Has Monetary Policy Become Less Effective?

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Abstract

High-powered money has been declining relative to nominal GDP in the United States. Does the ability of monetary policy to affect aggregate activity decline as the money-income ratio falls? In this paper, I specify a simple model economy, examining the effects that monetary policy actions and financial innovation would have on the equilibrium money-income ratio. The downward trend in the money-income ratio can be accounted for by increasing inflation, falling reserve requirements, or steady financial development. Whereas higher inflation and falling reserve requirements would reduce the potency of monetary policy, monetary policy's effects are invariant to financial innovation.

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1 Introduction

Figure 1 plots quarterly observations of the ratio of money to nominal GDP (upper panel) and money to nominal spending on consumer nondurables and services (lower panel) for the period 1947-93. Note that the low-frequency observation, measured by the Hodrick-Prescott growth component, is also included in the figure. In both panels, the evidence indicates that there is a downward trend in the money-spending ratio until about 1980. Since 1980, however, the money-income ratio has changed very little.[1]

The purpose of this paper is examine the question, Does the secular decline money-income ratio correspond to a change in the potency of monetary policy? Two terms needs to be addressed up front. First, potency refers to the size of the effects of monetary policy; more precisely, potency is the (absolute value of) the change in the equilibrium growth rate in response to a change in a monetary policy variable. Second, monetary policy has two tools at its disposal: the rate of money growth and the reserve requirement ratio.

Volumes have been written about the effects of monetary policy and the channels through which it affects economic activity. One very familiar position is the notion that economies exhibit long-run neutrality with respect to changes in money supply. Or the superneutrality variant maintains that no real effects accompany a permanent change in the growth rate of money.[2] According to the superneutrality view, the

[1] Gordon, Leeper, and Zha (1999) focus on the inverse of the money-income ratio–velocity during the postwar period. They argue that velocity exhibits three distinct patterns. First, there is a steady increase in velocity, followed by a period in which velocity was fairly constant. In the 1990s, there has been a downward trend in velocity. Note that Figure 1 excludes the most recent five years worth of data. It is difficult to extract the "correct" low-frequency component from the Hodrick-Prescott filter with the most recent data. This is not to deny the 1990s change in trend observed in Gordon, Leeper, and Zha. Rather, the statistical identification scheme adopts a "wait-and-see" approach.

[2] See Abel (1985) for a discussion of conditions in which superneutrality holds along the transition

question posed in the title of this paper is moot: monetary policy does not have a long-run effect on economic activity.[3] Its effects neither shrink nor expand over time because there are no monetary policy effects. Tobin (1965) and Stockman (1981) offered alternative, conflicting views regarding the direction of change in the steady-state capital stock that follows a change in monetary policy. As in Cole and Ohanian (1998), the question posed in this paper is about changes in effects of monetary policy over time. Cole and Ohanian focus on monetary policy effects at business-cycle frequencies, finding that the size of monetary policy effects are invariant to changes in money's unit-of-account role. However, the relationship between money's medium-of-exchange role and the potency of monetary policy can vary, depending crucially on identifying the chief holder of money balances–firms or households. Gordon, Leeper and Zha (1998) address the issue of secular movements in velcoity–the inverse of the money-income ratio. They focus on ways to account for low-frequency movements in velocity. Using a Bayesian VAR to construct inflation forecasts, Gordon, *et al* conclude that the low-frequency behavior of velocity can be accounted for by movements in the expected inflation rate.

In this paper, I use a simple, dynamic general equilibrium model to explore the correspondence between monetary policy, the money-income ratio and the growth rate of output. In this model economy, money serves two functions. It acts as a store of value and has an explicit medium-of-exchange role. Despite being rate of return dominated, money is valued because of a legal restriction–a reserve requirement–and because it is necessary to make some purchases. In this setup, one can identify which function plays the more important role–the medium of exchange function or the store of value function–in terms of transmitting monetary policy effects. Thus, the model economy embodies both the transaction-based approach and the asset-

path in the neighborhood of a steady state in a cash-in-advance model.

[3] There is a long list of papers in which long-run neutrality is a central feature. One of the more famous is Sidrauski (1967). For a thorough list of papers, see Woodford (1990).

substitutability approach that models frequently use to account for movements in the money-income ratio.[4]

In addition, it is possible to assess the role of financial innovation in this model economy. There are two alternative means of financing investment spending, hereafter referred to as banks and nonbanks. Banks face a reserve requirement, implying that the bank's assets are divided between two stores of value with unequal rates of return. The nonbank faces an additional cost that is banks do not face. Because the nonbank's costs are convex in the quantity of contracts, financing will come from both sources as long as the nonbank's cost are not bounded from above. Banks and nonbanks are not meant to be taken literally. Indeed, the setup permits one to ask questions about the impact that financial innovation or financial deregulation would have on the potency of monetary policy.[5]

In this paper, I proceed in two steps. First, I explore the relationship between monetary policy and the equilibrium level of the money-income ratio. The second step is to focus on the relationship between monetary policy and growth. Together, the two steps permit one to see if there is a correspondence between changes in the money-income ratio and the potency of monetary policy.

The findings can be easily summarized. The downward trend in the money-income ratio can be accounted for by increasing inflation, falling reserve requirements, or steady financial development. I quantify the potency of monetary policy using a calibrated version of the model economy. The quantitative evidence shows that effectiveness of monetary policy declines as the inflation rate rises and as the reserve

[4]The transactions-based model include Ireland (1995), Bansal and Coleman (1996), and Lacker and Schreft (1996). Asset subsitutability was stressed by Gurely and Shaw (1960), Tobin (1961, 1980), Brunner and Meltzer (1972), and Bordo and Jonung (1987, 1990).

[5]In this setup, financial innovation has to do with the costs of administering alternative stores of value. Here, financial innovation is treated as a change in storage technology. As such, the notion of financial innovation is slightly different from those forwarded in other recent papers. Ireland (1995), for instance, models financial innovation as changes in the means of payment. See also Lacker and Schreft (1996) for a similar treatment in which the means of payment is endogenous.

requirement falls, but is not affected by financial innovation. In short, gross real return to deposits is a function of the inflation rate and the reserve requirement, but is not affected by movements in the nonbank's cost structure. Thus, the findings presented in this paper indicate that it is crucial to understand why the money-income ratio is declining before one can argue that monetary policy is less effective.

The paper proceeds as follows. In Section 2, the model economy is characterized. Equilibrium and some basic properties are presented in Section 3. In Section 4, some simple computational experiments are presented. Because of the different channels operating in this model economy–two means of financing and two means of payment–there is little qualitative information obtained from the basic experiments. The computational experiments, therefore, permit one to obtain the direction of change in the equilibrium money-income ratio when, for instance, there an alternative monetary policy setting. I discuss the size of monetary policy effects in Section 5. I close with a brief summary of the results in Section 6.

2 The Model economy

In this section, I describe the model economy. There are five of economic players: firms, households, banks, nonbanks, and the government. In this setup, I assume that the government's decisions are set exogenously with respect to the other types of participants and that it can commit to sequences of policy variables. The number of households in this model economy is constant.

2.1 Government

The government controls the stock of fiat money, denoted M. The money stock evolves as follow: $M_t = \theta_t M_{t-1}$, so that θ is the growth rate of the money supply. New money is distributed as a lump-sum transfer to households. Let m be the measure of money stock per-household. The government budget constraint is

$$h_t = \frac{m_t - m_{t-1}}{p_t} \tag{1}$$

where h is the real value of the lump-sum transfer to households and p is the price level, or the quantity of fiat money it takes to acquire one unit of a consumption good.

2.2 Firms

Firms use capital to produce units of the consumption good. There are no barriers to entry in this industry. The rental price of capital is r goods (measured in units of the consumption good) per unit of capital and is taken as given by the firm. For simplicity, think of the economy as having one firm. The production technology is simple; each unit of date-t capital produces A units of the date-$t+1$ consumption good. To match the delay between the renting of capital and the realization of production, I assume that the rental fee paid at date-$t+1$ is for the capital stock rented at date t. Thus, the firm's date-t profit is

$$A(k_{t-1} + k_{t-1}^n) - r_t(k_{t-1} + k_{t-1}^n). \tag{2}$$

In this setup, there are two competing sources for renting capital to the firm. Let k denote the quantity of capital rented from the bank and k^n is the amount rented from the nonbank. More will be said about the distinction in the next section. The firm's profit function treats the two different sources as perfect substitutes.

