More on onetary Economics*

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Abstract

In the theory of heterogeneous returns to wealth of Menzio and Spinella (2025), monetary policy affects equilibrium outcomes even when real money balances are negligible and nominal rigidities are absent. Holding money is the households' investment option outside the financial market. Monetary policy affects the rate of return on holding money, the value of the households' option outside the financial market and, in turn, the rates of return inside the financial market. This is true even when the fraction of households that do exercise the outside option is negligible and, hence, even when real money balances are arbitrarily small. Quantitatively, monetary policy has a large impact on economic outcomes even in the cashless limit. These findings echo Lagos and Zheng (2022). They imply that one cannot use the observation that money balances are low (and may become even lower) as a justification to use models that abstract from the role of money as a store of value to assess monetary policy.

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1 Introduction

In Menzio and Spinella (2025), we developed a monetary version of the incomplete-markets model of Aiyagari (1994), Bewley (1983) and Huggett (1996), in which the market where households lend and firms borrow capital is subject to information frictions in the spirit of Butters (1977), Varian (1980) and Burdett and Judd (1983). Specifically, in the capital market, households cannot lend to just any firm but only to the discrete subset of firms with which they come into contact. Households that do not contact any firms or who do not wish to trade with any firms can hold their savings either in fiat money or in physical

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goods. In equilibrium, the law of one price fails in the capital market, in the sense that firms offer different rates of returns to households. Households with more financial human capital are better at acquiring information, contact more firms, and earn systematically higher rates of return than households with less financial human capital. The model is motivated by the observation made by Fagereng, Guiso, Malacrino and Pistaferri (2020) that households differ systematically in the rates of return that they earn on their wealth after controlling for differences in the composition of their portfolio.

In this paper, we use a version of Menzio and Spinella (2025) to echo a point made in Lagos and Zheng (2022). Lagos and Zheng (2022) developed a model in which money is used as a medium of exchange and showed that monetary policy affects equilibrium outcomes even when the real value of money holdings is arbitrarily small. Lagos and Zheng (2022) conclude that the observation that money holdings are relatively small (and might be even smaller in the future) cannot be used as a justification to do "onetary economics", that is, to abstract from the role of money as a medium of exchange and focus exclusively on nominal rigidities in order to evaluate monetary policy. In this paper, we show that, in a model where money is a store of value, monetary policy affects equilibrium outcomes even when the real value of money holdings is negligible. Hence, the observation that money holdings are small cannot be used to justify studying monetary policy in models that abstract from the role of money as a store of value. Even though the role of money is different in Lagos and Zheng (2022) and Menzio and Spinella (2025), the reason why monetary policy matters even when money demand is negligible is the same. Namely, monetary policy affects the value of some agents' option outside the financial market and, for this reason, it affects equilibrium outcomes in the financial market. Even when the fraction of agents that exercise the outside option is negligible, monetary policy affects the value of the outside option and equilibrium outcomes.

To study the role of monetary policy in a cashless limit, we slightly modify the model of Menzio and Spinella (2025). In particular, we allow the stochastic process describing the meetings between households and firms in the capital market to depend on two parameters. The first parameter characterizes the probability that a household does not have any trading opportunity in the capital market and, hence, it is forced to either hold fiat money or store consumption goods in order to save. The second parameter characterizes the average number of firms contacted by a household, conditional on having some trading opportunities in the capital market. The first parameter controls money demand. The second parameter controls the extent to which firms compete against one another in the capital market. By letting the first parameter go to zero, we can study economies in which money demand is arbitrarily small, while keeping the extent of competition within the capital market unchanged.

In the first part of the paper, we establish three theoretical results. First, we establish that the cashless limit of the monetary equilibrium depends on monetary policy and, in particular, on the growth rate of money supply. Second, we establish that the cashless limit of the monetary equilibrium is generally different from the non-monetary equilibrium. Lastly, we prove that the cashless limit of the monetary equilibrium coincides with the non-monetary equilibrium and, hence, is independent of monetary policy only when every household that accesses the capital market is in contact with multiple firms and, hence, the capital market is perfectly competitive.

The intuition for these results is simple. The rate of return that households earn on their savings outside of the capital market affects the distribution of rates of return offered by firms inside of the capital market, since there are some households for which keeping their savings outside of the capital market is the only available alternative to lending to a particular firm in the capital market. In a monetary equilibrium, the rate of return that households earn on their savings outside of the capital market is the real rate of return on money. The rate of return on money is the negative of the inflation rate, which depends on monetary policy and, in particular, on the growth rate of money supply. Therefore, monetary policy affects the rates of return offered by firms in the capital market, the rates of return earned by households in the capital market, and, in turn, all the other equilibrium outcomes. Obviously, this is the case even when the fraction of households that exercise the outside option is negligible and, hence, in the cashless limit of the monetary equilibrium.

In a monetary equilibrium, the rate of return that households can earn outside of the capital market is the real rate of return on money. In a non-monetary equilibrium, the rate of return that households earn outside of the capital market is the rate of return on storing physical goods. Since the households' outside option affects the rates of return offered by firms in the capital market, the monetary equilibrium differs from the non-monetary equilibrium as long as the rate of return on money is different from the rate of return on storing goods. Again, this is so even when the fraction of households that exercise the outside option is negligible.

The rate of return that households earn outside of the capital market does not affect the rates of return offered by firms inside of the capital market only when there are no households for which keeping their savings outside of the capital market is the only available alternative to lending their savings to a particular firm in the capital market. Indeed, in this case, there are multiple firms competing for every lender and every firm offers a rate of return equal to the marginal product of capital. The capital market becomes perfectly competitive. Therefore, when the capital market becomes perfectly competitive, the cashless limit of the monetary equilibrium does not depend on monetary policy, and it coincides with the non-monetary equilibrium.

In the second part of the paper, we calibrate the model. The calibrated model reproduces the extent to which different households earn systematically different rates of return on their wealth after controlling for differences in portfolio composition. In this sense, the model captures the extent of imperfect competition in the capital market. The calibrated model also reproduces the monetary holdings of different households. In this sense, the model captures money demand. We use the calibrated model to study the effect of the growth rate of money supply (a simple monetary policy instrument) in the cashless limit of the monetary equilibrium. We find that changes in the growth rate of money supply have relatively small effects on the steady-state values of aggregate capital, output, and consumption, but underneath these small macroeconomic effects lie dramatic changes to the micro structure of the capital market—i.e., the rates offered by firms, the rates earned by households with different financial human capital, and the distribution of households across rungs of the financial human capital ladder—and large adjustment dynamics. Quantitatively, monetary policy matters even in the cashless limit. We find that the effect of an increase in the growth rate of money supply is very different in the cashless limit and in the baseline calibration with actual money demand. Quantitatively, actual money demand is high enough to make the cashless limit a poor approximation of the actual economy. Lastly, we find that the cashless limit is noticeably different from the non-monetary equilibrium.

2 Environment and Equilibrium

The model is based on Menzio and Spinella (2025), which introduces information frictions in the capital market in the spirit of Butters (1977), Varian (1980) and Burdett and Judd (1983) into a monetary version of the incomplete markets model of Aiyagari (1994), Bewley (1983) and Huggett (1996). The Law of One Price fails in the capital market and, for this reason, different households earn different rates of return. Households may hold money as a store of value when they fail to find firms in which to invest in the capital market. In Section 2.1, we describe the environment and highlight the differences with respect to Menzio and Spinella (2025). In Section 2.2, we formulate the problem of the firm. In Section 2.3, we formulate the problem of the household. In Section 2.4, we formulate the market clearing conditions and we define a monetary and a non-monetary equilibrium. Throughout the paper, we restrict attention to stationary equilibria and, for this reason, we omit the dependence of value and policy functions from the aggregate state of the economy.

2.1 Environment

The economy is populated by households, firms, and a government. There is a measure h of households per firm. Each household maximizes the expected sum of current and future periodical utilities $u(c)$ discounted at the factor $\beta \in (0, 1)$, where $u(c)$ is a strictly increasing and concave function of consumption $c \in R_+$. Households are heterogeneous with respect to their endowment of efficiency units of labor $z \in \mathbb{R}_+$, wealth $a \in \mathbb{R}_+$, and financial human capital $i \in \{1, 2, ...I\}$. Each household owns an equal share of the firms.

There is a measure 1 of firms. Firms operate a constant returns to scale technology that turns capital $k \in \mathbb{R}_+$ and efficiency units of labor $\ell \in R_+$ into $y(k, \ell) + (1 - \delta_k)k$

units of the consumption good, where $y(k,\ell)$ is output and $(1-\delta_k)k$ is undepreciated capital, which can be turned back into the consumption good at the rate of 1 for 1. The production function $y(k,\ell)$ is strictly increasing and concave in k and ℓ, and features constant returns to scale.

