{-\alpha},
\]

\[
r_t = \alpha K_t^{\alpha-1} N_t^{1-\alpha}.
\]

Because the production function is homogeneous of degree one, profits are zero and firm ownership is unimportant. We therefore assume a representative firm.

2.3 The household sector

Households inelastically supply one unit of labor per period, and face idiosyncratic shocks to labor productivity. A household with shock \( z_t \) receives labor income \( w_t z_t \), where \( z_t \) follow a finite state Markov process with support \( \mathcal{Z} \) and transition probability matrix \( \mathcal{P}(z, z') = \Pr(z_{t+1} = z'|z_t = z) \). The Markov chain generating \( z_t \) has just one ergodic set, no transient states and no cyclically moving subsets. Household preferences are defined over stochastic processes for consumption, \( c_t \), given by the following utility function:

\[
E_0 \left[ \sum_{t=0}^{\infty} \beta^t u(c_t) \right], \quad \beta \in (0, 1).
\]

The one-period utility function is represented by:

\[
u(c) = \frac{c^{1-\sigma} - 1}{1 - \sigma},
\]
where $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution.

### 2.3.1 The credit market and budget constraint

Agents own capital, make deposits and get loans from financial intermediaries. A loan is a promise by a household in period $t - 1$ to pay back $(1 + i_{L,t})l_t$ to the bank at the beginning of period $t$, against the immediate delivery by the bank to the household of $l_t$ units of final good. A deposit is a promise by the bank to deliver $(1 + i_{D,t})d_t$ units of the final good at the beginning of period $t$ against a deposit by a household of $d_t$ units of final good during period $t - 1$. Let $\gamma_t$ denote lump-sum transfers.\(^8\)

The one-period budget constraint of each household is

$$c_t + k_{t+1} + d_{t+1} - l_{t+1} \leq w_t z_t + r_t k_t + (1 - \delta) k_t + (1 + i_{D,t}) d_t - (1 + i_{L,t}) l_t + \gamma_t . \tag{8}$$

The net worth of a household at the beginning of period $t+1$, $a_{t+1}$, is capital plus deposits made in the previous period, minus loans from the previous period.

$$a_{t+1} = k_{t+1} + d_{t+1} - l_{t+1}. \tag{9}$$

Therefore, we can rewrite the one-period budget constraint as:

$$c_t + a_{t+1} \leq a_t + w_t z_t + (r_t - \delta) k_t + i_{D,t} d_t - i_{L,t} l_t + \gamma_t. \tag{10}$$

Households allocate resources to consumption, investment in capital, or deposits; they can also borrow from banks.

\(^8\)The lump-sum transfers are important in the welfare calculations. We assume intermediation costs are redistributed back to households. Therefore, welfare numbers indicate only the inefficiency generated by costly intermediation, which affects agents’ ability to smooth consumption over time.
2.3.2 Arbitrage

Competition among banks drives interest rate $i_{D,t}$ to a level such that households are indifferent between making a deposit or investing in capital. One unit of consumption good invested in capital in period $t - 1$ yields $1 + r_t - \delta$ units of the consumption good in period $t$. If households deposit one unit of consumption good in period $t - 1$, they will have available $1 + i_{D,t}$ units of consumption good in period $t$. Therefore:

$$r_t - \delta = i_{D,t}.$$  \hfill (11)

In addition, if $\tau$ is positive and the agent net worth $a_{t+1}$ is negative, then $k_{t+1} + d_{t+1} = 0$ and $l_{t+1} > 0$; likewise, $a_{t+1} > 0$ implies $l_{t+1} = 0$. Using this fact and arbitrage condition (11), the agent’s budget constraint (10) can be rewritten as

$$c_t + a_{t+1} \leq a_t (1 + i^*_t) + w_t z_t + \gamma_t,$$  \hfill (12)

where

$$i^*_t(a_t) = i_{D,t} + \tau I(a_t < 0).$$

$I(a_t < 0)$ is an indicator function that takes value 1 if $a_t < 0$ and 0 otherwise. Agent position in period $t$ is therefore entirely described by asset holdings and the current labor shock, $x_t = (a_t, z_t)$.

2.3.3 Borrowing limit and households’ problem

We consider two default penalties that make lending incentive compatible. Kehoe and Levine (1993) assume an endogenous limit on assets, $a$, such that it is not optimal for agents to default. Alternatively, Aiyagari (1994) defines a “natural” borrowing limit where in an agent’s worst possible state, $z$, interest payments do not exceed labor income (i.e., current debt can at least be rolled over after a long spell of low productivity shocks). This section develops the first case and details of the natural borrowing limit are in Appendix A.
At the beginning of any period \( t \), an agent with real asset holdings \( a_t \) observes productivity shock \( z_t \), and receives labor income \( w_t \).

(i) If \( a_t < 0 \), the agent decides whether to default. Default would avoid payment \((1 + i_{L,t})a_t\) but lead to exclusion from future trade. Otherwise, she either asks for a loan to roll over the debt, in which case \( a_{t+1} < 0 \), or repays the debt and makes a deposit or purchases capital, which corresponds to \( a_{t+1} \geq 0 \).

(ii) If \( a_t \geq 0 \), there is no default decision; she either asks for a loan \((a_{t+1} < 0)\) or maintains a positive asset position \((a_{t+1} \geq 0)\).

Finally, the agent consumes any remaining units of output.

The lower limit on assets, \( a_\ast \), is determined endogenously. We assume a very large upper bound, \( \bar{a} \).\(^9\) Define \( X = [a_\ast, \bar{a}] \times \mathcal{Z} \) and let \( \chi \) be the associated Borel \( \sigma \)-algebra. For each \( B \in \chi \), \( \lambda(B) \) is the mass of households whose individual state vectors lie in \( B \). An agent’s value function depends on the current idiosyncratic state and aggregate variables such as the wage and interest rate, which are affected by the current measure \( \lambda_t \). To compute this measure in the next period, households must know the current period’s entire measure \( \lambda_t \), and an aggregate law of motion, which we call \( H \), such that \( \lambda_{t+1} = H(\lambda_t) \). We will define \( H(\cdot) \) shortly and use standard dynamic programming notation to denote future variables (e.g., \( a_{t+1} = a' \) and \( \lambda' = H(\lambda) \)).