The firm can costlessly transform the output into either of two final consumption goods. The quantity of the two goods are denoted c_1 and c_2, respectively. The distinction is made in two contexts. First, as the reader will see later the different goods enter the households utility function separately. Second, the timing of trade within a period is different for the two goods in this model economy. More specifically, the market for the cash good meets before factor payments are made. As such, a cash good (c_1) requires payment when the market meets. Because credit is not permitted in this transaction, the household must bring cash to the market to make the exchange. Alternatively, the credit good (c_2) can be traded with non-interest bearing intra-period credit serving as the means of payment.[6]

It is trivial to show that with the linear technology, the zero-profit condition is that $A = r_t$. If this condition is not satisfied, the firm will either shutdown, or enjoy unbounded profits.

2.3 Banks and nonbanks

In this model economy, there are two specialized institutions referred to as banks and nonbanks. Each accepts goods from households, transforming these goods into units of capital. For the sake of simplicity, the two institutions share a common transformation technology, changing the consumption good one for one into capital.[7]

Banks offer one-period deposit contracts. For each good deposited at the bank in date t, the depositor receives q date-$t+1$ goods Thus, q is the real return on deposits. In addition, the bank faces a reserve requirement such that at least $\gamma\%$ of goods deposited at the bank must be held in the form of fiat money. Whatever the bank does not hold as money is transformed into capital and rented to firms. The firm pays the rental fee and returns any unused capital to the bank. Capital evolves according to the expression: $k_t = (1-\delta)k_{t-1} + x_t$, where δ is the rate of capital depreciation and x is the quantity of goods added to the capital stock at date t. There is free entry into the bank industry. Moreover, banks take q as given. For simplicity, I assume that there is one bank.

To recap, the bank's revenues come from renting capital, the value of the bank's money holding, plus the undepreciated value of the bank's capital return; that is,

[6] Intra-period credit simply means that the firm is willing to trade the credit good for the household's IOU. After this period's factor payments are received by the household, the IOU is repaid.

[7] See also Chari, Jones and Manuelli (1996) and Haslag and Young (1998) for economies in which agents can choose between competing means of financing.

$$p_t r_t k_{t-1} + p_t(1-\delta)k_{t-1} + b_{t-1} - p_t q_t d_{t-1} \tag{3}$$

which is maximized subject to

$$p_t k_{t-1} + b_{t-1} \leq p_t d_{t-1} \tag{4}$$

and

$$\gamma_{t-1} p_{t-1} d_{t-1} \leq b_{t-1} \tag{5}$$

where p denotes the price level, or the number of pieces of fiat money per unit of the consumption good and b is the quantity of bank reserves. Equation (3) is the bank's profit, equation (4) is the bank's balance sheet, and equation (5) is the reserve requirement ratio. The bank solves a sequence of identical problems represented by equations (3)-(5). Hence, knowing the solution for one-period problem is sufficient. For the case in which the return to capital is strictly greater than the return to bank reserves, the reserve requirement holds as an equality. Thus, the bank's zero-profit condition is $q_t = \left(1 - \gamma_{t-1}\right)(r_t + 1 - \delta) + \frac{\gamma_{t-1} p_{t-1}}{p_t}$.

The nonbank also rents capital to firms for one period. Like the bank, the nonbank offers one-period contracts to households. Let n denote the quantity of nonbank contracts acquired by the household (each contract corresponds to the nonbank receiving one unit of a household's consumption good). When the contract matures, the nonbank pays the household q^n goods. The nonbank is a price taker in both the market for renting capital and offering deposit contracts. Contrary to the bank, the nonbank's costs depend on the quantity of contracts. Specifically, the function is given by $\alpha \left(n_{t-1}\right)^{\epsilon}$, where n denotes the quantity of nonbank contracts issued to households.[8] Note that these costs are not paid to another type of economic par-

[8] The convex cost structure assumed here is a necessary condition for both nonbank and bank deposit contracts to coexist. One can think of these costs as consisting of regulatory, institutional, and management costs associated with nonbank contracts.

ticipant. As such, the reader can treat these costs as if the nonbank throws these goods into the ocean. Because of the cost structure, I assume there is one nonbank in the economy. Further, I assume that $\alpha > 0$ and $\epsilon > 1$. The key property of this function is that the costs of the nonbank contracts are convex in n. Firms can rent capital from either the bank or the nonbank, implying that r is the same for both.

So, the nonbank's profits are characterized as:

$$pr_t^b = r_t k_{t-1}^n + (1-\delta)k_{t-1}^n - q_t^n n_{t-1} - \alpha\left(n_{t-1}\right)^{\epsilon} \tag{6}$$

s.t.

$$n_{t-1} \geq k_{t-1}^n \tag{7}$$

where pr^b denote the nonbank's profits and k^n is the quantity of capital that the nonbank rents to the firm. The nonbank loses profits if its does not rent the full value of its deposit contracts so that, in equilibrium, equation (7) will hold as an equality.[9] Thus, the nonbank's first-order condition is: $q_t^n = r_t + (1-\delta) - \alpha\epsilon\left(k_{t-1}^n\right)^{\epsilon-1}$. Profits from the nonbank are paid to the household.

2.4 Household

The economy consists of a continuum of households with identical preferences. Households are infinitely lived and choose the sequence of cash and credit goods to maximize the discounted sum of utilities represented by

$$\sum_{t=0}^{\infty} \beta^t U\left(c_{1t}, c_{2t}\right) \tag{8}$$

The representative household faces two constraints: a budget constraint and a cash-in-advance constraint. Hence, utility is maximized subject to

[9] More formally, with $r > 0$, it follows immediately $n_t = k_t^n$.

$$p_t q_t d_{t-1} + s_{t-1} + h_t + p_t q_t^n n_{t-1} + p r_t^b \geq p_t \left(c_{1t} + c_{2t} + d_t + n_t \right) + s_t \tag{9}$$

and

$$s_{t-1} + h_t \geq p_t c_{1t} \tag{10}$$

where s denotes the quantity of currency held by the household.

3 Equilibrium

An equilibrium in this model economy is a sequence of prices $\{p_t, r_t, q_t, q_t^n\}$, household allocations $\{c_{1t}, c_{2t}, x_t, d_t, n_t, s_t\}$, bank allocations $\{d_t, b_t, k_t\}$, nonbank allocations $\{n_t, k_t^n\}$, firm allocations $\{k_t, k_t^n\}$, policy variables $\{\gamma_t, m_t\}$, and initial values: s_0, k_0, k_0^n, d_0, n_0, m_0, such that:

(i) Given prices and policy settings, the household allocations solve the household's maximization problem [equations (8)-(**??**)];

(ii) given prices and policy settings, the bank allocation solve the bank's maximization problem [equations (3)-(5)];

(iii) given prices and policy settings, the nonbank allocation solve the nonbank's maximization problem [equations (6)-(7)];

(iv) given prices and policy settings, the firm allocation solve the firm's maximization problem [equation (2)];

(v) markets for goods and financial assets clear and the government budget constraint holds with equality.

This is a standard definition of equilibrium. The corresponding necessary conditions are:

$$\frac{U_2(t)}{U_2(t+1)} = \beta q_t \tag{11}$$

$$\frac{U_1(t)}{U_2(t)} = \pi_t q_t \tag{12}$$

$$q_t = \left(1-\gamma_{t-1}\right)(A+1-\delta) + \frac{\gamma_{t-1}}{\pi_t} = (A+1-\delta) - \alpha\epsilon\left(k_{t-1}^n\right)^{\epsilon-1} = q_t^n \tag{13}$$

Along with the associated transversality conditions:

$$\lim_{T\to\infty} \beta^T \eta_T d_T = \lim_{T\to\infty} \beta^T \eta_T n_T = \lim_{T\to\infty} \beta^T \eta_T s_T = 0. \tag{14}$$

where η is the Lagrange multiplier for the household's budget constraint.

Equation (11) is the standard Euler equation. In words, the optimizing household is indifferent between foregoing one unit of the credit-consumption good at date t, depositing the good at the bank and consuming the proceeds (q units) at date $t+1$. Equation (12) is the marginal rate of substitution between the cash and credit good. A household is willing to forgo marginal utility of U_1 associated with the cash-consumption good in order to receive πq worth of the credit-consumption good valued at marginal utility U_2. Equation (12) indicates that, in equilibrium, the household is indifferent between consuming more of the credit good or more of the cash good when the ratio of the marginal utilities equals the nominal interest rate.[10] Equation (13) is an arbitrage condition, indicating that, in equilibrium, the rate of return paid by deposits is equal to that paid nonbank contracts. Otherwise, rate of return dominance would lead the household to choose that contract that offered the higher rate of return. Lastly, the transversality conditions [equation (14)] limits the amount to which the household can short deposit contracts, nonbank contracts, and cash.