Within a period, events unfold as follows. First, the labor market opens. The labor market is centralized and frictionless. Households supply efficiency units of labor, and firms demand efficiency units of labor according to the amount of capital that they borrowed in the previous period. Both households and firms take as given the real wage w, where w is such that supply and demand of efficiency units of labor are equal.

Second, production takes place. A firm that borrowed k units of capital in the previous period and hired ℓ efficiency units of labor in the current period produces $y(k,\ell)+(1-\delta_k)k$ units of the consumption good. The firm pays $w\ell$ units of output to its workers. The firm pays rk units of the consumption good to its lenders, where r is the gross real interest rate that the firm promised to the lenders in the previous period. The firm rebates any profits to its owners.

Third, the government injects additional fiat money into the economy through a lump-sum transfer to the households, or it withdraws some fiat money from the economy through a lump-sum tax. Let M denote the stock of money at the beginning of the period, and let γ denote the net growth rate of money. For $\gamma > 0$, the government injects $M\gamma$ units of money through a lump-sum transfer. The real value of the transfer to each household is $M\gamma\phi/h$, where ϕ denotes the price of a unit of money in terms of the consumption good. For $\gamma < 0$, the government withdraws $M\gamma$ units of money through a lump-sum tax. The real value of the tax on each household is $-M\gamma\phi/h$. Hence, whether γ is positive or negative, a household receives a net transfer $M\gamma\phi/h$ from the government. After receiving the transfer, a household allocates its resources into consumption $c \in R_+$, expenditures in financial education $e \in R_+$, and savings $s \in R_+$.

Next, the capital market opens. The capital market is decentralized and frictional. Each firm posts a real rate of return r. Each household comes into contact with a number of firms that depends on its financial human capital. In particular, a household with financial human capital i comes into contact with n firms, where

$$\begin{aligned} n &= 0, && \text{w.p. } \theta_i, \\ n &= 1, 2, ... && \text{w.p. } \frac{1-\theta_i}{1-e^{-\lambda_i}} \frac{e^{-\lambda_i}\lambda_i^n}{n!}. \end{aligned} \tag{2.1}$$

In words, the household does not contact any firms with probability $\theta_i \in [0,1]$. Conditional on contacting at least one firm, the household contacts a number n of firms that is distributed as a Poisson with coefficient $\lambda_i > 0$ truncated at $n = 1$. The household observes the real rate of return offered by the n firms that it has contacted, and decides whether and where to invest its savings s. Firms collect the savings from the household and turn them into capital at the rate of 1 for 1.

If a household does not lend its savings to a firm, it can either store the consumption good or hold money. If the household stores the consumption good, it enjoys the real interest rate $1-\delta_c$, where $\delta_c \in [0,1]$ is the depreciation rate of consumption. If the household holds money, it enjoys a real rate equal to $\hat{\phi}/\phi$, where $\hat{\phi}$ is the price of a unit of money in terms of the consumption good in the next period, and ϕ is the price of money in terms of the consumption good in the current period. The real interest rate $\underline{r}$ enjoyed by a household that does not lend its savings to a firm is the maximum between the return on storage $1-\delta_c$ and the return on money $\hat{\phi}/\phi$.

Lastly, the household's idiosyncratic shocks for next period are realized. The household's endowment of efficiency units of labor in the next period is $\hat{z}$ with probability $\omega_\ell(\hat{z}|z)$, where z denotes the household's endowment of efficiency units in the current period. The household's financial human capital in the next period is $\hat{\imath}$ with probability $\omega_f(\hat{\imath}|i,e)$, where i is the household's financial human capital in the current period, and e is the household's investment in financial education in the current period.

The environment described above is a version of Menzio and Spinella (2025), in which the number of firms that a household contacts in the capital market follows a richer stochastic process. In Menzio and Spinella (2025), the number n of firms contacted by a household in the capital market is distributed as a Poisson with coefficient λ_i. The parameter λ_i determines the probability that the household does not have trading opportunities in the capital market and, hence, it is forced to hold its savings in fiat money or consumption goods. Conditional on the household having some trading opportunities, the parameter λ_i also determines the number of firms contacted by the household in the capital market. This formulation of the search process implies that the same parameters $\{\lambda_1, \lambda_2, ...\lambda_I\}$ determine both aggregate money demand and the extent of competition between firms in the capital market. In particular, whenever the parameters $\{\lambda_1, \lambda_2, ...\lambda_I\}$ are such that money demand vanishes, i.e. whenever $\{\lambda_1, \lambda_2, ...\lambda_I\} \to \infty$, the capital market becomes perfectly competitive. In this sense, this formulation of the search process only allows us to study the *frictionless limit* of the economy, where households can always access the capital market and they can trade with infinitely many firms.

In this paper, the probability that a household does not have any trading opportunities in the capital market and, hence, it is forced to hold its savings in fiat money or consumption goods is given by the parameter θ_i. Conditional on the household having some trading opportunities in the capital market, the average number of firms contacted by the household is determined by the parameter λ_i. Therefore, money demand is determined by the parameters $\{\theta_1, \theta_2, ...\theta_I\}$, while the extent of between-firm competition in the capital market is determined by the parameters $\{\lambda_1, \lambda_2, ...\lambda_I\}$. This formulation of the search process allows us to consider environments in which money demand is vanishing, i.e. $\{\theta_1, \theta_2, ...\theta_I\} \to 0$, without simultaneously changing the extent of between-firm competition in the capital market. In this sense, this formulation of the search process allows us to study the *cashless limit* of the economy, where households can always access the capital market, but they can only trade with a finite and constant (random) number of firms.

2.2 Problem of the firm

We first examine the problem of the firm in the labor market. Consider a firm that borrowed k units of capital at the rate of return r in the capital market. The firm's problem is

$$\max_{\ell\geq 0} y(k,\ell)+(1-\delta_k)k-w\ell-rk. \tag{2.2}$$

The firm's revenues are given by the sum of the revenues from selling its output $y(k,\ell)$ and the revenues from selling its undepreciated capital $(1-\delta_k)k$. The firm's costs are given by the wage bill $w\ell$ and the capital bill rk. The firm chooses how many efficiency units of labor ℓ to hire in order to maximize its profit, which is given by the difference between revenues and costs.

The optimality condition for the firm's problem is

$$y_2(k,\ell)=w, \tag{2.3}$$

where $y_2(k,\ell)$ denotes the derivative of the production function $y(k,\ell)$ with respect to its second argument. Since $y(k,\ell)$ is homogeneous of degree 1 in k and ℓ, $y_2(k,\ell)$ is homogeneous of degree 0 in k and ℓ. Therefore, the optimality condition (2.3) implies that the efficiency units of labor hired by the firm are $g(w)k$, where $g(\cdot)$ is the inverse of the function $y_2(1,\cdot)$.

The firm's maximized profit is

$$\begin{aligned} & y(k,g(w)k)+(1-\delta_k)k-wg(w)k-rk \\ = \; & y\left(1,g(w)\right)k+(1-\delta_k)k-y_2(1,g(w))g(w)k-rk \\ = \; & y_1(1,g(w))k+(1-\delta_k)k-rk \\ = \; & \left(r^*-r\right)k. \end{aligned} \tag{2.4}$$

The second line in (2.4) makes use of the fact that $y(k,\ell)$ is homogeneous of degree 1 in k and ℓ, and the fact that $w=y_2(k,kg(w))=y_2(1,g(w))$. The third line makes use of the fact that, since $y(k,\ell)$ is homogeneous of degree 1, $y(k,\ell)$ is equal to $y_1(k,\ell)k+y_2(k,\ell)\ell$ for any k and ℓ. The last line is obtained by defining r^* as the marginal product of capital $y_1(1,g(w))+1-\delta_k$. Overall, the maximized profit for a firm that has borrowed k units of capital at the rate of return r is equal to k times the difference between r^* and r.

Next, we turn to the problem of the firm in the capital market. To formulate the problem of the firm, we need to introduce some notation. Specifically, we let $F(r)$ denote the fraction of firms that offer to their lenders a rate of return smaller or equal to r, $F(r-)$ denote the fraction of firms that offer a rate of return strictly smaller than r, and $\zeta(r)$ denote the measure of firms that offer a rate of return equal to r. We let h_i denote the measure of households with financial human capital i, and $H_i(s)$ denote the fraction of households with financial human capital i whose savings are smaller or equal to s.