Recall that in case of default, households are excluded from intertemporal trade. The value of the household problem under autarky is:

\[
v(z, \lambda) = u(wz) + \beta E[v(z', \lambda') | z].
\]

The value function of a household with net worth \( a \) and labor productivity \( z \) is defined by

\(^9\)Such that if \( a_t > \pi \), then agents choose to decrease asset holding \( a_{t+1} < \pi \).
the following maximization problem:

$$v(a, z, \lambda) = \max_{a'} \{ u(a(1 + i^*) + wz + \gamma - a') + \beta E[v(a', z', \lambda')|z] \}$$  \hspace{1cm} (13)$$

subject to

$$v(a', z', \lambda') \geq v(z', \lambda'), \quad \forall z' \in Z$$ \hspace{1cm} (14)

$$\lambda' = H(\lambda).$$

Constraint (14) ensures agents honor promises and do not default. Value function \(v(a, z, \lambda)\) is non-decreasing in \(a\),\(^{11}\) therefore (14) defines a lower bound \(a\), such that \(a' \geq a\).\(^{12}\)

### 2.4 Equilibrium

Let \(x = (a, z)\) be the individual state vector of a particular agent. The policy function associated with problem (13) is \(a' = h(x, \lambda)\). Given policy function \(h(x, \lambda)\) we can compute \(l' = h_l(x, \lambda)\) and \(c = h_c(x, \lambda)\). Define \(Q(x, \lambda, B; h)\) as the endogenous transition probability of the households’ state vector, which describes the probability that a household with state \(x = (a, z)\) will have a state vector lying in \(B\) next period, given current asset distribution \(\lambda\) and decision rule \(h\). Therefore,

$$Q(x, \lambda, B; h) = \sum_{(h(x, \lambda), z') \in B} \mathcal{P}(z, z').$$

The aggregate law of motion implied by transition function \(Q\) is an object \(T(\lambda, Q)\) that assigns a measure to each Borel set \(B\), with \(\lambda'(\cdot) = T(\lambda, Q)(\cdot)\), computed as

$$T(\lambda, Q)(B) = \int_X Q(x, \lambda, B; h) d\lambda.$$

\(^{10}\)Here we use budget constraint (12) in the one-period utility function.

\(^{11}\)The envelope condition shows that \(v_a(a, z, \lambda) = (1 + i^*)u'(c)\), which is always positive for \(c > 0\) and \(i^* > -1\).

\(^{12}\)Since \(X = [a, \overline{a}] \times Z\) is bounded, value function \(v(a, z, \lambda)\) is a contraction mapping. Thus, there is a unique fixed point such that \(v(a, z, \lambda)\) is the solution of (13).
The resource constraint and market clearing conditions for loans, capital and labor are

\[
\int_X h_c(x, \lambda) d\lambda + K' + \tau \int_X h_l(x, \lambda) d\lambda = AK^\alpha N^{1-\alpha} + (1 - \delta)K \tag{16}
\]

\[
\int_X h_l(x, \lambda) d\lambda = (L^b)' \tag{17}
\]

\[
\int_X h(x, \lambda) d\lambda = K' \tag{18}
\]

\[
\int_X z d\lambda = N. \tag{19}
\]

Equation (18) takes into account that loans and deposits net out to zero. Moreover,

\[
\gamma \int_X d\lambda = \tau \int_X h_l(x, \lambda) d\lambda. \tag{20}
\]

**Definition 1** An equilibrium is a vector of prices \((w, r, i_D, i_L)\) and a pair \((h, H)\) such that: equations (3), (5), and (6) are satisfied; \(h\) is the solution to (13) given \(H\); \(H(\lambda)\) coincides with \(T(\lambda, Q)\); all markets clear; and (20) holds with equality.

**Definition 2** A stationary equilibrium is an equilibrium where the probability measure \(\lambda\) is stationary, i.e., \(\lambda(B) = T(\lambda, Q)(B)\) for all \(B \in \chi\).

### 3 Quantitative experiments

The purpose of the quantitative analysis is to assess numerically the impact of intermediation costs on welfare, including distributional effects. The exercises require us to calibrate the theoretical model (i.e., determine values for a set of parameters for preferences, technology, the stochastic process on labor productivity, and intermediation costs). We choose parameter values consistent with empirical observations in the United States and then perform counter-factual analysis by investigating the effects of high (or low) intermediation costs on the economy and welfare.
3.1 Calibration and computation

We now describe how parameter values are set. The model period is one year.

**Utility and Production Technology:** Risk aversion coefficient $\sigma$ is set at 2.0,\textsuperscript{13} consistent with micro evidence in Mehra and Prescott (1985). Utility discount factor $\beta$ and depreciation rate $\delta$ are chosen jointly such that the real risk free interest rate is 2 percent and the capital to output ratio is 3, which are numbers consistent with the United States economy (see Castañeda, Díaz-Giménez, and Ríos-Rull, 2003). We obtain $\beta = 0.935$ and $\delta = 0.08$. The capital income share $\alpha$ is set to 0.30, which is in the range estimated by Gollin (2002).

**Stochastic process on labor productivity:** We follow Krueger and Perri (2004) and, as in Aiyagari (1994), use a finite approximation of an AR(1) process:

$$\ln(z') = \rho \ln(z) + \varepsilon' , \quad \varepsilon' \sim \text{iidN}(0, \sigma^2_\varepsilon).$$  \hspace{1cm} (21)

They set $\rho = 0.989$, similar to an estimate by Storesletten, Telmer, and Yaron (2004). Guvenen (2008) estimates a significantly lower persistence, $\rho = 0.82$. We set $\rho$ to 0.9.