Ultimately, the goal is to quantify growth effects in this model, I focus on a particular functional form for preferences. Let $U\left(c_{1t}, c_{2t}\right) = (1-\sigma)^{-1}\left[\left(c_{1t}^{-\lambda} + \omega c_{2t}^{-\lambda}\right)^{-\frac{1}{\lambda}}\right]^{1-\sigma}$,

[10] This is a straightforward application of the Fisher equation, where π is the inflation rate and q is the gross real return.

where λ, σ, and ω are parameters. Let γ and θ, the monetary policy settings, be constant over time. Thus, for this model economy, the balanced growth equations are:

$$\frac{c_2}{c_1} = (\omega \pi q)^{\frac{1}{1+\lambda}} \tag{15}$$

$$q = (1-\gamma)(A+1-\delta) + \frac{\gamma}{\pi} \tag{16}$$

$$\rho = \beta q^{\frac{1}{\sigma}} \tag{17}$$

$$\theta = \rho \pi \tag{18}$$

Note that along the balanced-growth path, $\rho = \frac{c_{1t+1}}{c_{1t}} = \frac{c_{2t+1}}{c_{2t}} = \frac{d_{t+1}}{d_t} = \frac{k_{t+1}}{k_t}$.

Equation (15) indicates that the ratio of the two consumption goods depends on the parameter λ. Note $\lambda > -1$ holds. Pick two extreme values for the purposes of illustration. With $\lambda \to -1$, the marginal rate of substitution is approaching infinity. Hence, the two goods are perfects substitutes. Alternatively, with $\lambda \to \infty$, the utility function is Leontieff, such that the cash and credit goods are perfect complements and consumed in fixed proportions.

The model economy possesses two properties worth noting.

Remark 1 *As $t \to \infty$, the ratio $\frac{d}{n} \to \infty$. This feature of the model economy reflects the assumptions regarding capital acquisition in this model economy. The gross real return to nonbank contracts is decreasing in the quantity of these contracts, owing to the assumption that the cost function is convex in n. In words, capital accumulation comes from the continued accumulation of bank deposits. Other things being equal, banks have an advantage over nonbanks in the sense that the quantity of deposits will increase over time while the quantity of nonbank contracts will be constant. With production technology in this model economy, it follows that the asymptotic growth rate of output, $\frac{y_{t+1}}{y_t} = \rho$.*

In addition, the model economy has the following property with respect to money-income ratio.

Lemma 1 *Along, the balanced growth path, the growth rate of the money-income ratio is invariant to monetary policy settings.*

Proof. Let $\mu_t = \frac{m_t}{p_t c_{1t}}$. It follows that $\frac{\mu_{t+1}}{\mu_t} = \frac{\theta}{\rho\pi}$. By equation (18), $\frac{\mu_{t+1}}{\mu_t} = 1$.[11] ■

The lemma does not say that the money-income ratio is invariant to different monetary policy settings. However, this model economy has the feature that the money-income ratio has a constant growth rate; indeed, the growth rate equals one along the balanced-growth path. With the linear production technology, the transition dynamics are trivial.

Generally, the complexity of the model economy makes it difficult to obtain unambiguous signs for the direction of change. For example, consider the effect that a higher reserve requirement would have on the equilibrium level of the money-income ratio. With a higher reserve requirement, banks would hold more reserves, acquiring less capital. As such, bank reserves would increase and the equilibrium money-income ratio would increase, holding everything else constant. In addition, with an increase in the reserve requirement, the gross real return on deposits decreases. With lower q, bank deposits are less attractive relative to the nonbank contracts, lowering the quantity of bank reserves. There is also an effect on the ratio of credit good to cash good. As equation (15) shows, the cash good becomes relatively cheaper, meaning more cash and pushing the money-income ratio higher. The computational experiments will permit one to determine the direction of change for a reasonably calibrated version of this model economy.

[11] If one defines $v_t = \frac{p_t y_t}{m_t}$, the lemma is slightly modified; velocity growth is asymptotically invariant to monetary policy settings.

4 Monetary policy and the money-income ratio

4.1 Calibration

The next step is to calibrate the model economy. I select parameter values using a combination of findings from previous studies and facts directly obtained from postwar U.S. data. The model economy is a simple growth model so that low-frequency values are used where applicable. Since growth facts are going to be annualized, I assume the period in this model as one year.

There are a standard set of values in the literature. For example, the discount factor $\beta = 0.9733$. Thus, with $\gamma = 0$ and $\pi = 1$, $\rho = \beta (A + 1 - \delta)^{\frac{1}{\sigma}} = 1.02$. Let $\delta = 0.1$ and $\sigma = 2$. It follows that $A = 0.169$.[12]

The next step is select parameter values that determine the marginal rate of substitution for the two consumption goods. In a nonmonetary version of the model economy, ω would represent a relative expenditure share. For this monetary version, ω measures the fraction of total consumption in which the means of payment is credit. The Federal Reserve has commissioned several surveys on transactions. .The survey evidence suggests that, on average, consumers use cash in roughly 30% of their transactions (by volume). Hence, $c_1 = 0.3 (c_1 + c_2)$, implying that $\frac{c_2}{c_1} = 2.33$. The average postwar inflation rate in the United States is 4.1%, or $\pi = 1.041$. The average ratio of reserves to bank deposits–checkable deposits, demand deposits, and savings accounts–in the United States is 3.6%, or $\gamma = 0.036$.[13] Based on equation (15), one can infer the value of ω for a given value of λ. Let $\lambda = 1$.[14] Thus, the

[12] In this paper, each of the experiments satisfies the condition for finite utility; that is, $\beta\rho^{1-\sigma} < 1$.

[13] Bank deposits are defined as the sum of checkable deposits and savings accounts. Clearly, this measure is an average reserve ratio, not the desired average marginal reserve requirement. For the U.S., the distinction may be less important than for other countries. Historically, the level of excess reserves has been quite small.

[14] I also compute the equilibrium for a case in which $\lambda = -0.5$. In this case, the cash and credit goods are gross complements. Compared with the findings reported in the paper, there is a smaller response to changes in the nominal interest rate when cash and credit goods are gross complements.

implied values for ω is 1.3642.

Lastly, one needs to calibrate the relative shares of capital financed by banks and by everything else. Given the definition of bank-financed capital in the model economy, I use the ratio of bank deposits against which reserves must be held–checkable deposits and savings accounts–to the sum of private fixed capital and consumer durables. Data are available from *Fixed, Reproducible Tangible Wealth.* This ratio measures the fraction of capital that the bank could finance with deposits against which reserve requirement apply. On average, the ratio is 0.27 for the period 1947-89. Thus, the model economy should be calibrated so that this is the average ratio for $\frac{k}{k+k^n}$. The relevant parameters are in the cost function for the nonbank. There are two of them, α and ϵ. The added degree of freedom presents problems. I report the findings for a combination in which $\alpha = 0.1$ and $\epsilon = 12.5$. Several other combinations were considered; for example, $\alpha = 0.25$ and $\epsilon = 22.5$, $\alpha = 150$ and $\epsilon = 45$. There is virtually no quantitative difference between the various combinations. For those interested, the results for those parameter combinations not reported in the paper are available from the author upon request.

The computational experiments are grouped into two distinct groups. The first group considers the effects of changes in monetary policy settings; that is, both the reserve requirement and the inflation rate on money-income ratio. The second group focuses on the effects that reductions in the cost of nonbank contracts would have on the money-income ratio.

Lemma 1 forms the basis for conducting the experiments in a "level" setting. In words, I consider economies in which the policy settings are constant over time. Since the growth rate of the money-income ratio equals one, I can examine the impact that changes in policy settings have on the *level* of the money-income ratio. Thus, the experiments consider cases in which there is a permanent, unanticipated change in

Quantitative differences are minor, so I report only the case with $\lambda = 1$ in the paper. The findings for the case with $\lambda = -0.5$ are available from the author upon request.

the parameter settings.

4.1.1 Monetary policy settings

Consider a case in which the central bank chooses the rate of inflation. With higher inflation, the credit good becomes relatively cheaper than the cash good, inducing smaller cash holdings in equilibrium. In addition, the gross real return to deposits falls, making nonbank contracts relatively more attractive. For the money-income ratio, this means fewer deposits and smaller bank reserves. However, the decline in gross real return to deposits corresponds to making the cash good less expensive relative to the credit good, inducing larger cash hoards. Overall, the nominal interest rate rises as the inflation rate increases, swamping the decline in the real return on deposits. Figure 2 shows this, plotting the combinations of the inflation rate and the money-income ratio. The experiment considers inflation rates from 1% to 100% ($\pi \in [1.01, 1.02, ..., 2.0]$). Figure 2 shows that the equilibrium level of money-income ratio declines as the inflation rate is raised.