The profit for a firm that offers the rate of return $r \geq \underline{r}$ in the capital market is

$$\pi(r) = \sum_{i=1}^{I} \left[\sum_{n=0}^{\infty} \int h_{i,n} \mu_{i,n}(r) \left(r^* - r \right) s dH_i(s) \right], \tag{2.5}$$

where

$$h_{i,n} = h_i \frac{1-\theta_i}{1-e^{-\lambda_i}} \frac{e^{-\lambda_i} \lambda_i^{n+1}}{(n+1)!} \left(n+1 \right), \tag{2.6}$$

and

$$\mu_{i,n}(r) = F(r-)^n + \sum_{j=1}^{n} \binom{n}{j} \frac{F(r-)^{n-j} \zeta(r)^j}{j+1}. \tag{2.7}$$

In the capital market, the firm meets a measure $h_{i,n}$ of households with financial human capital i that are in contact with n other borrowers. The probability $\mu_{i,n}(r)$ that one of these households lends its savings to the firm is given by the sum of the probability of two events. The first event is such that all the other n contacts of the household offer a rate of return strictly smaller than r. The second event is such that j of the other n contacts of the household offer a rate of return equal to r, the remaining $n-j$ contacts of the firm offer a rate of return strictly smaller than r, and the household randomly chooses to lend to the firm. If the household lends to the firm, the firm enjoys a profit of $(r^* - r)s$, where s are the household's savings. For any $r < \underline{r}$, the firm does not manage to borrow any capital and $\pi(r) = 0$.

The distribution F is consistent with firm's profit maximization if and only if (2.5) is maximized at every r on the support of F. Using this equilibrium condition, it is easy to show that F does not have any mass points (see, e.g., Lemma 1 in Menzio 2024). Since F does not have any mass points, the firm's profit (2.5) can be written as

$$\pi(r) = \left[\sum\nolimits_{i=1}^{I} \frac{1-\theta_i}{1-e^{-\lambda_i}} e^{-\lambda_i(1-F(r))} \lambda_i S_i \right] \left(r^* - r \right), \tag{2.8}$$

where S_i denotes the aggregate savings of households with human capital i.

It is also easy to show that the support of F is an interval $[r_\ell, r_h]$, with $r_\ell = \underline{r}$ (see, e.g., Lemma 2 in Menzio 2024). Since $\underline{r}$ is on the support of F, the firm's profit function attains its maximum π^* at $\underline{r}$. Since $\underline{r}$ is the lower bound of the support of F, $F(\underline{r}) = 0$. These observations imply that

$$\pi^* = \left[\sum\nolimits_{i=1}^{I} \frac{1-\theta_i}{1-e^{-\lambda_i}} \lambda_i e^{-\lambda_i} S_i \right] (r^* - \underline{r}). \tag{2.9}$$

Since $r \in [r_\ell, r_h]$ is on the support of F, the firm's profit function attains its maximum

π^* at r. This observation implies that

$$\pi^* = \left[\sum\nolimits_{i=1}^{I} \frac{1-\theta_i}{1-e^{-\lambda_i}} \lambda_i e^{-\lambda_i(1-F(r))} S_i\right] (r^* - r). \tag{2.10}$$

Equating the right-hand side of (2.10) to the right-hand side of (2.11) yields

$$\begin{aligned} &\left[\sum\nolimits_{i=1}^{I} \frac{1-\theta_i}{1-e^{-\lambda_i}} \lambda_i e^{-\lambda_i} S_i\right] (r^* - \underline{r}) \\ = &\left[\sum\nolimits_{i=1}^{I} \frac{1-\theta_i}{1-e^{-\lambda_i}} \lambda_i e^{-\lambda_i(1-F(r))} S_i\right] (r^* - r). \end{aligned} \tag{2.11}$$

The expression above uniquely pins down the equilibrium distribution F.

2.3 Problem of the household

Consider a household with financial wealth a, efficiency units of labor z, and financial human capital i. The household's maximized lifetime utility $V_i(a, z)$ is such that

$$\begin{aligned} &V_i(a,z) = \max_{(c,e,s)\in\mathbb{R}^3_+} u(c) \\ &+\beta \mathbb{E}_{\hat{z}|z} \left\{ \sum_{\hat{\imath}=1}^{I} \omega_f(\hat{\imath}|i,e) \left[\theta_i V_{\hat{\imath}}(s\underline{r}, \hat{z}) + \sum_{n=1}^{\infty} \frac{1-\theta_i}{1-e^{-\lambda_i}} \frac{e^{-\lambda_i}\lambda_i^n}{n!} \int V_{\hat{\imath}}(sr, \hat{z}) dF_n(r) \right] \right\}, \\ &\text{s.t. } c + e + s \leq a + wz + M\gamma\phi/h + \pi^*/h. \end{aligned} \tag{2.12}$$

In the current period, the household earns wz from supplying its efficiency units of labor, it receives profits π^*/h from the firms, and a transfer $M\gamma\phi/h$ from the government. The household chooses how to allocate these resources and its wealth a into consumption c, investment in financial human capital e, and savings s. In the capital market, the household does not meet any firms with probability θ_i. In this case, the household earns the real rate of return $\underline{r}$ on its savings. The household meets $n = 1, 2, ...$ firms with probability $[(1-\theta_i)/(1-\exp(-\lambda_i))] \exp(-\lambda_i)\lambda_i^n/n!$. In this case, the household earns the real rate of return r on its savings, where r is a draw from $F_n(r)$, and $F_n(r)$ is the distribution $F(r)^n$ of the highest of n independent draws from $F(r)$. In the next period, the household's financial wealth is sr. The household's efficiency units of labor are $\hat{z}$ with probability $\omega_\ell(\hat{z}|z)$. The household's financial human capital is $\hat{\imath}$ with probability $\omega_f(\hat{\imath}|i, e)$.

2.4 Market clearing

The clearing condition for the capital market is

$$\sum\nolimits_{i=1}^{I} (1-\theta_i) S_i = K. \tag{2.13}$$

The left-hand side of (2.13) is the capital that is lent by households to firms, which is given by the savings S_i of households with financial human capital λ_i multiplied by the fraction $1-\theta_i$ of these households that meet at least one firm in the capital market. The right-hand side of (2.13) denotes the amount of capital borrowed by firms from households.

The clearing condition for the labor market is

$$L = g(w)K. \tag{2.14}$$

The left-hand side of (2.14) is the amount of efficiency units of labor supplied by households, which we denote as L. The right-hand side of (2.14) is the amount of efficiency units of labor hired by firms, which is equal to the amount of capital borrowed by firms multiplied by $g(w)$.

The clearing condition for the money market depends on whether we are in a monetary equilibrium—an equilibrium in which money has value—or in a non-monetary equilibrium—an equilibrium in which money has no value. Clearly, for a monetary equilibrium to exist, it has to be the case that households prefer holding money than storing goods or, equivalently, $\hat{\phi}/\phi \geq 1-\delta_c$. In this case, the clearing condition for the money market is

$$\sum\nolimits_{i=1}^{I} \theta_i S_i = M(1+\gamma)\phi. \tag{2.15}$$

The left-hand side of (2.15) is the real money demand by households, which is given by the savings S_i of households with financial human capital λ_i multiplied by the fraction θ_i of these households that do not meet any firms in the capital market. The right-hand side of (2.15) is the real value of the money supplied by the government.

Using the clearing condition for the money market in the next period, we can recover the real return on money. The clearing condition for the money market in the next period is

$$\sum\nolimits_{i=1}^{I} \theta_i S_i = M(1+\gamma)^2\hat{\phi}. \tag{2.16}$$

The demand for money from the households in the next period is the same as in the current period. The supply of money from the government increases by the factor $1+\gamma$, and the value of a unit of money is $\hat{\phi}$ rather than ϕ.

Equating the right-hand sides of (2.15) and (2.16) yields

$$\frac{\hat{\phi}}{\phi} = \frac{1}{1+\gamma}. \tag{2.17}$$

The real return on money is the inverse of the gross growth rate of the quantity of money in the economy or, equivalently, the inverse of the gross growth rate of the price of consumption in units of money (the inverse of the inflation rate). The expression in (2.17) implies that a monetary equilibrium may exist only if $1/(1+\gamma) \geq 1-\delta_c$.

We can now define a monetary equilibrium.