Since not all differences in income come from idiosyncratic shocks, Krueger and Perri (2004) regress household earnings from the US Consumer Expenditure Survey on age, race, sex and education. They interpret the residuals as idiosyncratic shocks to labor productivity. Parameter $\sigma^2_\varepsilon$ is calibrated such that the cross-sectional variance of idiosyncratic household income is similar to the data, i.e., 0.719.

**Intermediation costs:** The net interest margin corresponds to banks’ actual interest revenue minus their actual interest expense divided by total assets. Clearly, not all the difference in interest revenues and interest expenses comes from intermediation costs.\textsuperscript{14}

\textsuperscript{13}It has long been recognized in the public finance literature (e.g., King and Rebelo, 1990) that the welfare effects of public policies critically depend on the elasticity of inter-temporal substitution (EIS), where $\sigma = \frac{1}{\text{EIS}}$. Appendix B contains sensitivity analysis with respect to parameter $\sigma$.

\textsuperscript{14}Some of this difference is explained, for instance, by banks’ profits. More generally, intermediation costs reflect explicit and implicit financial sector taxes (e.g., taxes on financial transactions and intermediary
Table 1: Parameter values, baseline economy.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
<th>Comment/Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma$</td>
<td>2</td>
<td>Risk aversion coefficient based on micro evidence in Mehra and Prescott (1985)</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.30</td>
<td>Capital income share based on estimations by Gollin (2002)</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.935</td>
<td>Discount rate of utility such that real interest rate on risk free asset is 2%</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.08</td>
<td>Capital depreciation rate such that capital to output ratio is $K/Y = 3$</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.9</td>
<td>Intermediate value from Storesletten, Telmer, and Yaron (2004) and Guvenen (2008)</td>
</tr>
<tr>
<td>$\sigma^2_e$</td>
<td>0.719</td>
<td>Cross-sectional variance of shocks based on Krueger and Perri (2004)</td>
</tr>
<tr>
<td>$\tau$</td>
<td>3.9%</td>
<td>Intermediation costs based on Demirgüç-Kunt and Levine (2000) and Demirgüç-Kunt, Leaven, and Levine (2004)</td>
</tr>
</tbody>
</table>

Demirgüç-Kunt and Huizinga (1999) show that the net interest margin can be decomposed into after tax banks’ profit plus overhead costs, loan loss provisions and taxes, minus non-interest income, all divided by total assets:

$$
\text{NIM} = \frac{\frac{\text{After tax profits}}{\text{TA}} + \frac{\text{OVC}}{\text{TA}} + \frac{\text{LLP}}{\text{TA}} + \frac{\text{Taxes}}{\text{TA}} - \frac{\text{NII}}{\text{TA}}}{\text{TA}}.
$$

We use the sum of overhead costs and taxes as a share of total assets to measure intermediation costs. As in Barth, Caprio, Jr, and Levine (2006), we interpret greater overhead costs as reflecting operational inefficiency.

Data from Demirgüç-Kunt and Levine (2000) show that overhead costs over total asset in the United States is 3.4 percent and Demirgüç-Kunt and Huizinga (1999) show that banks’ taxes over total assets is 0.5 percent. Thus, we set $\tau = 3.9$ percent.

Table 1 summarizes the parameters and how they were selected.
### 3.2 Benchmark economy

This section analyzes properties of the benchmark economy. Table 2 reports statistics for the US economy and model, under the two different borrowing constraints. Observe that the model matches well the wealth Gini index. The model has less earnings inequality than the data, but not all inequality in the data comes from idiosyncratic shocks to labor productivity. Part is due to differences in individual characteristics, such as schooling and experience. When we evaluate wealth, table 2 shows that the model predictions for the wealth distribution depend on the form of the borrowing limit.

The first row of table 2 shows that in the data, the top 1 percent of households have 29.6 percent of all wealth. Under the borrowing constraint with permanent exclusion, the top 1 percent of households hold only 10 percent of total wealth and the bottom 20 percent have more negative wealth than in the data. This model misses the top and bottom tails of the distribution, but does a reasonable job in the middle.\(^\text{15}\) The model with a natural borrowing limit better matches the data. This occurs because there is little penalty for default, and hence much less borrowing. In contrast, the penalty is very severe in the endogenous borrowing case – permanent exclusion from intertemporal trade. In the bottom 20 percent of wealth negative assets are -1.8 percent for the natural limit instead of -6.8 percent under exclusion, much closer to the data value of -0.4 percent.

Other sources suggest that the number of households with net negative wealth is large. Using data from the 1995 Survey of Consumer Finances, Wolff (1998) defines two different measures of net wealth: “net worth” and “financial wealth”. The first includes almost all assets that can readily be converted to cash. The second is more restricted and is defined as net worth minus net equity in owner-occupied housing. The fraction of households with negative net worth in 1995 was 18.5%, while those with negative financial wealth were 28.7% of the total. The comparable figure for the baseline calibration is 27%.

\(^{15}\) Quadrini and Ríos-Rull (1997) and Castañeda, Díaz-Giménez, and Ríos-Rull (2003) note that this is a common feature of neoclassical growth models with heterogeneous agents and uninsurable idiosyncratic shocks to earnings. Quadrini (2000), for instance, shows that entrepreneurs accumulate more assets because they face risk associated with business activities and higher returns on savings than workers. Therefore, entrepreneurs play an active role in shaping the wealth distribution.