The next step is to assess the quantitative effects accompanying a change in the reserve requirement. Figure 3 plots combinations of the equilibrium level of money-income ratio and reserve requirements. The direct and general equilibrium effects of a change in reserve requirements is described above. As Figure 3 shows, an increase in the reserve requirement results in a higher money-income ratio.

4.1.2 Financial development

In this paper, financial development is modeled as a decline in the marginal cost of nonbank contracts. Figure 4 plots the combinations of equilibrium money-income ratio and the percentage decline in the total factor cost term, α. With lower marginal costs for nonbank contracts, the nonbank contracts become more attractive, lowering the quantity of reserves. The money-income ratio decreases. Note that in Figure 4, with a greater percentage decline in the marginal costs for nonbank contracts, the equilibrium value for the money-income ratio declines.

The answers obtained from the first part of this study demonstrate that a combination of movements in financial development, reserve requirements, and the inflation rate could account for the behavior in trend money-income in the postwar United States. The inflation-rate experiments are in the same spirit as those forwarded in Gordon, Leeper and Zha. Specifically, an increase in the inflation rate could account for a decline in the money-income ratio (in their case an increase in velocity). In this paper, I build on the Gordon, Leeper, Zha proposal to include the possibility that falling reserve requirements or continuing financial innovation could also account for the low-frequency behavior of the money-income ratio. To give further credence to these alternative notions, Figure 5 plots the reserve ratio in the United States from 1947-89. As the data show, there is clear downward trend in the reserve ratio.[15] Financial innovation is more difficult to measure. Casual empiricism, however, would suggest that the United States has experienced some financial innovation.[16]

5 Monetary policy and growth

The second stage of this paper develops the relationship between monetary policy and the growth rate. In doing so, one can establish the conditions in which a decline in the money-income ratio corresponds to less potent monetary policy. Clearly, the

[15] The reserve ratio is the bank reserves divided by the sum of checkable deposits, demand deposits, and savings accounts. This is not the average, marginal reserve requirement. For the U.S., however, required reserves make up the bulk of total reserves.

[16] Gertler (1988) provides an excellent overview of the structure of the financial environment, discussing the potential effects on macroeconomic activity. In addition, Levine (1997) proposes $\frac{M2}{GDP}$ as an indicator of financial innovation.

McGrattan (1998) notes that M1 velocity did not decline in the 1980s and 1990s as interest rates declined. Meanwhile, base velocity declined. She offers technological changes in transactions and financial deregulation as possible explanations for these differences the behavior of M1 velocity and base velocity.

view taken here is that movements in the money-income ratio are endogenous. The decline in the money-income ratio is not the outcome of an exogenous decline in money demand.

I begin by writing the growth-rate expression in a form in which monetary policy settings are apparent.

$$\rho = \left[\beta\left[(1-\gamma)(A+1-\delta)+\left(\frac{\gamma}{\pi}\right)\right]\right]^{\frac{1}{\sigma}}. \tag{19}$$

Equation (19) is the basis for assessing the impact of the alternative exogenous forces. From Lemma 1, a downward trend in the level of the money-income ratio can be accounted for by a upward trend in the inflation rate, a downward trend in reserve requirements, and/or continuing declines in the marginal cost of nonbank contracts.

First, consider a case in which the inflation rate setting were raised. It is straightforward to show that

$$\frac{d\rho}{d\pi} = \frac{1}{\sigma}\left[\beta q\right]^{\frac{1}{\sigma}-1}\left(-\frac{\gamma}{\pi^2}\right) < 0. \tag{20}$$

Similarly, for the case in which the reserve-requirement setting is raised, the change in the growth rate is

$$\frac{d\rho}{d\gamma} = \frac{1}{\sigma}\left[\beta q\right]^{\frac{1}{\sigma}-1}\left[\beta\left(\frac{1}{\pi}-(A+1-\delta)\right)\right] < 0 \tag{21}$$

Figures 6 and 7 plot the combinations of the change in the growth rate for different levels of the inflation rate and reserve requirement, respectively. As Figure 6 shows, the change in the growth rate declines as the inflation rate rises. In words, monetary policy is less potent at high inflation rates than at low inflation rates. The intuition is straightforward. In the inflation-rate case, an increase in the inflation rate has a smaller and smaller impact on the gross real return to deposits. As the inflation rate gets larger, the marginal impact that it has on the gross real return on fiat money declines, approaching zero in the limit. Likewise, Figure 7 shows that monetary policy effects decline as the reserve requirement declines. Evaluated at a lower reserve requirement, one sees that further decline in the reserve requirement has a smaller effect on the gap between the return to capital and the return on fiat money. Thus, monetary policy becomes less potent because the distortion to the gross real return to deposits is shrinking.

Thus, increases in the inflation rate and decreases in the reserve ratio could account for the decline in the money-income ratio. In addition, the properties of the model economy indicate that monetary policy would be less potent if either movements in the inflation rate or reserve requirements were responsible for the downward trend in the money-income ratio.

The limiting case for the reserve requirement is particularly important for assessing the size of monetary policy effects. Note that with $\gamma = 0$, the rate of growth is invariant to the inflation rate setting. This finding highlights how monetary policy affects economic activity, least at the low frequencies. Money serves two roles in this model economy–a store-of-value function and a medium-of-exchange-function. Monetary policy settings affect the rate of growth through the store-of-value function; that is, the rate of return on fiat money affects the rate of return that household's receive. It is possible to separate monetary policy's impact from the rate-of-return earned on deposits: eliminate reserve requirements.[17] In doing so, the size effects of monetary policy effects are disconnected from the rate of return on deposits. In short, we are back in a world in which long-run neutrality holds.[18] Though the money-income ratio would be positive–the representative household would hold fiat money for transactions purposes–monetary policy would be impotent. The implication is

[17] Money will still serve as a store of value because of the cash-in-advance constraint. The primary role for money in the cash-in-advance constraint is the medium-of-exchange function; that is, money is needed for transactions purposes.

[18] It is naive to argue that eliminating reserve requirements would eliminate the need for financial institutions to hold fiat money. Clearing balances would still be needed. Another way to eliminate monetary policy effects would be to pay interest on reserves, including these clearing balances. Growth-rate effects are present in this model economy because there is a gap between the rate of return on reserves and the rate of return on capital.

that it is the store of value function, not the medium-of-exchange role- though which monetary policy affects low-frequency economic activity.

To demonstrate the effect of different reserve requirements, consider the following experiment. I compute the impact that a change in the inflation-rate has on the growth rate under two different reserve requirements. The "high" reserve requirement setting is close to what he reserve ratio was in the 1950–10%. The "low" reserve requirement setting is 2.5%, close to what the reserve ratio has been in the 1990s. Figure 8 plots the change in the growth rate for different levels of the inflation rate, showing that the size of the monetary policy effect is smaller under the low-reserve-requirement setting as compared with the high-reserve requirement setting. As such, the findings would support the notion that monetary policy, implemented through changes in the money growth rate, have a smaller impact on growth in the 1990s than the same policy would have had in the 1950s.

Lastly, consider the case in which there is a permanent, unanticipated financial innovation, manifested as a decline in the marginal cost of nonbank contracts With a decline in the marginal cost of nonbank contracts, households shift goods from deposits to nonbank contracts. However, financial innovations do not affect the gross real return to deposits, only inducing a shift between the two competing means of storing goods for future consumption. With q unchanged, the growth rate of the economy is unchanged. In short, the size of monetary policy effects are invariant to financial innovation.

Remark 2 *There is an important caveat. Suppose, for instance, that*

$$\alpha\epsilon\left(k^n\right)^{\epsilon-1} < \gamma(A+1-\delta) - \frac{\gamma}{\pi} \qquad \forall k^n$$

When this condition is satisfied, nonbank contracts rate of return dominate bank deposits.[19] In this case, monetary policy does not affect the growth rate. Indeed,

[19] A sufficient condtion for such an inequality is $\alpha = 0$.

bank deposits, in the narrow sense used here, disappear. In this special case, financial development, which results in a decrease in money-income ratio, also corresponds to a case in which the size of monetary policy is less potent.

6 Concluding remarks

Is there a correspondence between the potency of monetary policy and changes in the money-income ratio? The answer to this question is important because the postwar period in the U.S. has been dominated by a secular decline in the money-income ratio. If, for example, there a positive relationship between the potency of monetary policy and the money-income ratio, then monetary policy is less potent now that it was in the 1950s.