Definition 1. *A Stationary Monetary Equilibrium is a tuple* $\{F, r^*, \underline{r}, w, \phi, c_i, e_i, s_i, \pi^*, \mathcal{H}_i, S_i\}$

such that: (i) The distribution F of interest rates offered by firms is consistent with profit-maximization and, hence, given by (2.11), where r^* is given by $y_1(1, g(w)) + 1 - \delta_k$ and $\underline{r}$ is given by $1/(1+\gamma) \geq 1 - \delta_c$; (ii) The wage w satisfies the clearing conditions (2.13) and (2.14) for the capital and labor markets; (iii) The price of money ϕ satisfies the clearing condition (2.15) for the money market; (iv) The policy functions $c_i(a, z)$, $e_i(a, z)$ and $s_i(a, z)$ solve the problem of the household (2.12); (v) The firm's profit π^* is given by (2.9); (vi) The distribution $\mathcal{H}_i(a, z)$ of households is stationary; (vii) The savings S_i are consistent with the distribution $\mathcal{H}_i(a, z)$, and with the policy function $s_i(a, z)$.

In a non-monetary equilibrium, money has no value. Clearly, in a non-monetary equilibrium, households prefer storing goods than holding money. When households prefer storing goods than holding money, the clearing conditions for the money market imply $\phi = 0$ and $\hat{\phi} = 0$. Hence, a non-monetary equilibrium may exist for any γ.

A stationary non-monetary equilibrium is formally defined below.

Definition 2. *A Stationary Non-Monetary Equilibrium is a tuple $\{F, r^*, \underline{r}, w, c_i, e_i, s_i, \pi^*, \mathcal{H}_i, S_i\}$ such that: (i) The distribution F of interest rates offered by firms is consistent with profit-maximization and, hence, given by (2.11), where r^* is given by $y_1(1, g(w)) + 1 - \delta_k$ and $\underline{r}$ is given by $1 - \delta_c$; (ii) The wage w satisfies the clearing conditions (2.13) and (2.14) for the capital and labor markets; (iii) The price of money ϕ equals 0; (iv) The policy functions $c_i(a, z)$, $e_i(a, z)$ and $s_i(a, z)$ solve the problem of the household (2.12); (v) The firm's profit π^* is given by (2.9); (vi) The distribution $\mathcal{H}_i(a, z)$ of households is stationary; (vii) The savings S_i are consistent with the distribution $\mathcal{H}_i(a, z)$, and with the policy function $s_i(a, z)$.*

3 Monetary Policy in the Cashless Limit: Theory

Consider a stationary monetary equilibrium. Assume that this type of equilibrium is unique. Let $r_m(x, \theta)$ denote the rate of return offered by a firm at the x-th quantile of the F distribution in the stationary monetary equilibrium, given the vector of parameters $\theta = \{\theta_1, \theta_2, ...\theta_I\}$. From (2.11), it follows that $r_m(x, \theta)$ is such that

$$r_m(x, \theta) = r_m^*(\theta) - \frac{\sum_{i=1}^{I} \frac{1-\theta_i}{1-e^{-\lambda_i}} \lambda_i e^{-\lambda_i} S_i^m(\theta)}{\sum_{i=1}^{I} \frac{1-\theta_i}{1-e^{-\lambda_i}} \lambda_i e^{-\lambda_i(1-x)} S_i^m(\theta)} \left[r_m^*(\theta) - \frac{1}{1+\gamma} \right], \tag{3.1}$$

where $r_m^*(\theta)$ denotes the marginal product of capital, and $S_i^m(\theta)$ denotes the savings of households with financial human capital i given the vector of parameters θ.

Consider a stationary non-monetary equilibrium. Assume that this type of equilibrium is unique. Let $r_n(x, \theta)$ denote the rate of return offered by a firm at the x-th quantile of the F distribution in the stationary non-monetary equilibrium, given the vector of parameters θ. From (2.11), it follows that $r_n(x,\theta)$ is such that

$$r_n(x,\theta) = r_n^*(\theta) - \frac{\sum_{i=1}^{I} \frac{1-\theta_i}{1-e^{-\lambda_i}} \lambda_i e^{-\lambda_i} S_i^n(\theta)}{\sum_{i=1}^{I} \frac{1-\theta_i}{1-e^{-\lambda_i}} \lambda_i e^{-\lambda_i(1-x)} S_i(\theta)} \left[r_n^*(\theta) - (1-\delta_c) \right], \tag{3.2}$$

where $r_n^*(\theta)$ denotes the marginal product of capital and $S_i^n(\theta)$ denotes the savings of households with financial human capital i given the vector of parameters θ.

As discussed in Menzio and Spinella (2025), the distribution of rates of returns offered by firms in the capital market depends on the marginal product of capital, on the rate of return that households can obtain outside of the capital market, and on the distribution of the number of contacts that households have in the capital market. The marginal product of capital affects the rates of returns offered by firms because it affects the value to a firm of borrowing an extra unit of capital and, hence, the incentives of firms to offer higher rates. The rate of return that households can earn outside of the capital market affects the rates of return offered by firms in the capital market because there are some households for which keeping their savings outside of the capital market is the only available alternative to lending to a particular firm in the capital market. The distribution of the number of contacts that households have in the capital market determines the extent of competiton between firms.

Now consider a sequence of stationary monetary equilibria with $\theta \to 0$, in the sense that $\{\theta_1, \theta_2, ...\theta_I\} \to \{0, 0, ...0\}$. In other words, consider a sequence of stationary monetary equilibrium in which the probability that a household is forced to invest its savings outside of the capital market converges to zero. Assuming that the stationary monetary equilibrium is continuous in θ, the limit of the rate of return offered by a firm at the x-th quantile of the F distribution is such that

$$\lim_{\theta\to 0} r_m(x,\theta) = \lim_{\theta\to 0} r_m^*(\theta) - \frac{\sum_{i=1}^{I} \frac{1}{1-e^{-\lambda_i}} \lambda_i e^{-\lambda_i} S_i^m(\theta)}{\sum_{i=1}^{I} \frac{1}{1-e^{-\lambda_i}} \lambda_i e^{-\lambda_i(1-x)} S_i^m(\theta)} \left[r_m^*(\theta) - \frac{1}{1+\gamma} \right]. \tag{3.3}$$

Consider the stationary non-monetary equilibrium for $\theta = 0$. In the stationary non-monetary equilibrium, the rate of return offered by a firm at the x-th quantile of the F distribution is such that

$$r_n(x,0) = r_n^*(0) - \frac{\sum_{i=1}^{I} \frac{1}{1-e^{-\lambda_i}} \lambda_i e^{-\lambda_i} S_i^n(0)}{\sum_{i=1}^{I} \frac{1}{1-e^{-\lambda_i}} \lambda_i e^{-\lambda_i(1-x)} S_i^n(0)} \left[r_n^*(0) - (1-\delta_c) \right]. \tag{3.4}$$

The expressions in (3.3) and (3.4) allow us to make three important observations. The first observation pertains to the monetary equilibrium. Even in the limit for $\theta \to 0$, the distribution of rates of returns offered by firms to households in the capital market depends on the growth rate γ of the stock of money supply. This observation may seem surprising. Indeed, in the limit for $\theta \to 0$, the fraction of households holding money converges to zero and, as it is obvious from the market clearing condition (2.15), the real value of the aggregate stock of money converges to zero. Yet, even though the real value of the money held by households is negligible, the rates of returns offered by firms to households depend on the growth rate γ of money supply.

The intuition for this seemingly surprising result is straightforward. In a monetary equilibrium, the rate of return that households earn outside of the capital market is the real rate of return on holding money, which is the inverse of the growth rate of money supply. The rate of return that households earn outside of the capital market affects not only the rate of return earned by the households that do not trade in the capital market, but also the rate of return earned by the households that do trade in the capital market, since these households always have the option of holding their savings in cash and, hence, firms have to compete against this option. In particular, the firm that offers the lowest rate of return in the capital market knows that it will only borrow from households that are not in contact with any other firm. Therefore, the firm that offers the lowest rate of return in the capital market knows that it is only competing against the households' outside option and, hence, it will offer to households a rate of return equal to the rate of return on holding money. Changes in the rate of return on holding money, therefore, affect the rates offered by the firms at the bottom of the distribution and, through the equal profit condition (2.11), they affect the rates of return offered by all the firms. Since the rate of return on holding money affects the rates of return offered by firms in the capital market, it also affects the rates of returns earned by households and, in turn, other equilibrium outcomes.