<table>
<thead>
<tr>
<th>Capital-output ratio</th>
<th>Wealth Gini (%)</th>
<th>Income Gini (%)</th>
<th>Percentage wealth in the top 1%</th>
<th>5%</th>
<th>10%</th>
<th>20%</th>
<th>20%</th>
<th>60%</th>
</tr>
</thead>
<tbody>
<tr>
<td>US data</td>
<td>3.0</td>
<td>78</td>
<td>63</td>
<td>29.6%</td>
<td>54.0%</td>
<td>66%</td>
<td>79.5%</td>
<td>-0.4%</td>
</tr>
<tr>
<td>Model: exclusion</td>
<td>3.0</td>
<td>73.8</td>
<td>42</td>
<td>10%</td>
<td>33%</td>
<td>50%</td>
<td>74%</td>
<td>-6.7%</td>
</tr>
<tr>
<td>Model: natural limit</td>
<td>3.0</td>
<td>66.0</td>
<td>42</td>
<td>28%</td>
<td>43%</td>
<td>65%</td>
<td>88%</td>
<td>-1.8%</td>
</tr>
</tbody>
</table>

with the endogenous constraint, and 16% with the natural limit constraint. Both versions of the model therefore imply a fraction of borrowers reasonably close to SCF data. This section focuses on results for the endogenous constraint model because it leads to more conservative welfare gains after intermediation costs are reduced, both in average terms and across the distribution of assets. See Appendix A for the natural borrowing limit.

We now analyze the quantitative properties of the model and the welfare implications of intermediation costs. We first consider the long run effects of intermediation costs on aggregate variables, and then study transitional dynamics and welfare effects.

### 3.3 Long run aggregate and distributional effects

A change in intermediation costs has two effects: a direct effect on the cost of borrowing and an indirect effect through general equilibrium price adjustments. Suppose that intermediation costs are reduced. For a given interest rate, the net borrowers’ consumption possibility frontier expands, since it is less costly to borrow to smooth consumption over time. All households are affected because even a net saver in period $t$ faces a positive probability of becoming a net borrower in the future, if labor productivity shocks are persistently bad. In addition to this direct effect, there is an indirect one: lower intermediation costs imply an increase in the demand for loans, and therefore the interest rate rises. This affects all agents, increasing borrowing costs and the return on deposits, and also
Table 3: Aggregate effects

<table>
<thead>
<tr>
<th>Benchmark, $\tau_b = 3.9%$</th>
<th>Interest rate (%)</th>
<th>Capital-output ratio</th>
<th>Output ($Y_b = 100$)</th>
<th>Average consumption ($C_b = 100$)</th>
<th>Wealth Gini (%)</th>
<th>Consumption Gini (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.02</td>
<td>3</td>
<td>100</td>
<td>100</td>
<td>73.86</td>
<td>32.8</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$\tau = 1%$</th>
<th>2.84</th>
<th>2.84</th>
<th>97.8</th>
<th>99.3</th>
<th>82.5</th>
<th>33.3</th>
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</thead>
<tbody>
<tr>
<td>$\tau = 0%$</td>
<td>2.83</td>
<td>2.76</td>
<td>96.6</td>
<td>98.8</td>
<td>86.5</td>
<td>33.7</td>
</tr>
<tr>
<td>$\tau = 8%$</td>
<td>1.66</td>
<td>3.11</td>
<td>101.6</td>
<td>100.5</td>
<td>67.7</td>
<td>32.5</td>
</tr>
</tbody>
</table>

implies a fall in the capital to output ratio and wage rate. Wealth becomes more unequal.

Table 3 shows the long run effects of intermediation costs on the interest rate, capital to output ratio, output, and inequality in wealth and consumption. Consider a decrease in intermediation costs from the baseline value of 3.9 to 1 percent. The interest rate increases by 0.52 percentage point and as a result the capital to output ratio falls from 3 to 2.84. The decrease in the capital to output ratio reduces aggregate output by 2.2 percent and consumption decreases by 0.7 percent. Inequality in wealth increases sharply, since at the lower tail of the wealth distribution it is cheaper to borrow and a rise in the interest rate also increases asset accumulation for agents with positive net worth. There is a small increase in consumption inequality. When intermediation costs fall to 0 the results are similar. Instead, when the costs increase from 3.9 to 8 percent, the interest rate decreases by 0.36 percentage point, increasing the capital to output ratio to 3.11. Small increases in aggregate output and consumption occur, and wealth inequality decreases.

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16 Some countries have very small intermediation costs. For example, from 1993 to 2006 the average overhead cost over total assets was less than 1 percent in Ireland (see Demirgüç-Kunt and Levine, 2000). The average value for the 10 percent of countries with the smallest costs is 1.1 percent.

17 Despite the increase in the interest rate, the cost of borrowing is lower now: the lending interest rate is 3.54 percent, while in the baseline economy the lending interest rate was 5.92 percent.

18 Agents borrow almost twice as much as in the baseline case. The decrease in consumption does not reduce aggregate welfare, since consumption smoothing is less costly with lower intermediation costs.

19 This is a level of intermediation costs is observed in Argentina (7.8%) and Brazil (7.9%) (see Demirgüç-Kunt and Levine, 2000 and Demirgüç-Kunt and Huizinga, 1999).

20 The borrowing rate increases from 5.92 to 9.66 percent.
Since we abstract from entrepreneurial activities, the effects of intermediation costs on output must be interpreted with care. We consider only consumption borrowing. Here changes in intermediation costs have a direct effect on aggregate savings. Results might be different when entrepreneurs are credit constrained and intermediation costs affect entrepreneurs’ ability to borrow. Antunes, Cavalcanti, and Villamil (2008), for instance, show that intermediation costs have a negative effect on entrepreneurial productivity and output even when the interest rate is endogenous. Many entrepreneurs rely on borrowing to produce, and intermediation costs decrease firm size and productivity.

3.4 Welfare

3.4.1 The United States

We measure the welfare implications of intermediation costs in the United States by the average permanent consumption supplement that makes households in an economy with benchmark intermediation costs (3.9 percent) as well off as in an economy with intermediation costs equal to 1 percent. This is a standard measure of welfare (e.g., Lucas, 1987). One caveat is important: In evaluating the welfare effects of intermediation costs we cannot focus on steady-state equilibria. The median agent, for instance, in the initial stationary distribution is not necessarily the same median agent in the final stationary distribution, and this is true for all agents ranked according to the wealth distribution. There is social mobility in the economy and comparing value functions of two different steady-states for agents at the same point of the wealth distribution might be misleading.