In this paper, I use a dynamic general equilibrium model to assess the effects that two monetary policy tools–the money growth rate and the reserve requirement ratio–as well as financial innovation on both the money-income ratio and the size of monetary policy effects on the equilibrium growth rate. Faster money growth and lower reserve requirements can account for the decline in the money-income ratio. Compared to their levels in the 1950s, average money growth rate has been higher in the 1990s and the reserve requirement is lower in the 1990s. So, the answers from model economy indicate that monetary policy is less potent in the 1990s than it was in the 1950s. Monetary policy would be losing its potency its effects on the gross real return are smaller.

In addition, financial innovation can also account for a decline in the money-income ratio. However, the potency of monetary policy is invariant to financial innovation. Financial innovation is modeled as similar to technological progress. Innovation means that alternative means of financing capital purchases become cheaper. As such, this notion of financial innovation is more closely associated with reducing the costs of new types of financial accounts–mutual funds. Financial innovation also includes new means of payment. This model economy has virtually nothing to say about the payment technology. Within this setup, about all one can say about the evolving means of payment is that if it were to effect the potency of monetary policy, it would need to affect the gross real return to savings.

An interesting outcome from this study is that monetary policy would appear to be its own worst enemy. Expansionary actions–faster money growth and lower reserve requirements–ultimately reduce monetary policies marginal ability to affect growth.

It is important to understand why monetary policy affects the growth rate. In doing so, it is possible to uncover which function of money is important for determining the potency of monetary policy. In this paper, the potency of monetary policy comes from its effects on the rate of return to savings. Specifically, part of base money is held as a complement to bank-financed capital. The upshot is that monetary policy operates through its store-of-value role. The model economy also includes a medium-of-exchange role for money. In contrast, changes in the monetary policy affect the relative importance of money in its medium-of-exchange role–credit becomes more prominent when the inflation rate rises–but monetary policy does not affect the equilibrium growth rate through its medium-of-exchange role. Specifically, the rate of return on the storage technologies is invariant to changes in the transaction technology. Where financial innovation can potentially affect the potency of monetary policy is by eliminating the link between money and capital accumulation. Indeed, if money and bank-financed capital were not complements, monetary policy would have zero impact on growth.

In terms of future research, the model economy focuses on an economy in which money is nonneutral because there is a "Stockman effect;" that is, money and capital are complements. It would be interesting to see if the results extend to an economy in which there is a "Tobin" effect; that is, where money and capital are gross substitutes. In addition, there room for more fully developing the transaction role of money. In doing so, it would be to gain deeper insight into the relationship between this role and nonneutrality of monetary policy.

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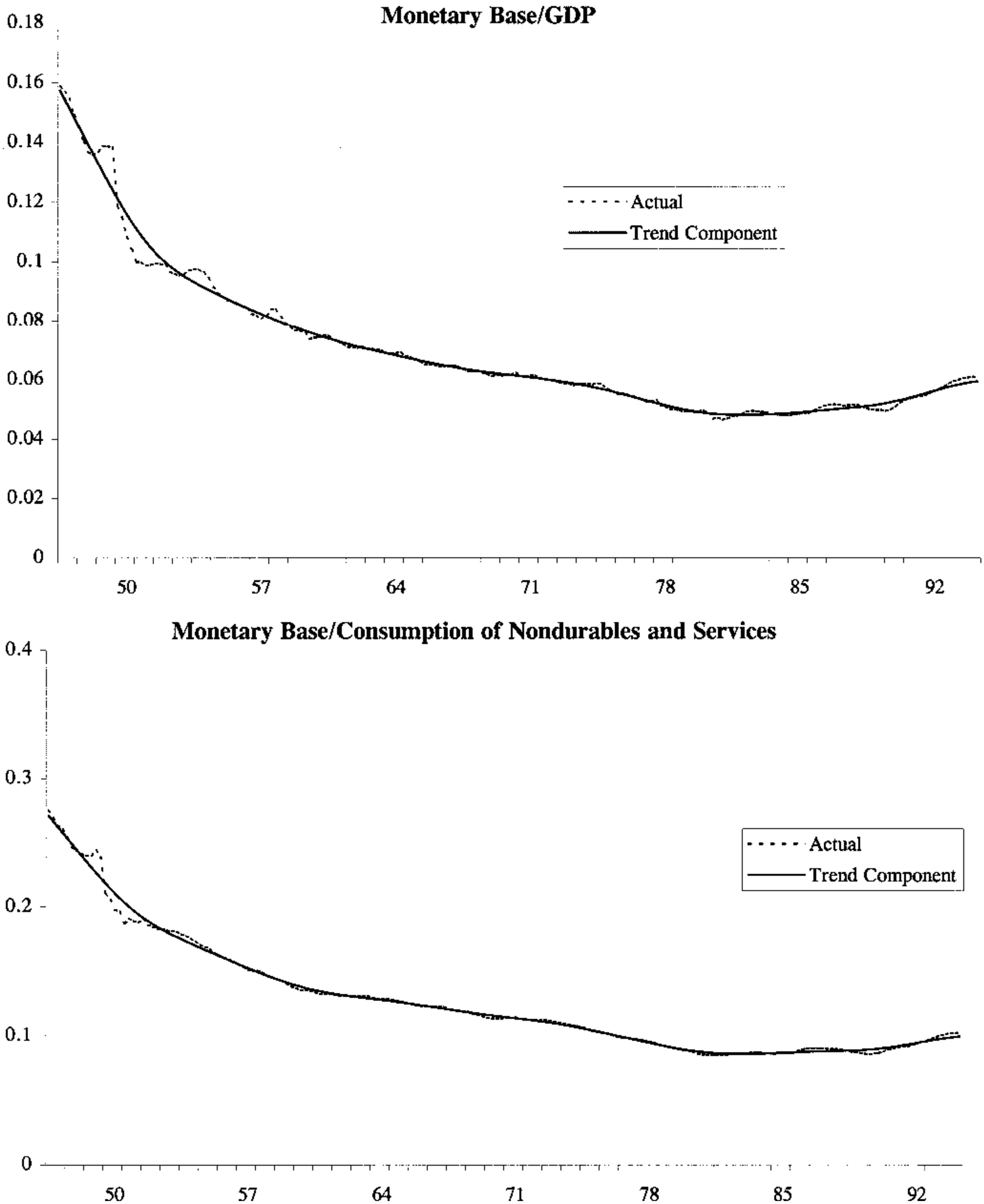
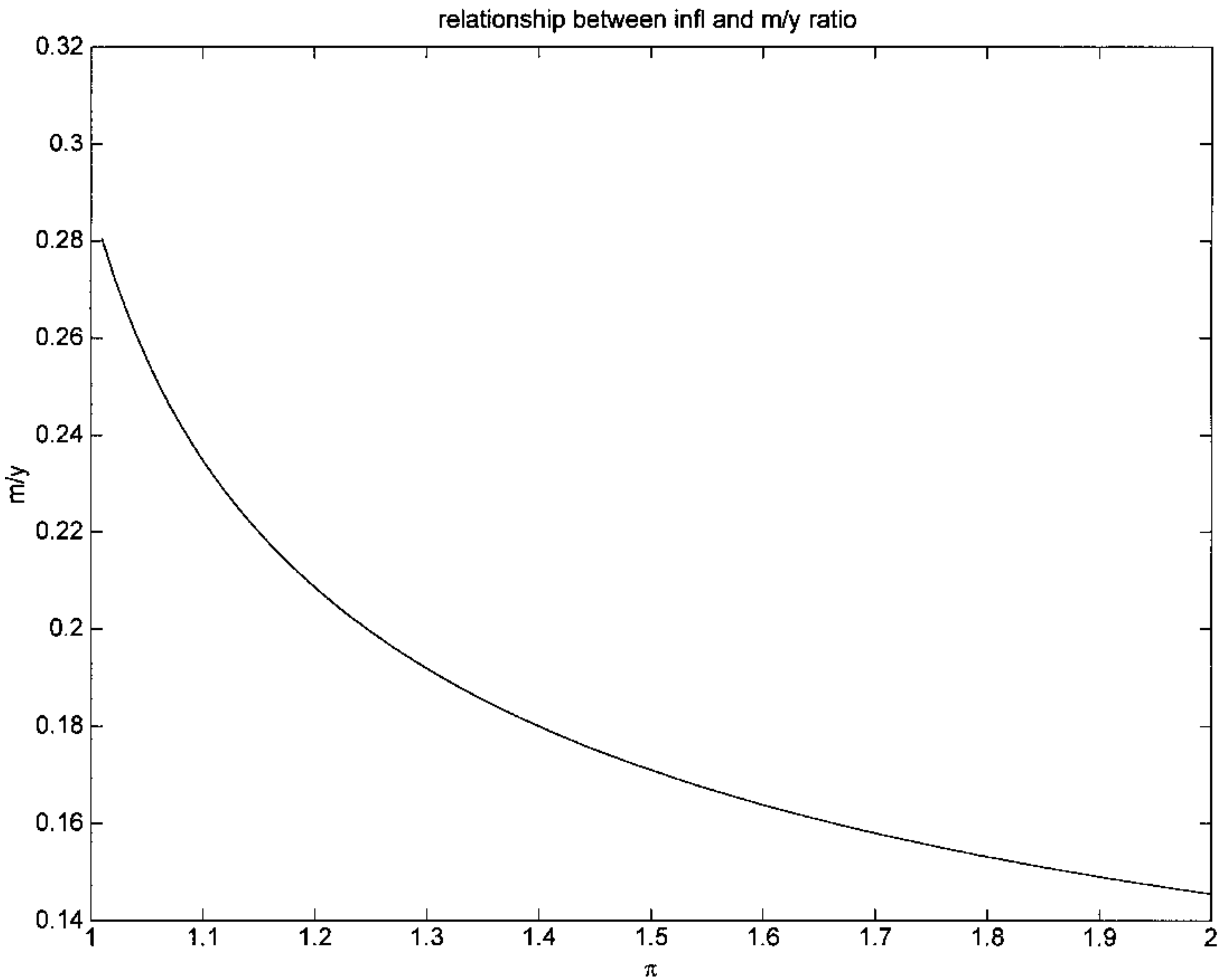
Figure 1