The second observation that follows from examining the expressions in (3.3) and (3.4) pertains to the relationship between monetary and non-monetary equilibrium. Even in the limit for $\theta \to 0$, the distribution of rates of returns offered by firms to households in the monetary equilibrium is generally different from the distribution of rates of return offered by firms to households in the non-monetary equilibrium. This observation may also seem surprising. Indeed, in the limit for $\theta \to 0$, the real value of the aggregate stock of money converges to zero. Yet, in the limit for $\theta \to 0$, the monetary equilibrium does not converge to the non-monetary equilibrium. The intuition for this observation is also straightforward. In a monetary equilibrium, the rate of return that households earn outside of the capital market is the rate of return on money. In a non-monetary equilibrium, the rate of return that households earn outside of the capital market is the rate of return on storing the consumption good. In general, these two returns are different. Even when the fraction of households that exercises the outside option is arbitrarily small, the outside option affects the rates of return offered by firms inside the capital market. Therefore, as long as the rate of return on money and the rate of return on storing goods are different, the rates of return offered by firms in the capital market are different, and so are the other equilibrium outcomes.

Monetary policy matters, even in the cashless limit of a monetary equilibrium, because the capital market is not perfectly competitive. Indeed, if the capital market was perfectly competitive, every firm would offer a rate of return equal to the marginal product of capital. Then, the growth rate of money supply, γ, and the rate of return on money, $1/(1+\gamma)$, would not affect the rate of return offered by firms, nor the rate of return earned by households in the capital market. In the cashless limit of a monetary equilibrium, the growth rate of money supply and the rate of return on money would have no effect on the rate of return earned by any households, since the measure of households that needs to keep its savings in cash is negligible. This argument can be formalized using (3.1)-(3.4). For $\lambda = \{\lambda_1, \lambda_2, ...\lambda_I\} \to \infty$, every household that accesses the capital market is in contact with multiple firms, and the rate offered by a firm at the x-th quantile of the F distribution converges to the marginal product of capital r^*. For $\theta \to 0$, every household that accesses the capital market earns r^* and the fraction of households that do not access the capital market is equal to 0. And, if all households earn the marginal product of capital on their wealth, the equilibrium allocation does not depend on the growth rate of money, nor it depends on whether the economy is in a monetary or non-monetary equilibrium.[1]

We summarize our findings in the following proposition.

Proposition 1. Monetary policy in the cashless limit.

(i) *In the limit for $\theta \to 0$ of the monetary equilibrium, the rates of return offered by firms in the capital market depend on the growth rate γ of money supply.*

(ii) *In the limit for $\theta \to 0$, the rates of return offered by firms are different in the monetary and in the non-monetary equilibrium as long as $\delta_c \neq \gamma/(1+\gamma)$.*

(iii) *In the limit for $\lambda \to \infty$ and $\theta \to 0$, the rates of return offered by firms in the monetary equilibrium do not depend on γ, and are equal to the rates of return offered by firms in the non-monetary equilibrium.*

The theoretical findings in Proposition 1 suggest that, in order to measure the role of money in a cashless economy, it is critical to know whether the capital market is perfectly competitive, and, if it is not, the extent to which the capital market is imperfectly competitive. Fagereng, Guiso, Malacrino and Pistaferri (2020) document, using Norwegian data, that different households earn systematically different rates of return on their wealth, even after controlling for portfolio composition. These empirical findings are compelling evidence that the financial market is not perfectly competitive. These empirical findings can be used–as we shall see momentarily–to measure the extent of imperfect competition in the financial market.

4 Monetary Policy in the Cashess Limit: Empirics

We calibrate the model and use it to measure the effect of monetary policy in the cashless limit of the monetary equilibrium. In Section 4.1, we calibrate the model to match the

[1]These observations also imply that monetary policy does not matter in the frictionless limit, where households always access the capital market and contact infinitely many firms.

extent to which different households earn systematically different rates of return on their wealth, after controlling for differences in portfolio composition. In this sense, the model is designed to capture the extent of imperfect competition in the capital market. We also calibrate the model to match the fraction of monetary holdings in the portfolio of different households. In this sense, the model is designed to capture money demand. In Section 4.2, we measure the effect of the growth rate of money supply (a simple type of monetary policy) in the cashless limit of the monetary equilibrium. We show that the growth rate of money supply has large effects on equilibrium outcomes, even when real balances are negligible. In particular, the growth rate of money supply has dramatic effects on the structure of the capital market–i.e., the rates offered by firms, the rates earned by households with different financial human capital, and the distribution of households across rungs of the financial human capital ladder. We also show that the effect of the growth rate of money supply is in the cashless limit is quite different from the effect of the growth rate of money supply in a model calibrated to actual real balances.

4.1 Calibration

Let us first review the parameters of the model. The household's preferences are described by the utility function $u(c)$ and the discount factor β. We specialize the utility function to have the CRRA form $u(c) = c^{1-\nu}/(1-\nu)$, where ν denotes relative risk aversion. The technology of the firm is described by the production function $y(k, \ell)$ and by the depreciation rate δ_k. We specialize the production function to have the Cobb-Douglas form $y(k, \ell) = k^{\alpha}\ell^{1-\alpha}$, where α denotes the elasticity of output with respect to capital. We specialize the stochastic process $\omega_{\ell}(\hat{z}|z)$ for the evolution of the household's efficiency units of labor to be $\log \hat{z} = \rho \log z + \epsilon$, where ρ is an autocorrelation coefficient, and ϵ is a random variable normally distributed with mean 0 and standard deviation σ. The stochastic process for z is discretized and normalized so that the aggregate measure of efficiency units of labor, L, equals 1. The measure h of households is normalized to 1.

We specialize the stochastic process $\omega_f(\hat{\imath}|i, e)$ for the household's financial human capital to be a process of climbing up and down a ladder. There are three rungs of the financial human capital ladder, associated with the parameters $\{\theta_1, \theta_2, \theta_3\}$ and $\{\lambda_1, \lambda_2, \lambda_3\}$, where $\theta_1 \geq \theta_2 \geq \theta_3$ and $\lambda_1 \leq \lambda_2 \leq \lambda_3$. For $i = 2$ or 3, we set $\omega_f(i-1|i, e) = \delta_f$. For $i = 1$ or 2, we set $\omega_f(i+1|i, e) = \max\{1 - \exp(-\eta e), 1 - \delta_{\lambda}\}$. For $i = 1$, 2 or 3, we set $\omega_f(i|i, e) = 1 - \omega_f(i+1|i, e) - \omega_f(i-1|i, e)$. We assume that λ_3 is equal to some arbitrary large number (namely, $\lambda_3 = 5$). In this sense, we normalize the highest financial human capital to be such that households essentially earn the highest rate offered in the market. The real interest rate that the household can earn outside of the capital market is given by$1/(1+\gamma)$ in a monetary equilibrium, and by $1 - \delta_c$ in a non-monetary equilibrium.

Next, let us turn to the calibration of the parameters of the model. We assume that the economy is in a stationary monetary equilibrium. We assume that the length of a period is 1 year. We set the coefficient of relative risk aversion ν to 1.5. We set the

Table 1: Calibrated Parameters

Assigned			*Internally Calibrated*		
ν	1.5	CRRA	β	0.953	Discount factor
α	0.36	Capital elasticity	λ_1	0.83	n. of contacts, low fhc
δ_k	8%	Capital depreciation	λ_2	2.28	n. of contacts, med fhc
γ	2%	Growth rate of money	(λ_3)	(5.00)	n. of contacts, high fhc
			η	0.73	Scale parameter for e
			δ_λ	1.0%	Fhc depreciation
			θ_1	0.69	prob. outside, low fhc
Auclert et al. (2021)			θ_2	0.20	prob. outside, med fhc
ρ	0.87	AR(1) coeff. log z	θ_3	0.10	prob. outside, high fhc
σ	0.23	St.dev. log z shocks			

elasticity α of output with respect to capital to 0.36. We set the depreciation rate of capital δ_k to 8%. We calibrate the stochastic process for the household's endowment of efficiency units to capture statistics of labor earnings documented by Auclert, Bardoczy, Ronglie and Straub (2021). We set the growth rate of the aggregate stock of money to be 2%, which guarantees that, in a stationary monetary equilibrium, the inflation rate is 2%. We assume that the depreciation rate δ_c on consumption goods is high enough to allow for the existence of a stationary monetary equilibrium.

To calibrate the remaining parameters, we target moments of the distribution of returns to net worth documented by Fagereng, Guiso, Malacrino and Pistaferri (2020) using Norwegian data. Fagereng, Guiso, Malacrino and Pistaferri (2020) regress yearly individual returns on net wealth on individual fixed-effects, portfolio composition, and wealth percentile. Since the regression controls for portfolio composition, the fixed-effect describes the additional return that a particular individual earns on its net wealth for the level of risk. Since the regression contains 11 years of observations per individual, the fixed-effect describes the additional return that a particular individual earns systematically relative to others. We use the 10th, 25th, 75th and 90th percentiles of the fixed-effect distribution as calibration targets. We also target the average rate of return across households weighted by wealth, which is reported by Fagereng, Guiso, Malacrino and Pistaferri (2020). These moments are informative about the distribution of λ's across households and, in turn, about the extent of imperfect competition in the financial market. In order to calibrate the distribution of θ's across households, we target the fraction of wealth held in monetary instruments (cash and deposits) by households at different percentiles of the wealth distribution. In order to calibrate the persistence of financial human capital, we target the Shorrocks index of the wealth distribution, computed from Halvorsen, Hubmer, Ozkan and Salgado (2024).