We calculate the value function of each agent considering the transition from one steady state to another. This guarantees that we are evaluating the welfare of the same agent with and without a policy change.\textsuperscript{21} Also, $\tau L$ is redistributed back to households as a lump-sum transfer, isolating the effect of the inefficiency generated by costly intermediation on welfare, which affects the ability of agents to smooth consumption over

\textsuperscript{21}If the transition from one stationary equilibrium to another is fast, one might abstract from transitional effects. However, the graph on the left in figure 2 shows that it takes about 12 years for the interest rate to reach about 85 percent of the distance between the first and the second steady-state values.
Figure 2: Transition from baseline economy ($\tau = 3.9\%$) to an economy with intermediation costs of 1%. Left graph: Interest rate. Right graph: Percentage of individuals at lowest asset level.

The left graph in figure 2 plots the adjustments of the interest rate from the baseline economy to an economy with intermediation costs equal to 1 percent. Notice that, as discussed previously, the interest rate rises when intermediation costs decrease. The right graph in figure 2 shows the percentage of individuals with the lowest asset level. This is the group of households that are credit-constrained. When $\tau$ decreases, for a given interest rate, the value function $v(a, z, \lambda)$ of an agent with negative asset increases. This makes borrowing constraints less tight, for a given interest rate, which implies that the percentage of households at the lowest asset level decreases. As the economy converges to the new stationary equilibrium it is less costly to borrow, and the percentage of individuals at the lowest asset level increases.

Figure 3 displays a three dimensional graph of the welfare gains of decreasing intermediation costs from 3.9 to 1. The welfare gains are on the $z$-axis, while the $x$-axis and $y$-axis contain the labor shocks ($wz$) and agent net worth ($a$), respectively.\footnote{We use the shocks and the net worth of the each agent in the period before the policy change.} Qualita-
Figure 3: Distribution of welfare gains: change intermediation costs from 3.9% to 1%

respectively, all agents have positive welfare gains. Borrowing costs are lower since the lending rate decreases from 5.92 to 3.54 percent. This increases the ability of agents to smooth consumption over time, which increases welfare not only in the lower tail of the wealth distribution, but even for agents with positive net worth.\textsuperscript{23} Additionally, a higher interest rate increases income from deposits,\textsuperscript{24} which increases welfare in the upper tail of the wealth distribution. In the lower tail of the asset distribution, as productivity shocks improve, welfare gains are reduced. In the next section we will decompose the overall welfare effect of intermediation costs into a direct effect and a general equilibrium effect.

Quantitatively, the welfare gains are larger for agents with negative net worth and persistently bad labor productivity shocks. Table 4 part (a) reports the average welfare gain per income percentile. For agents at the bottom decile of wealth, average welfare gains from reducing intermediation costs from 3.9 to 1 percent are roughly 11 percent of baseline consumption. However, welfare gains are substantial even for agents at the top of

\textsuperscript{23}There is a positive probability that an agent with positive wealth might experience negative labor shocks resulting in negative net wealth.

\textsuperscript{24}The deposit interest rate increases from 2.02 to 2.54 percent.
Table 4: Welfare effects: Endogenous borrowing constraint

<table>
<thead>
<tr>
<th>Part (a): Endogenous interest rate</th>
<th>Average welfare gain</th>
<th>Wealth percentil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark, $\tau_b = 3.9%$</td>
<td>3.5</td>
<td>11.1</td>
</tr>
<tr>
<td>$\tau = 1%$</td>
<td>11.1</td>
<td>4.8</td>
</tr>
<tr>
<td>$\tau = 0%$</td>
<td>14.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Part (b): Exogenous interest rate</td>
<td>1.1</td>
<td>15.5</td>
</tr>
<tr>
<td>$\tau = 1%$</td>
<td>15.5</td>
<td>6.6</td>
</tr>
<tr>
<td>$\tau = 0%$</td>
<td>19.2</td>
<td>1.7</td>
</tr>
<tr>
<td>$\tau = 0%$</td>
<td>16.6</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Table 4 reports an average welfare measure, which is a weighted average of the welfare gains of all agents in the economy. This aggregate welfare gain is about 3.5 percent of consumption equivalent of the baseline economy when $\tau$ decreases to 1 percent, a substantial measure. We also calculate the welfare gains for the case when intermediation costs decrease to zero, and the average welfare gain is about 4.70 percent of consumption equivalent of the baseline level. Finally, table 4 shows the distributional welfare gains of changing intermediation costs.

25Mehra, Piguillem, and Prescott (2008) estimate intermediation costs using data from the National Income and Product Account. They find that in the United States, the implied spread between deposit and loan rates is 2 percent. Appendix C contains quantitative exercises for this $\tau$ and shows that welfare gains are still large.

26We could instead calculate an “aggregate value function” as a weighted average of the value function of each agent. Then, we could calculate the aggregate consumption equivalent for the baseline economy and for the economy after the policy change. The welfare gains in this case are somewhat larger, so we use the method described in the text.

27We recognize that a zero intermediation cost is hard to implement. This experiment approximates the smallest overhead cost of 0.2 percent observed in the sample, in Ireland in 1994 (see Demirgüç-Kunt and Levine, 2000).
3.4.2 Welfare decomposition

As explained before, there are two effects on welfare after a change in intermediation costs: A direct effect and a general equilibrium one. Here we decompose the welfare change into these two effects. For a given interest rate, when intermediation costs decrease households’ ability to smooth consumption over time improve. Agents with negative net wealth have an increase in their consumption possibility frontier and agents with positive net wealth and high productivity shocks also benefit (they may need to borrow in the future to smooth consumption). There is also an indirect effect on price adjustment since lower intermediation costs increase the demand for loans and therefore the interest rate. Such adjustments offset in part the benefits of lower intermediation costs for those with negative net wealth, but they increase interest income for those at the upper tail of the wealth distribution.