Monetary Base/GDP
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
50
57
64
71
78
85
92
Actual
Trend Component
Monetary Base/Consumption of Nondurables and Services
0.4
0.3
0.2
0.1
0
50
57
64
71
78
85
92
Actual
Trend Component

Figure 2



relationship between infl and m/y ratio
0.32
0.3
0.28
0.26
0.24
0.22
0.2
0.18
0.16
0.14
m/y
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
π

Figure 3

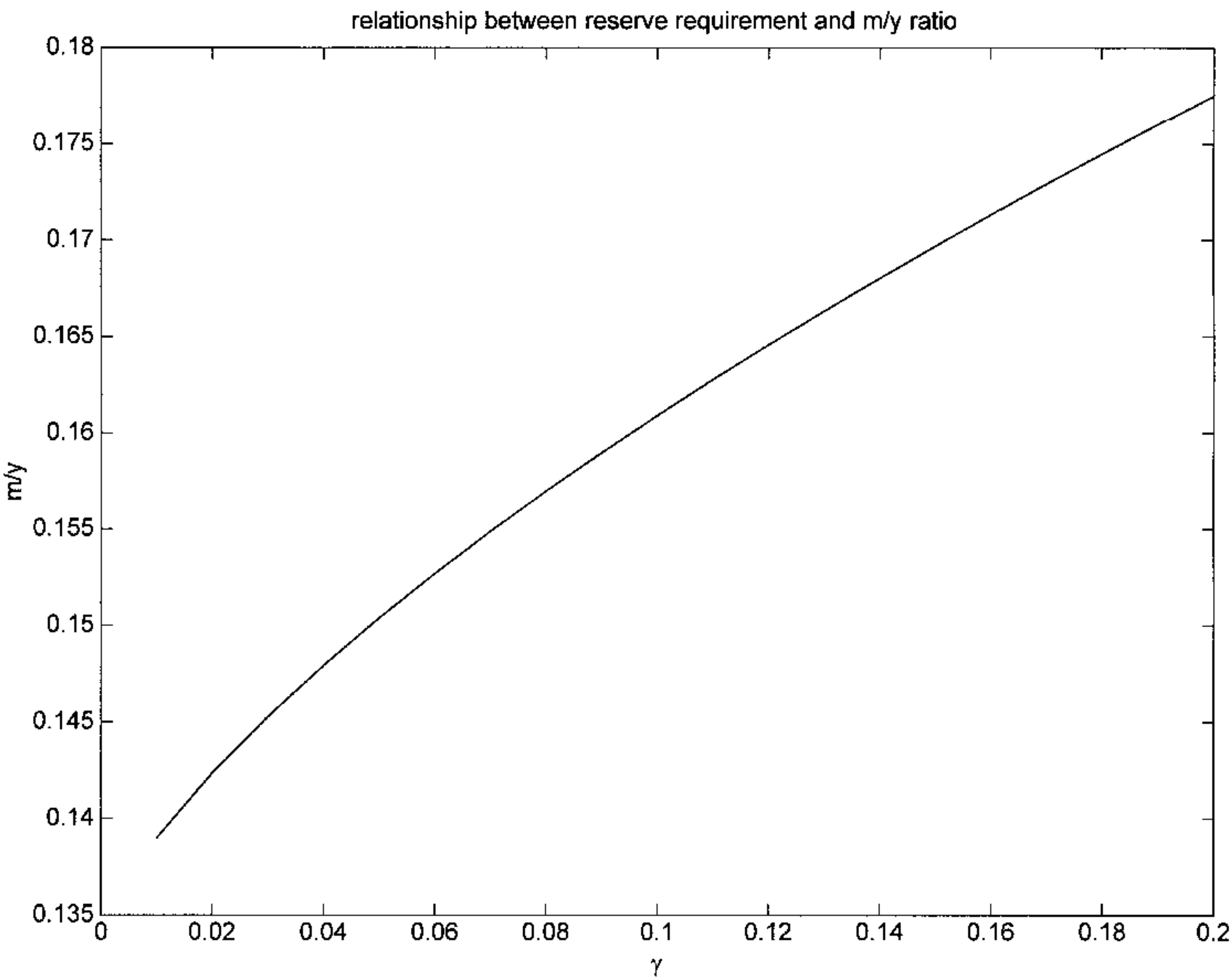

relationship between reserve requirement and m/y ratio
0.18
0.175
0.17
0.165
0.16
0.155
0.15
0.145
0.14
0.135
m/y
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
γ