Table 2: Targets and fit

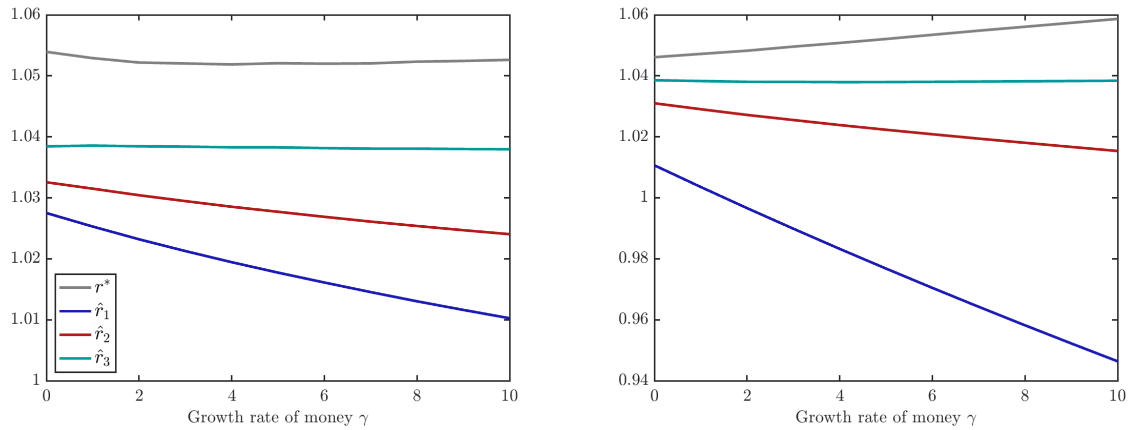
	Model	Target
Individual FEs Distribution		
10th percentile	-3.1653	-3.0300
25th percentile	-1.8467	-1.5800
75th percentile	1.5386	1.8600
90th percentile	2.1956	3.5000
Cash / Total Assets across Wealth Distribution		
10-20 %	0.4891	0.7300
20-50 %	0.3600	0.2800
50-90 %	0.1364	0.0900
90-95 %	0.0989	0.1000
$\mathbb{E}_s(r)$	0.0344	0.0356
Shorrocks index	0.4086	0.5876

Table 1 reports the calibrated parameter values. Households with the lowest financial human capital have a 69% probability of not finding any investment opportunity in the capital market. Conditional on finding some investment opportunities, these households are in contact with an average of 0.83 firms. Households with the intermediate level of financial human capital have a 20% probability of not finding any investment opportunities in the capital market. Conditional on finding some opportunities, these households are in contact with an average of 2.27 firms. Households with the highest financial human capital have a 9% probability of being left outside of the capital market. Conditional on accessing the capital market, these households find an average of 5 investment opportunities. Table 2 reports the calibration targets together with the model-generated analogues. The calibrated model does a decent job at matching the calibration targets.

4.2 Cashless limit

Using the calibrated model, we can measure the role of money in the cashless limit. We compute the cashless limit of the stationary monetary equilibrium by setting $\theta_1 = \theta_2 = \theta_3 = 0.001$, so that the fraction of households that hold their wealth in money is negligible and so is the real value of the stock of money. We compare outcomes in the stationary monetary equilibrium associated with different growth rates of money supply.

The left panel of Figure 1 plots the marginal product of capital and the average rates of return earned by households with different levels of financial human capital against the growth rate of money supply γ. The average rate of return earned by households with



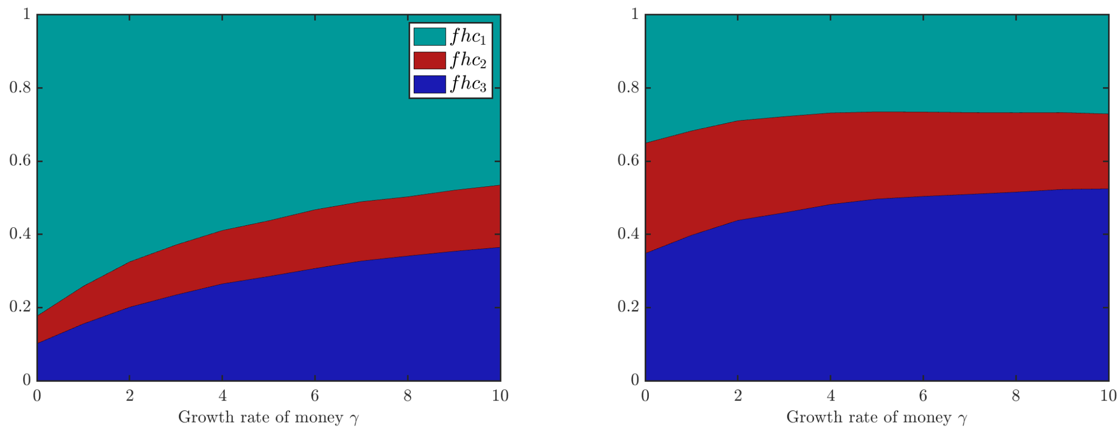
(a) Cashless limit

(b) Baseline

Figure 1: Returns by financial human capital.

the lowest human capital is sharply decreasing in γ. For $\gamma = 0\%$, the average rate of return earned by these households is 2.75%. For $\gamma = 10\%$, the average rate of return earned by these households is 1%. The average rate of return earned by households with the intermediate level of financial human capital is decreasing in γ, but less than for the least financially sophisticated households. For $\gamma = 0\%$, the average rate of return earned by these households is 3.25%. For $\gamma = 10\%$, the average rate of return earned by these households is 2.40%. The average rate of return earned by households with the highest level of financial human capital is essentially independent from γ. Indeed, the average rate of return for this households is 3.84% when $\gamma = 0\%$ and 3.80% when $\gamma = 10\%$.

Let us provide some intuition for the findings illustrated in the left panel of Figure 1. An increase in the growth rate of money supply lowers the real rate of return on cash, which is the rate of return that households earn outside of the capital market. Even when the fraction of households that exercises the outside option is negligible, as is the case in the cashless limit, the real rate of return on cash affects the rates of return that firms offer in the capital market. As established in Menzio and Spinella (2025), the extent to which firms respond to the decline in the real rate of return on cash varies according to the firm's position in the distribution F. Firms at the bottom of the distribution F lower their rate of return 1-for-1 with the decline in the rate of return on cash. This is because firms at the bottom of the distribution only borrow capital from households whose only alternative investment is cash. Firms at higher quantiles of the distribution F lower their rate of return less than 1-for-1 with the decline in the rate of return on cash. This is because firms at higher quantiles of the distribution F trade with a lower and lower fraction of households whose only alternative investment is holding cash and with a larger and larger fraction of households whose alternative investment is lending to some other firm. Since households with lower financial human capital have fewer contacts, they end up trading with firms at lower quantiles of the distribution F and, hence, their rate



(a) Cashless limit

(b) Baseline

Figure 2: Distribution of financial human capital.

of return tends to decline by more. Since households with more financial human capital have more contacts, they end up trading with firms at higher quantiles of the distribution F and, hence, their rate of return tends to decline by less.

The left panel in Figure 2 plots the fraction of households with different levels of financial human capital as a function of the growth rate of money supply. The fraction of households with the lowest level of financial human capital declines from about 80 to about 50% as the growth rate of money supply increases from 0 to 10% per year. Conversely, the fraction of households with the highest level of financial human capital increases from about 10 to about 30% as the growth rate of money supply goes from 0 to 10% per year. The phenomenon illustrated in Figure 2 is easily understood. As the growth rate of money supply increases, the gap between the average rate of return earned by households with low and high financial human capital widens. In response to this widening gap, households find it optimal to invest more in financial human capital and, for this reason, the fraction of households at the lowest level of financial human capital shrinks, while the fraction of households at the highest level of financial human capital expands.