Table 4 part (b) reports the welfare gains from changing intermediation costs from 3.9 to 0 and 1 percent for an exogenous interest rate. At the aggregate level, welfare gains are twice as large for an economy with an exogenous interest rate than when there are price adjustments. Figure 4 shows the average welfare gain for each asset value when the interest rate is exogenous (dotted red line) and endogenous (solid blue line). For the lower tail of the wealth distribution, welfare gains are larger when the interest rate is exogenous, but for the right tail of the wealth distribution, due to higher interest income, welfare gains are larger for the endogenous interest rate case. We conclude that the two effects are quantitatively significant. Therefore, as in Antunes, Cavalcanti, and Villamil (2008) and Castro, Clementi, and MacDonald (2004), policy reforms aimed to improve intermediary efficiency would have stronger impacts on economies open to financial capital flows.

\[ ^{28} \text{All prices are exogenously given when the interest rate does not adjust to changes in intermediation costs.} \]

\[ ^{29} \text{The average welfare gain is 7.3 percent of equivalent consumption for an exogenous interest rate and 3.5 for the case when the interest rate is endogenous.} \]
Figure 4: Average welfare gain per asset value from changing intermediation costs from 3.9 to 1 percent. Blue solid line: Endogenous interest rate; Dotted red line: Exogenous interest rate.

3.4.3 A glimpse at other countries

We now keep the technology and preference parameters at the U.S. level, and study the welfare implications of changing intermediation costs from, for instance, Brazil’s or Argentina’s level (roughly 8 percent) to the U.S. level (3.9 percent) and to 1 percent – average value for countries in the lowest decile of overhead costs. The purpose of this counterfactual exercise is to investigate the welfare results of a reform that reduces intermediation costs in some countries to the U.S. level. Literally, however, we are investigating the welfare implications of increasing intermediation costs from the U.S. level to Brazil’s or Argentina’s level. A true welfare analysis of a reform that reduces intermediation costs from, for instance, the Brazilian level to the U.S. level would require a calibration of all parameter values to be consistent with the Brazilian economy. We still think that the numbers provided here can shed some light on this issue.

Table 5 reports the aggregate welfare gains as well as the distributional welfare effects. Our simulations suggest that the aggregate welfare benefits of changing intermediation costs from 8 to 3.9 are on the order of 2.8 percent of consumption equivalent of
the benchmark economy when the interest rate is endogenous and 5.3 percent for the exogenous interest rate case. When intermediation costs decrease from 8 to 1 percent, then aggregate welfare gains are about 5.9 percent of consumption equivalent to the benchmark economy. Such welfare gains are 2.4 percentage points larger than when intermediation costs decrease from 3.9 to 1 percent.

### 3.5 Welfare comparison to other policy changes

In our quantitative exercises we found that the average welfare gains from reducing intermediation costs from the US level (3.9 percent) to 1 percent correspond to about 3.5 percent of consumption equivalent of the baseline economy. It is important to compare such welfare gains with other policy changes. We consider the welfare effects of decreasing taxes on capital income, reducing inflation, and eliminating business cycle fluctuations.

**Capital Income Taxation:** Chamley (1986) shows in a simple setting that capital income should not be taxed in the steady-state. This well known Chamley Theorem states that if there exists a steady-state Ramsey allocation, the associated limiting tax rate on capital income is zero. The result follows a simple principle: similar goods should be taxed at the same rate (Atkinson and Stiglitz, 1972), and since taxation on capital implies heavier
taxes on future consumption, capital income should not be taxed (Lucas, 1990). Following this, Lucas (1990) showed in a neoclassical growth model with homogeneous agents that reducing capital income taxation from 36 to 0 percent results in a welfare gain across steady-states of over 5 percent of baseline consumption, and about 1 percent when transitional costs are taken into account. Therefore, when we consider the whole transition, the welfare gains of reducing intermediation costs from 3.9 to 0 percent is about 3.5 times larger than the welfare gains of reducing taxes on capital income from 36 to 0 percent.

In a model similar to ours with heterogeneous agents, Aiyagari (1995) shows that cutting the income tax to zero might lead instead to welfare losses. In a heterogeneous setting with idiosyncratic risks on labor productivity, there is a precautionary motive for accumulating capital, and the interest rate might be lower than the rate of time preference. A positive tax on capital might bring the tax on capital to equality with the rate of time preference. In our model, intermediation costs have the opposite effect of capital income taxes – they decrease borrowing and increase precautionary savings, decreasing the interest rate even more.

The Welfare Costs of Inflation: Friedman (1969) advocates for monetary policy to be conducted to keep nominal interest rates close to zero (i.e., a zero inflation tax). According to Correia and Teles (1996), the opportunity cost of holding money is the nominal interest rate and since money is costless to produce, it should be supplied at zero cost. Lucas (2000, page 247) posits that: “as long as interest rates are positive people could be made better off if money growth, and hence the average inflation rate and the interest rate, were reduced.” The quantitative results of Lucas (2000) suggest that the welfare gains from reducing the annual inflation rate from 10 percent to zero is equivalent to an increase in

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30 This theorem was derived under a narrow set of assumptions, but Chari and Kehoe (2000) show that Chamley’s result holds in quite general models such as when agents are heterogeneous rather than identical, the growth rate is endogenous rather than exogenous, the economy is open rather than closed, and agents live in overlapping generations rather than forever. They also show that under some classes of utility functions, optimal capital taxes are zero not only in the steady state, but also after the first period.