Figure 4

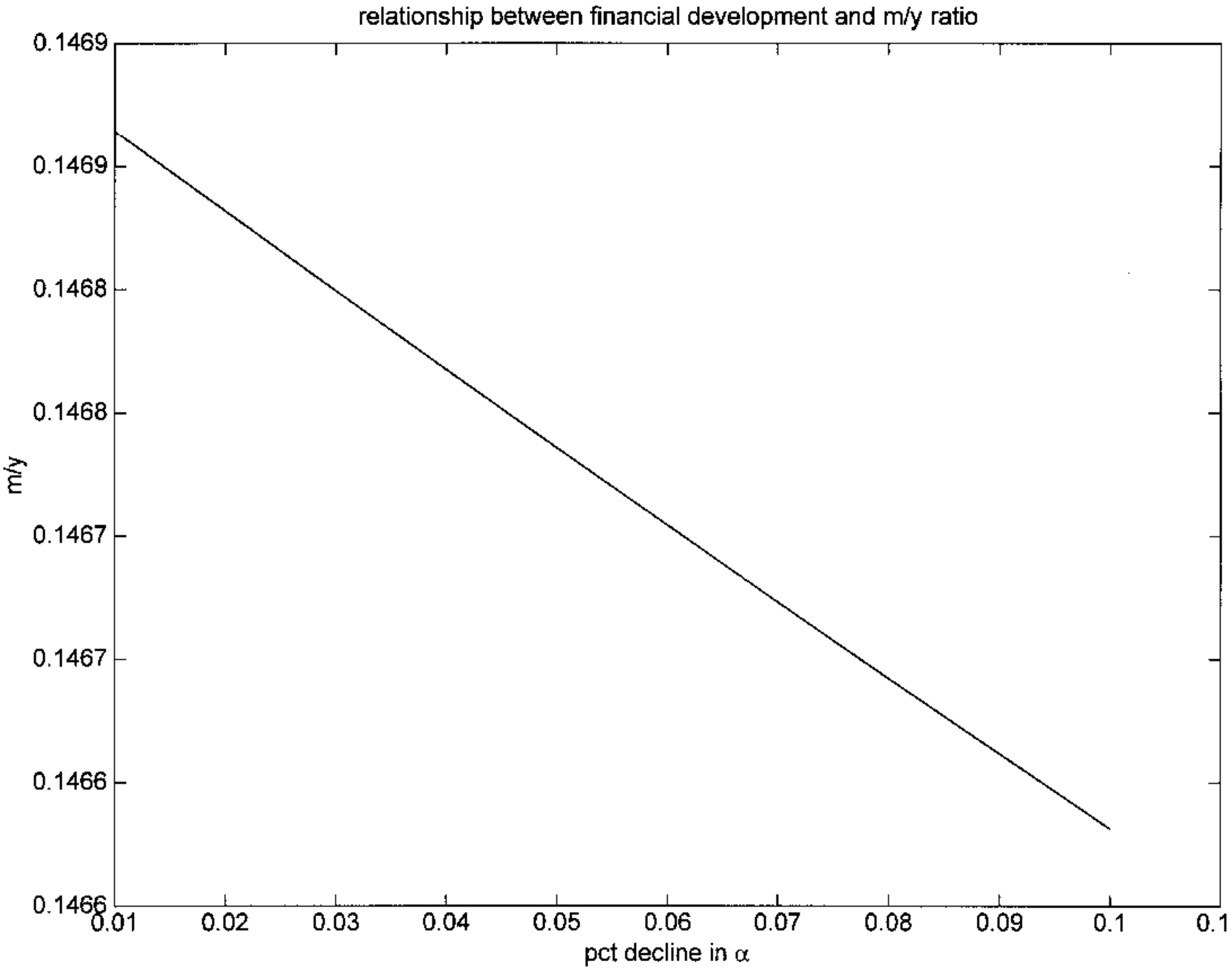
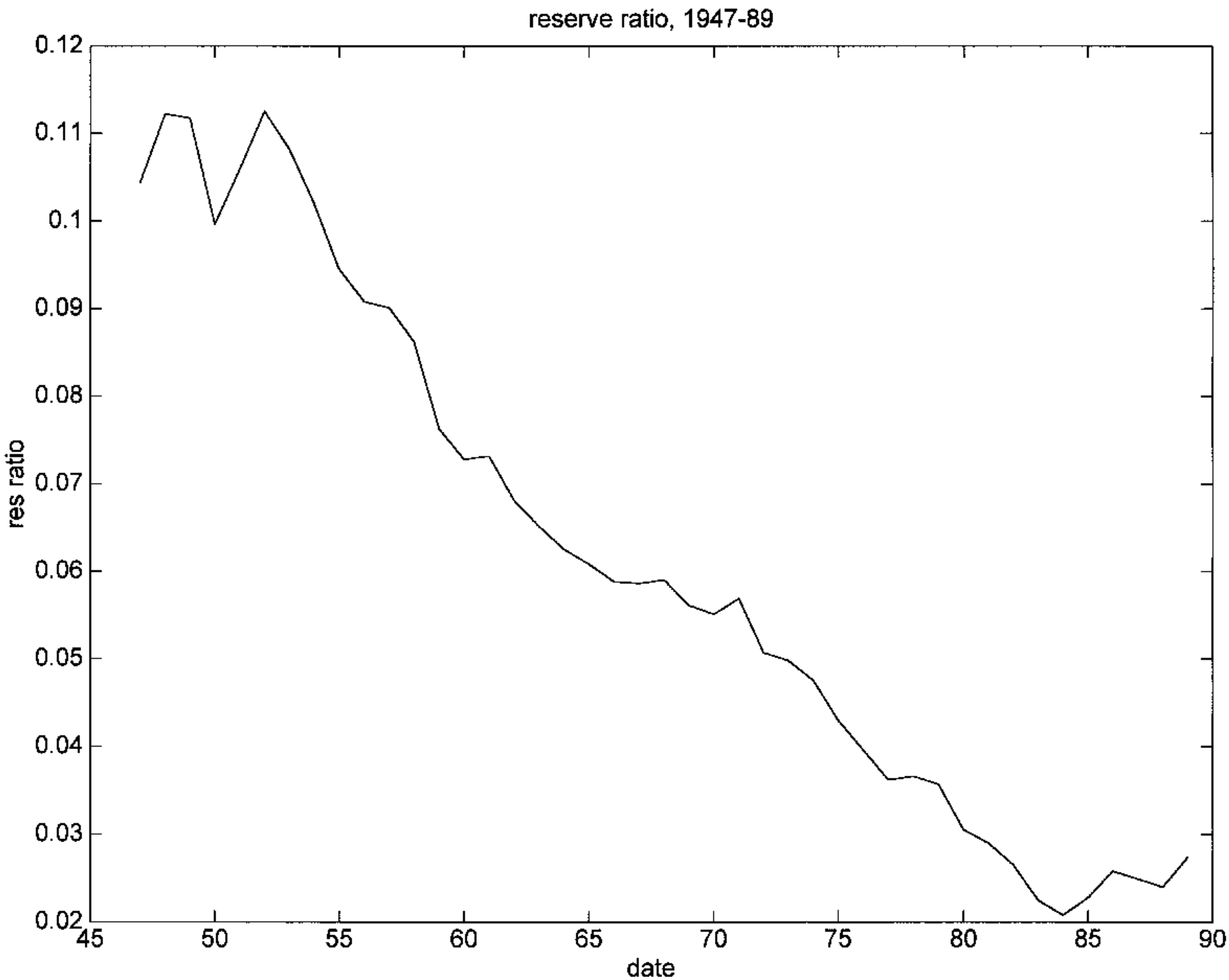

relationship between financial development and m/y ratio
0.1469
0.1469
0.1468
0.1468
0.1467
0.1467
0.1466
0.1466
m/y
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0.11
pct decline in α

Figure 5



reserve ratio, 1947-89
res ratio
date
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
45
50
55
60
65
70
75
80
85
90