Figure 3 plots the Lorenz curves of the wealth distribution for different growth rates of money supply. At a growth rate of money supply of 0%, the fraction of wealth owned by the poorest 50% of households is 10%, the fraction of wealth owned by the poorest 75% of households is 33.5%, and the fraction of wealth owned by the poorest 90% of households is 61.4%. At a growth rate of money supply of 10%, the poorest 50% of households own 6.3% of the wealth, the poorest 75% of households own 27.3% of the wealth, and the poorest 90% of households own 56.9% of the wealth. Overall, an increase in the growth rate of money supply tends to increase wealth inequality. The intuition behind this phenomenon is simple. An increase in the growth rate of money supply increases the gap between the rates of return earned by households with low and high financial human capital. Since

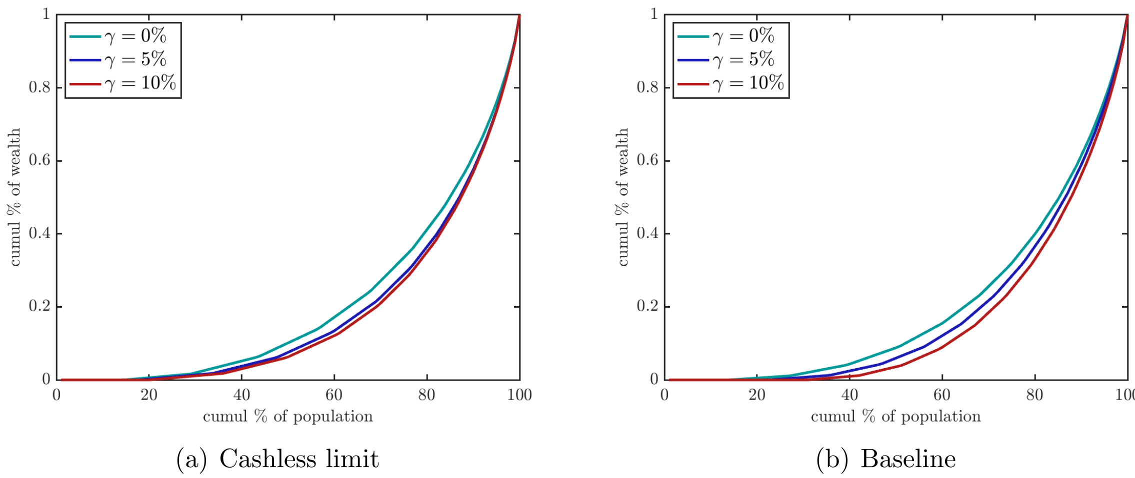
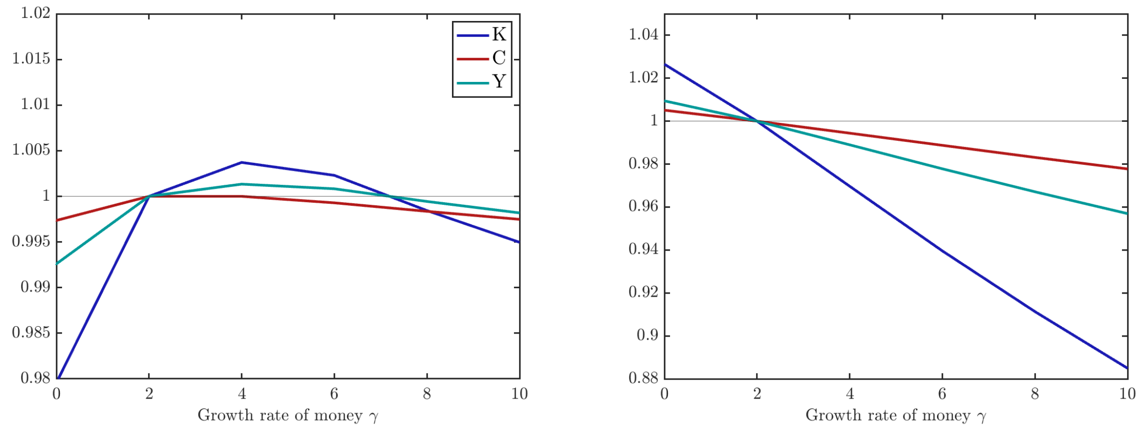


Figure 3: Wealth inequality.

wealthier households tend to have more financial human capital, an increase in the growth rate of money supply leads to an increase in wealth inequality.

Figure 4 plots some macroeconomic variables as a function of the growth rate of money supply. As the growth rate of money supply increases from 0 to 10% per year, the aggregate capital stock first increases by 2% and then falls by about 1%. Aggregate output and aggregate consumption follow a similar, albeit more muted, pattern. The response of these macroeconomic variables to changes in the growth rate of money supply is relatively small, but behind it there are large structural changes and large adjustment dynamics. As shown in Figure 2, the change in the growth rate of money supply leads to a large increase in financial human capital. As one can understand from Figure 1, the large increase in financial human capital allows households to maintain a stable rate of return on their wealth. It is for this reason that the increase in the growth rate of money supply does not end up having much of an effect on capital, output, and consumption. Moreover, while capital, output, and consumption change vary little across steady states, they do exhibit large adjustment dynamics. Figure 5, for example, illustrates the adjustment of these variables to a permanent and unanticipated increase in the growth rate of money supply from 0 to 10%.

It is useful to compare the effect of the growth rate of money supply in the cashless limit and in the baseline calibration with actual money demand. The right panel of Figure 1 plots the marginal product of capital and the rates of return earned by households with different financial human capital in the baseline calibration. Qualitatively, the effect of γ on the rates of return earned by households is similar in the baseline calibration and in the cashless limit. Quantitatively, the effect of γ on the rates of return earned by households is larger in the baseline calibration than in the cashless limit. Intuitively, the decline in the rates of return is larger in the baseline calibration because, in the baseline calibration, households suffer not only from the lower rates of return offered by firms in the capital



(a) Cashless limit

(b) Baseline

Figure 4: Aggregate capital, output, and consumption in steady state.

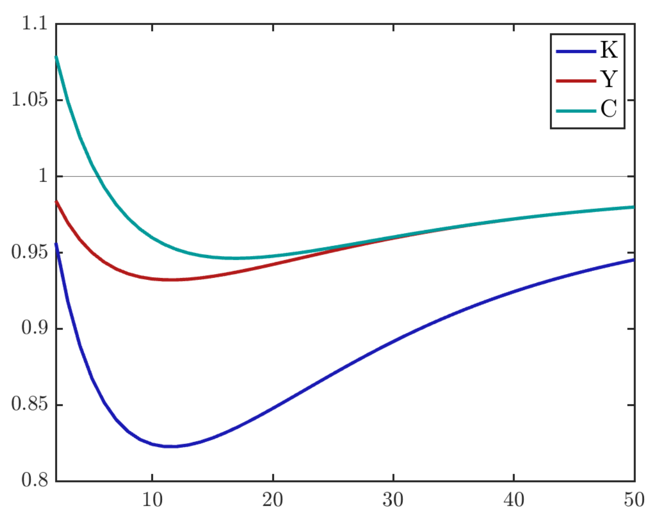


Figure 5: Response to an unexpected increase in γ from 0 to 10%.

market, but also from the lower rate of return on money. The right panel of Figure 2 plots the fraction of households with different financial human capital in the baseline calibration. Qualitatively, the effect of γ on the fraction of households with the lowest, intermediate and highest financial human capital is similar in the baseline calibration and in the cashless limit. Quantitatively, the effect of γ on the households' financial human capital is more muted in the baseline calibration than in the cashless limit. Intuitively, in the baseline calibration, the gap between the rates of return of different types of households is large even for low γ and, hence, most households with some financial wealth already have reached the second or third rungs of the financial human capital ladder.

The right panel of Figure 4 plots aggregate capital, output, and consumption in the baseline calibration. In contrast to the cashless limit, capital, output, and consumption decline monotonitically with γ and the decline is sizeable. As the growth rate of money supply increases from 0 to 10%, capital falls by approximately 12%, output falls by about 5%, and output falls by almost 3%. Figure 2 contains the intuition behind the different response of these macroeconomic variables in the cashless limit and in the baseline calibration. In the cashless limit, an increase in γ brings about a larger increase in financial human capital, which neutralizes the decline in the rate of return earned by households at a given level of financial human capital. In the baseline calibration, an increase in γ brings about a much smaller increase in financial human capital, which fails to neutralize the decline in the rate of return earned by households at a given level of financial human capital. As a result, households accumulate less wealth, the capital stock declines, and so do output and consumption.

The left panels of Figures 1, 2, 3 and 4 show that monetary policy has sizeable effects on the economy even in the cashless limit. In particular, monetary policy dramatically affects the structure of the capital market–i.e., the returns earned by households with different financial human capital, and the distribution of households across rungs of the financial human capital ladder. In this sense, claiming that money balances are vanishing cannot be used *quantitatively* as a justification to evaluate monetary policy using models that abstract from the role of money as a store of value. The comparison between the left and the right panels of Figures 1, 2, 3 and 4 reveals that the effect of monetary policy on the economy is quite different in the cashless limit and in the baseline calibration. In this sense, money balances are currently large enough to make the cashless limit a *quantitatively* poor approximation of the effect of monetary policy.