31 Cavalcanti and Villamil (2003) show that in the presence of tax evasion the Friedman Rule is not optimal and decreasing the inflation tax to zero might lead to welfare losses.
consumption of slightly less than one percent.\footnote{Similar numbers are found by Dotsey and Ireland (1996) in a model in which inflation distorts a variety of marginal decisions and Imrohoroglu (1992) finds the gain of reducing inflation from 10 to 0 percent is about 1 percent of income.}

In a heterogenous setting in which agents face uninsurable idiosyncratic risk but no aggregate uncertainty, Erosa and Ventura (2002) show that the welfare costs of inflation are not evenly distributed across households.\footnote{Doepke and Schneider (2006a) emphasize that unanticipated inflation generates wealth redistribution by affecting the value of nominal assets. They also show (Doepke and Schneider, 2006b) that the main losers from inflation are the major bondholders, while the winners are households with large debt. Their simulations suggest that welfare effects of moderate unanticipated inflation episodes are positive in the aggregate.} At the aggregate level, their quantitative exercises imply that an increase in inflation from 0 to 10 percent leads to a welfare loss of 1.57 percent of equivalent consumption. The impact on welfare of low productivity agents is about 2.77 percent of equivalent consumption, while highly productive agents have a welfare gain of 1.11 percent of equivalent consumption. Overall, our calculations suggest that decreasing intermediation costs from 3.9 to 1 percent would lead to a welfare gain about 3.5 times larger than reducing inflation from 10 to 0 percent in the United States.

\textit{The Welfare Costs of Business Cycle:} In an influential monograph Lucas (1987) shows in a representative agent model that the welfare gains of eliminating business cycle fluctuations are quantitatively small. Recently, Alvarez and Jermann (2004), using an asset price model, confirm Lucas’ findings by showing that the costs of business cycle fluctuations are between 0.08 percent and 0.49 percent of baseline consumption. In a model with heterogeneous agents that face idiosyncratic productivity shocks and aggregate uncertainty, Storesletten, Telmer, and Yaron (2001) find that the welfare gains of eliminating business cycle fluctuations are roughly 1.44 percent of equivalent baseline consumption.

\section{Concluding remarks}

This paper developed a neoclassical growth model in which agents face uninsurable idiosyncratic shocks to labor productivity, an endogenous borrowing limit and costly financ...
cial intermediation. Intermediation costs generate a wedge between the loan and deposit rate. We calibrated the model to match key statistics of the United States economy and performed counter-factual experiments. Reducing intermediation costs leads to two effects. For a given interest rate, it implies that borrowing costs decrease. There is an expansion in net borrowers’ consumption possibility frontier and households with positive net wealth can also benefit because they may need to borrow in the future to smooth consumption. There is also an indirect effect: lower intermediation costs imply an increase in the demand for loans, and therefore the interest rate rises. Such price adjustments offset part of the decrease in borrowing costs and increase interest income.

Quantitatively, we show that the welfare implications of intermediation costs are large. The average welfare gain from reducing intermediation costs from 3.9 (the US level) to 1 percent (the 10th percentile of countries with the smallest overhead costs) corresponds to about 3.5 percent of consumption equivalent of the baseline economy. This is roughly 3.5 times larger than: 34 (i) reducing the capital income tax rate from 36 to 0 percent; (ii) reducing inflation from 10 to 0 percent; and (iii) eliminating all business cycle fluctuations. We also show that welfare gains are not evenly distributed across agents. For some households with negative net worth who experience persistently bad shocks the average welfare gains is 11 percent of their baseline consumption. Welfare gains are substantial even for agents at the top of the wealth distribution with good labor productivity shocks. For those agents, welfare gains are about 1.1 percent of their baseline consumption. We also decompose the overall welfare gain into a direct and a general equilibrium effect. We show that the two effects are quantitatively important, but the direct effect dominates in the aggregate and for those agents in the left tail of the wealth distribution.

Our exercises show that policies aimed to reduce financial sector taxes and financial sector inefficiency can have a strong impact on welfare, especially for households who are experiencing persistently bad shocks to labor productivity. The welfare implications are larger for economies that are open to financial capital flows.

34 This is also about 3.5 times larger than reducing bank capital requirements in the United States (see Van den Heuvel, 2008).
References


CORREIA, I. H., AND P. TELES (1996): “Is the Friedman rule optimal when money is an intermediate good?,” *Journal of Monetary Economics*, 38, 223–244.


A Natural borrowing limit

We now consider the natural borrowing limit. Here, as in Aiyagari (1994), we define the borrowing limit by the value such that in an agent’s worst possible state, $z_i$, interest payments are not higher than the agent’s labor income. This requires that:

$$a' \geq -\frac{wz_i}{i_L}$$

(22)

This equation replaces equation (14) in the households’ problem. The rest of the economy is similar to the one presented in section 2. In order to simulate the model, we recalibrate parameters $\beta$ and $\delta$ to match the capital to output ratio and real interest rate. The new values are 0.928 and 0.0793, respectively. The remaining parameters have values similar to those in table 1.

Table 6 contains the welfare implications from changing intermediation costs from 3.9 to 1 percent with a natural borrowing limit. When the interest rate is endogenous, the aggregate welfare gain is larger than when the borrowing limit is endogenous, 4.5 percent of equivalent consumption instead of 3.5. The distribution of welfare gains are similar to

\[\text{footnote}{^35}\text{The penalty for default in the endogenous borrowing limit is large since agents are excluded permanently from future intertemporal trade.} \]
Table 6: Welfare effects: Natural borrowing constraint

<table>
<thead>
<tr>
<th></th>
<th>Average welfare gain</th>
<th>Wealth percentil 10%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benchmark, ( \tau_b = 3.9% )</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Part (a): Endogenous interest rate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \tau = 1% )</td>
<td>4.5</td>
<td>10.1</td>
<td>4.1</td>
<td>1.95</td>
<td>1.1</td>
<td>1.3</td>
</tr>
<tr>
<td><strong>Part (b): Exogenous interest rate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \tau = 1% )</td>
<td>15.3</td>
<td>32.2</td>
<td>17.3</td>
<td>10.1</td>
<td>5.8</td>
<td>3.6</td>
</tr>
</tbody>
</table>

those observed in table 4. When there is no price adjustments, aggregate welfare gains are roughly 15 percent of equivalent consumption to the baseline economy, about twice as large as in the economy with an endogenous borrowing constraint.