Figure 6

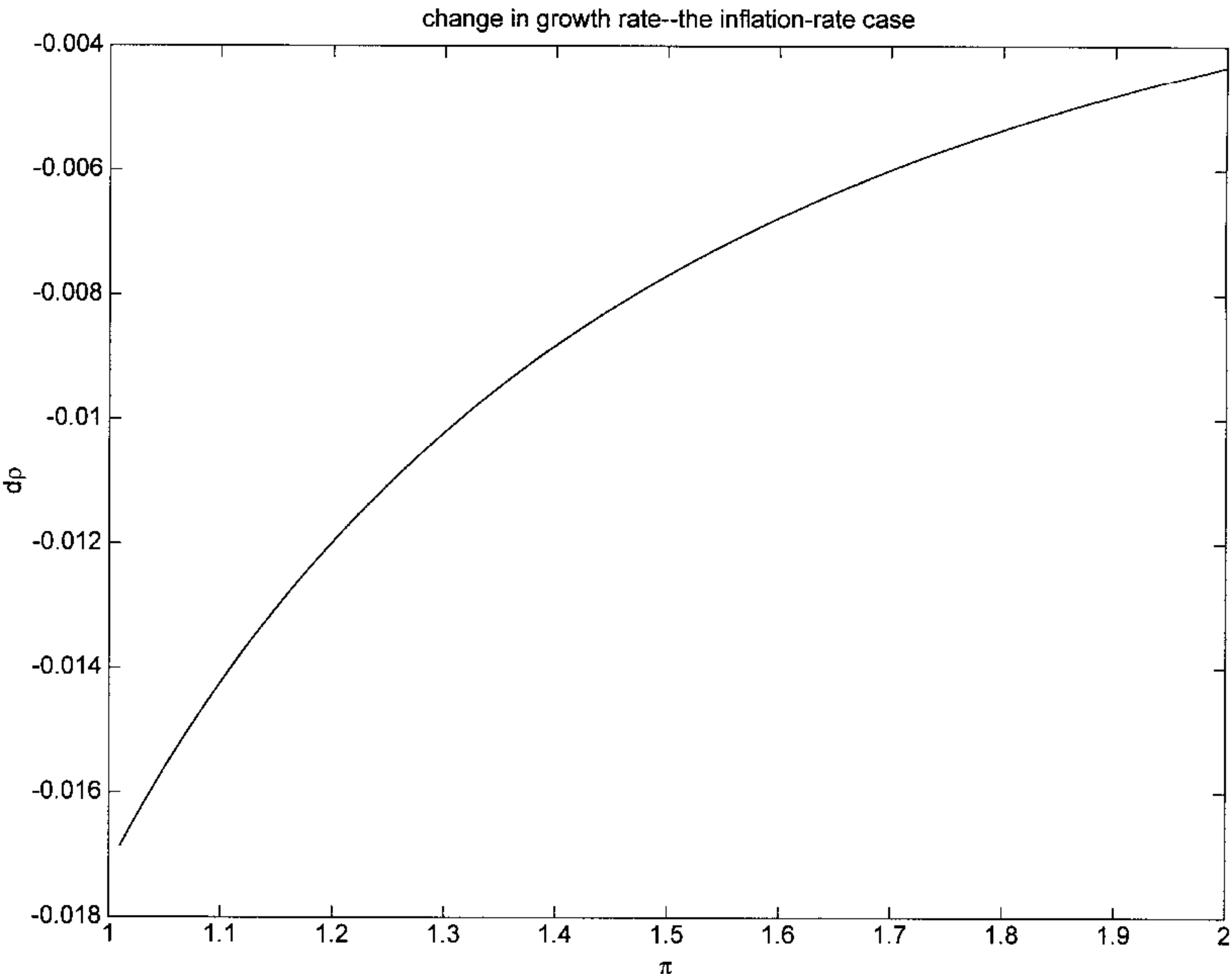
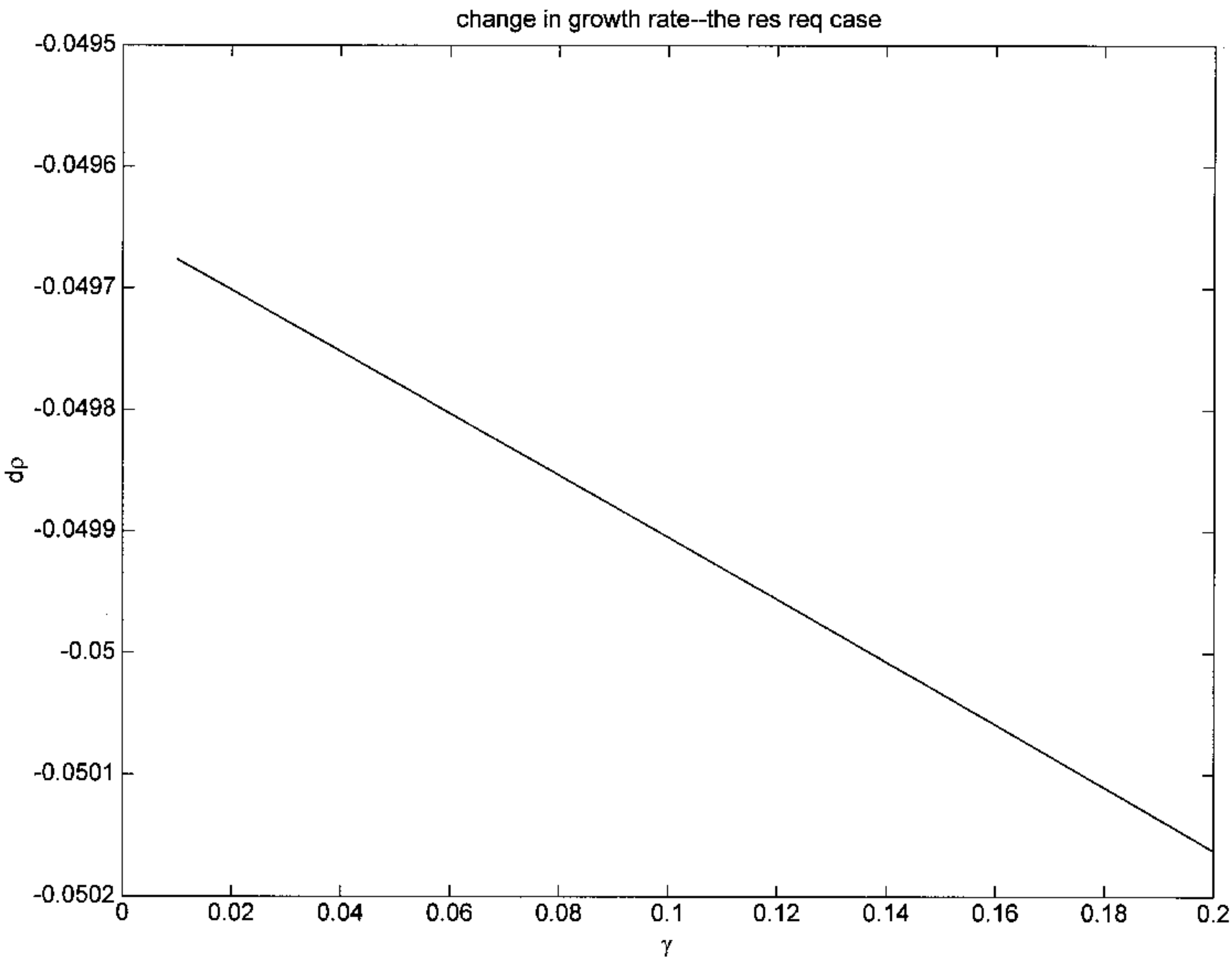
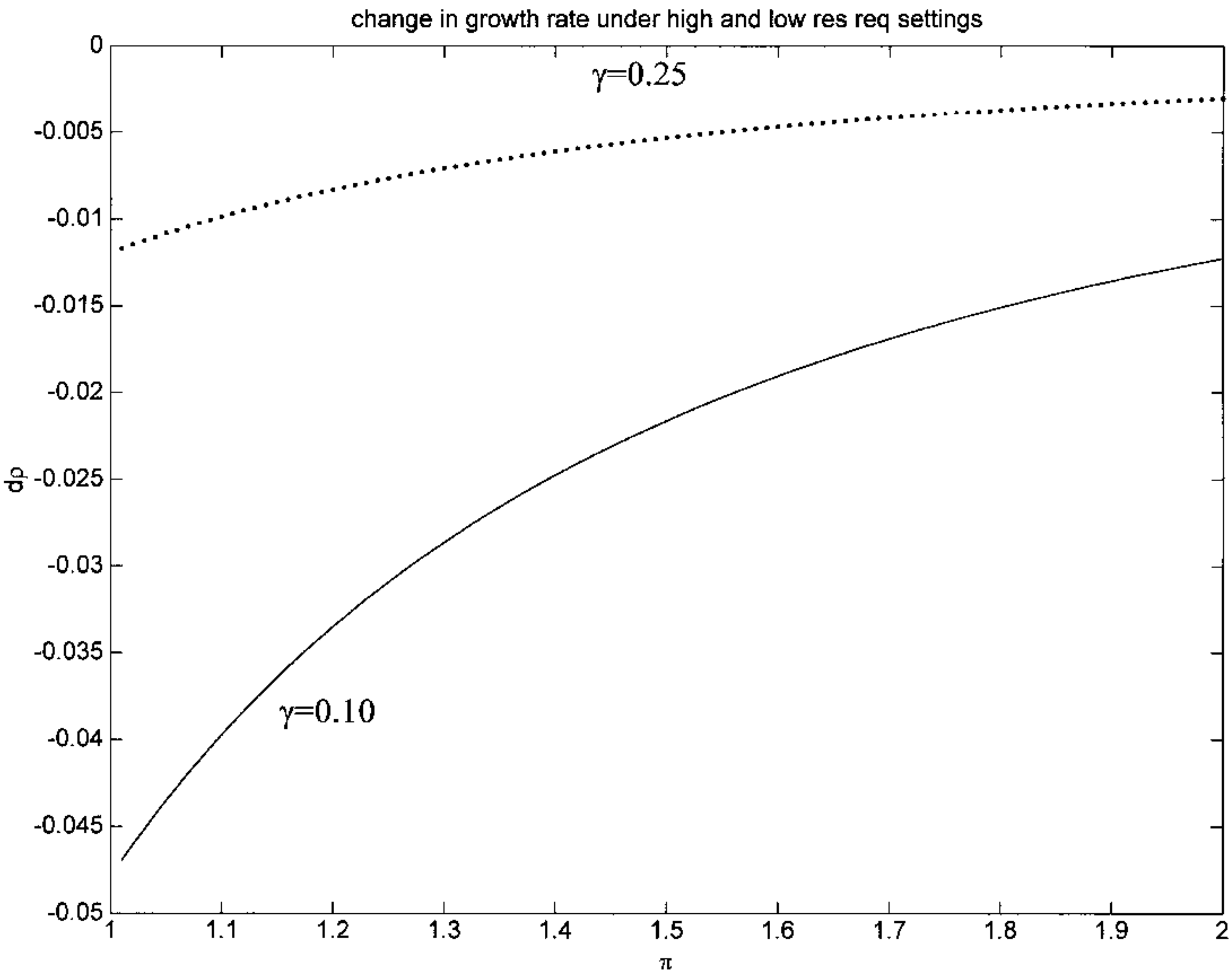

change in growth rate--the inflation-rate case
-0.004
-0.006
-0.008
-0.01
-0.012
-0.014
-0.016
-0.018
dρ
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
π

Figure 7



change in growth rate--the res req case
-0.0495
-0.0496
-0.0497
-0.0498
-0.0499
-0.05
-0.0501
-0.0502
dρ
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
γ

Figure 8


change in growth rate under high and low res req settings
γ=0.25
γ=0.10
dρ
π
0
-0.005
-0.01
-0.015
-0.02
-0.025
-0.03
-0.035
-0.04
-0.045
-0.05
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2