Next, we want to measure the difference between the cashless limit of a monetary equilibrium and the non-monetary equilibrium. Specifically, we compute the stationary monetary equilibrium for $\theta_1 = \theta_2 = \theta_3 = 0.001$. In order to compute the stationary monetary equilibrium, we need to choose the growth rate γ of money supply. We assume that, as in the baseline calibration, γ is 2% per year. We then compute the stationary non-monetary equilibrium for $\theta_1 = \theta_2 = \theta_3 = 0.001$. In order to compute the stationary non-monetary equilibrium, we need to take a stand on the depreciation rate δ_c of consumption.

Table 3: Cashless limit and non-monetary equilibria

	$\gamma = 2\%$	$\gamma = 4\%$	$\gamma = 6\%$	$\gamma = 8\%$	$\gamma = 10\%$	Non Monetary
$\hat{r}_1$	1.0232	1.0194	1.0161	1.0130	1.0103	1.0120
$\hat{r}_2$	1.0304	1.0285	1.0269	1.0254	1.0240	1.0249
$\hat{r}_3$	1.0384	1.0383	1.0381	1.0380	1.0380	1.0380
r^*	1.0522	1.0518	1.0520	1.0523	1.0526	1.0524
$\%\ fhc_1$	0.6747	0.5889	0.5322	0.4969	0.4648	0.4842
$\%\ fhc_2$	0.1239	0.1459	0.1605	0.1619	0.1702	0.1654
$\%\ fhc_3$	0.2014	0.2651	0.3073	0.3412	0.3651	0.3504
bottom 50%	0.0882	0.0794	0.0728	0.0671	0.0629	0.0656
bottom 75%	0.3095	0.2950	0.2854	0.2780	0.2730	0.2763
bottom 90%	0.5915	0.5807	0.5744	0.5710	0.5691	0.5704
Capital	4.7868	4.8045	4.7978	4.7793	4.7626	4.7747
Output	1.7572	1.7595	1.7586	1.7562	1.7540	1.7556
Consumption	1.3716	1.3716	1.3706	1.3693	1.3681	1.3689

We assume that δ_c is 8% per year, the same as the depreciation rate of capital.

Table 3 compares the cashless limit of the monetary equilibrium and the non-monetary equilibrium. Households earn higher rates in the monetary equilibrium than in the non-monetary equilibrium, and the gap is larger for households with lower financial human capital. In the monetary equilibrium, households with the lowest financial human capital earn an average rate of return of 2.3% on their wealth, households with the intermediate level of human capital earn an average return of 3%, and households with the highest level of human capital earn an average return of 3.85%. In the non-monetary equilibrium, households with the lowest financial human capital earn an average rate of return of 1.2% on their wealth, households with the intermediate level of human capital earn an average return of 2.5%, and households with the highest level of human capital earn an average return of 3.8%.

The intuition behind these findings is clear. In the monetary equilibrium, the household's investment option of the capital market is holding cash, which earns a real rate of return of -2% per year. In the non-monetary equilibrium, the household's investment option outside of the capital market is storing consumption, which earns a rate of return of -8% per year. Even though a negligible fraction of households exercises the outside option, the outside option still affects the rates of return offered by firms in the capital market. The effect of the outside option on the rates of return offered by firms is strongest at the bottom of the distribution F, and weakest at the top of the distribution F. For this reason, the difference between the rate of return earned by households in the monetary and in the non-monetary equilibrium is larger for those with lower financial human capital than for those with higher financial human capital.

Table 3 compares the fraction of households with different levels of financial human capital in the cashless limit of the monetary equilibrium and in the non-monetary equilibrium. In the monetary equilibrium, the fraction of households with the lowest financial human capital is 67.5%, the fraction of households with the intermediate financial human capital is 12.5%, and the fraction of households with the highest financial human capital is 20%. In the non-monetary equilibrium, the fraction of households with the lowest financial human capital is 48.5%, the fraction of households with the intermediate financial human capital is 16.5%, and the fraction of households with the highest financial human capital is 35%. In the non-monetary equilibrium, the increase in the rate of return obtained by moving up the financial human capital ladder is larger and, hence, households invest end up accumulating more in their financial education.

Table 3 compares the wealth distribution in the cashless limit of the monetary equilibrium and in the non-monetary equilibrium. In the monetary equilibrium, the poorest 50% of households own 8.8% of the wealth, the poorest 75% of households own 31% of the wealth, and the poorest 90% of the households own 59% of the wealth. In the non-monetary equilibrium, the poorest 50% of households own 6.5% of the wealth, the poorest 75% of households own 27.5% of the wealth, and the poorest 90% of the households own 57% of the wealth. In the non-monetary equilibrium, the difference between the rates of return earned by households with high and low financial human capital is larger. Since richer households tend to have more financial human capital, wealth inequality tends to be higher in the non-monetary equilibrium.

Lastly, Table 3 compares capital, output, and consumption in the cashless limit of the monetary equilibrium and in the non-monetary equilibrium. The capital stock is 0.25% lower in the non-monetary equilibrium than in the cashless limit. Output is 0.1% lower in the non-monetary equilibrium than in the cashless limit. And consumption is 0.22% lower in the non-monetary equilibrium than in the cashless limit.

The difference between the cashless limit of a monetary equilibrium with $\gamma = 2\%$ and a non-monetary equilibrium with $\delta_c = 8\%$ is equal to the difference between the cashless limit of a monetary equilibrium with $\gamma = 2\%$ and with $\gamma = 8\%$. In the cashless limit of a non-monetary equilibrium, the households' return outside of the capital market is approximately $-\gamma$. In a non-monetary equilibrium, the households' return outside of the capital market is $-\delta_c$. When θ is small, γ and δ_c only affect equilibrium through the value of the households' outside option and, hence, the non-monetary equilibrium with $\delta_c = 8\%$ is identical to the monetary equilibrium with $\gamma = 8\%$, and they are both quantitatively different from the monetary equilibrium with $\gamma = 2\%$. In general, since the cashless limit of the monetary equilibrium depends on γ, the cashless limit of the monetary equilibrium is different from the non-monetary equilibrium as long as γ is different from δ_c. The magnitude of the difference between the cashless limit of the monetary equilibrium and the non-monetary equilibrium depends on the gap between γ and δ_c, and it is equal to the difference between the cashless limit of the monetary equilibrium with γ and $\hat{\gamma} = \delta_c$.

References

[1] Aiyagari, R. 1994. "Uninsured Idiosyncratic Risk and Aggregate Saving." *Quarterly Journal of Economics*, 109: 659-684.

[2] Auclert, A., B. Bardóczy, M. Rognlie, L. Straub. 2021. "Using the Sequence-Space Jacobian to Solve and Estimate Heterogeneous-Agent Models." *Econometrica*, 89: 2375-2408.

[3] Bewley, T. 1983. "A Difficulty with the Optimum Quantity of Money." *Econometrica*, 51: 1485-1504.

[4] Burdett, K., and K. Judd. 1983. "Equilibrium Price Dispersion." *Econometrica*, 51: 955-969.

[5] Butters, G. 1977. "Equilibrium Distribution of Sales and Advertising Prices." *Review of Economic Studies*, 82: 892-928.

[6] Fagereng, A., L. Guiso, D. Malacrino, and L. Pistaferri. 2020. "Heterogeneity and Persistence in Returns to Wealth." *Econometrica*, 88: 115-170.

[7] Halvorsen, E., J. Hubmer, S. Ozkan, and S. Salgado. 2024. "Why Are the Wealthiest So Wealthy? New Longitudinal Empirical Evidence and Implications for Theories of Wealth Inequality." Manuscript, University of Pennsylvania.

[8] Huggett, M. 1996. "The Wealth Distribution in Life-Cycle Economies." *Journal of Monetary Economics*, 38: 469-494.

[9] Lagos, R., and S. Zhang. 2022. "The Limits of ONETARY ECONOMICS: On Money as a Constraint on Market Power." *Econometrica*, 90: 1177-1204.

[10] Menzio, G. 2024. "Markups: A Search-Theoretic Perspective." NBER Working Paper 32888.

[11] Menzio, G. and S. Spinella. 2025. "A Quantitative Theory of Heterogeneous Returns to Wealth." NBER Working Paper 33868.

[12] Varian, H. 1980. "A Model of Sales." *American Economic Review*, 70: 651-659.