B  Risk aversion coefficient sensitivity

Lucas (1987) uses logarithmic utility, \( \sigma = 1 \), to calculate the welfare gains from eliminating all consumption fluctuations. As noted by several authors, Lucas’ result is sensitive to the functional form for preferences (see, for instance, Otrok, 2001). In addition, it has long been recognized in the public finance literature (e.g., King and Rebelo, 1990) that the welfare effects of capital income taxation critically depend on the elasticity of inter-temporal substitution (EIS), where \( \sigma = \frac{1}{\text{EIS}} \). \(^{36}\) We investigate the welfare implications of intermediation costs when the utility function is logarithmic. \(^{37}\) We re-calibrate parameters \( \beta \) and \( \delta \), such that, as in the benchmark economy in table 1, the real risk free interest rate is 2 percent and the capital to output ratio is 3. The new values for \( \beta \) and \( \delta \) are 0.96204

\(^{36}\)Lucas (1990) uses \( \sigma = 2 \) to evaluate the welfare effects of capital income taxation. He notes that different values for \( \sigma \) have no implications for the welfare costs of capital taxation when only long run equilibria are compared. Lucas (2000) shows that since bonds dominate money in rate of return, the EIS is not relevant for the calculus of the welfare cost of inflation.

\(^{37}\)Logarithmic utility is often used in macroeconomics due to its analytical properties. There is a large literature on empirical estimates of the EIS with a range of estimates. Individual data estimates tend to be higher (higher than 2) than aggregate data/time series estimates (lower than two and close to one). See Guvenen (2006) for a discussion.
Table 7: Welfare effects: Endogenous borrowing constraint

<table>
<thead>
<tr>
<th></th>
<th>Average welfare gain</th>
<th>Wealth percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10%</td>
</tr>
<tr>
<td><strong>Benchmark, ( \tau_b = 3.9% )</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Part (a): Endogenous interest rate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \tau = 1% )</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td><strong>Part (b): Exogenous interest rate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \tau = 1% )</td>
<td></td>
<td>4.3</td>
</tr>
</tbody>
</table>

and 0.079401, respectively.

Table 7 displays the welfare effects of intermediation costs when \( \sigma = 1 \). When \( \tau \) decreases from 3.9 to 1 percent, average welfare gains are 2 percent of consumption equivalent to the baseline economy. This is smaller than when \( \sigma = 2 \), but is still substantial, especially in the lower tail of the distribution of wealth. Borrowers would still have an increase in welfare of roughly 4 percent of the consumption equivalent to the baseline if intermediation costs decreased from 3.9 to 1 percent. In addition, figure 5 shows that different welfare implications of intermediation costs for \( \sigma = 2 \) and \( \sigma = 1 \) are explained by the difference in welfare gains in the lower tail of the distribution of assets. At the upper, welfare gains are of the same order of magnitude for both values of the risk aversion coefficient. However, welfare gains in the lower tail of the wealth distribution are much higher for the case of \( \sigma = 2 \) than when \( \sigma = 1 \).

Recall that welfare gains from reducing intermediation costs can be decomposed into two effects: an increase in agents’ ability to smooth consumption over time; and a general equilibrium price effect. When \( \sigma \) decreases agents are less risk averse and the cost of consumption fluctuations decreases. The first effect is less important for smaller \( \sigma \). In fact, we can observe in tables 4 and 7 that, when the interest rate is exogenous, welfare gains are much smaller when \( \sigma = 1 \) than when \( \sigma = 2 \).
Figure 5: Average welfare gain per asset value from changing intermediation costs from 3.9 to 1 percent. Blue solid line: $\sigma = 2$; Dotted red line: $\sigma = 1$.

C Alternative measures of intermediation costs

Mehra, Piguillem, and Prescott (2008) estimate intermediation costs using data from the National Income and Product Accounts. They find that in the United States, the implied spread between deposit and loan rates is 2 percent. We recalibrate the model with $\tau = 0.02$ to match the capital to output ratio ($\frac{K}{Y} = 3$) and risk free rate ($r = 2\%$), for both the endogenous and natural borrowing constraints. Other parameter values are the same as in table 1, except for the subjective discount factor and the depreciation rate. For the endogenous borrowing constraint, $\beta = 0.9425$ and $\delta = 0.0793$, while for the natural borrowing constraint $\beta = 0.935$ and $\delta = 0.0791$.

Table 8 displays the welfare effects of intermediation costs. When the interest rate is endogenous and $\tau$ decreases from 2 to 1 percent, average welfare gains equal 1.6 or 2.5 percent of consumption equivalent in the baseline economy, for the endogenous and natural borrowing limits. This is significant since we change intermediation costs by only one percentage point. The bottom 10 percent of wealth would still have an increase in welfare of roughly 5 percent of the consumption equivalent to the baseline.
Table 8: Welfare effects: Mehra, Piguillem, and Prescott (2008) intermediation cost

<table>
<thead>
<tr>
<th>Benchmark, $\tau_b = 2%$</th>
<th>Average welfare gain</th>
<th>Wealth percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average welfare</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>gain</td>
<td></td>
</tr>
<tr>
<td>Part (a): Endogenous interest rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau = 1%$: endogenous borrowing limit</td>
<td>1.6</td>
<td>5.1</td>
</tr>
<tr>
<td>$\tau = 1%$: natural borrowing limit</td>
<td>2.5</td>
<td>5.9</td>
</tr>
<tr>
<td>Part (b): Exogenous interest rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau = 1%$: endogenous borrowing limit</td>
<td>3.4</td>
<td>9.4</td>
</tr>
<tr>
<td>$\tau = 1%$: natural borrowing limit</td>
<td>4.3</td>
<td>9.9</td>
</tr>
</tbody>
</table>