Journal of Economic Studies

The welfare effects of inflation and financial innovation in a model of economic growth: An Islamic perspective

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An Islamic perspective

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Keywords *Economics, Loss, Profit sharing, Inflation, Finance, Innovation*

Abstract *Constructs a simple neoclassical growth model in which financial factors play an important role. The model demonstrates that the injunction against fixed interest payments induces the monetary authority in the Islamic economy to develop and innovate alternative financial instruments that do not have fixed nominal values and do not bear predetermined rates of return. The model also proves that financial innovation is welfare enhancing, while inflation reduces welfare and hampers growth. The model further proves that the government in an Islamic economy can effectively coordinate its fiscal and monetary policies to finance the budget using the* Zakat *and seigniorage.*

Introduction

The Islamic injunction against fixed interest payments insinuates that most of the conventional monetary policy tools are not available to the monetary authority. Consequently, many important and tenacious questions remain unanswered. For example, what are the implications of the prohibition of charging of interest in the economy? How can the government commit to a sustainable rate of growth? What are the welfare costs of inflation? What are the effects of financial innovation? More importantly, what are the implications of fiscal and monetary policy on the rate of growth of the economy? In addition, what is the framework under which macroeconomic policies can be formulated to create a stable economic environment?[1]

To answer such questions, Islamic economists have advocated the replacement of the fixed rate of return (interest rate) by a variable rate of return based on a profit-loss sharing (PLS) system. Under such arrangements, the deposits in financial institutions receive share of the profits made by banks, while the loans extended have equity features. Critics of the Islamic model discern the difficulty of obtaining a rate of return in an economy based on PLS and the impact this rate has on resource mobilization. Specifically, they perceive that the ban against fixed-return securities may force the government to resort to the inflation tax to finance its deficit. Such policy, they envisioned,

An earlier draft of this paper was presented at The 4th Annual Conference of the Economic Research Forum/Arab Monetary Fund, Abu Dhabi, UAE, May 1996, and at The 2nd Harvard University Forum on Islamic Finance, Harvard University, Cambridge, Massachusetts, October 1998. The author thanks participants of both conferences, an anonymous referee, and the Editor of this Journal for their valuable comments. The usual caveat applies.

Journal of Economic Studies,
Vol. 29 No. 1, 2002, pp. 21-32.

DOI 10.1108/01443580210414094

would exacerbate high inflation and permit large-scale financial repression (see De Rosa, 1986; Pryor, 1985).

Proponents of the Islamic model, on the other hand, argue that the ban against fixed interest does not necessarily mean that the monetary authority in an Islamic economy is powerless. Although alternative instruments should be devised to conform to the Islamic ban on interest payments, the value and validity of monetary policy remain the same. In a model exemplifying the principal characteristics of an Islamic financial system, Khan and Mirakhor (1987), concluded that there were no fundamental differences between the conventional and the Islamic economic system in the way monetary policy affects economic variables. Meanwhile, the central bank would continue to control the supply of high-powered money, the reserve ratios on different types of liabilities, and exert substantial influence on the financial system. Using a portfolio selection model, Bashir and Darrat (1992) showed that the monetary authority can effectively use reserve requirements and profit-sharing ratio to direct monetary policy toward specific goals. Furthermore, Bashir and Darrat showed that changes in the reserve requirements are expansionary, while changes in the profit-sharing ratio are contractionary policies.

Indeed, the models formulated so far did not address a number of issues. First, Khan and Mirakhor did not examine how monetary policy stimulates economic growth. Second, they did not explain how the budget deficit is financed in the absence of fixed return securities. Third, the model did not address the role of *Zakat* in an Islamic economy[2]. On the other hand, the Bashir and Darrat model did not discuss the effects of monetary policy on growth or the deficit issue. The purpose of this paper is to fill some of the gaps not addressed by previous models. The model discussed here differs from the above-mentioned models in a number of ways. First, it investigates the relationship between money and growth in Islamic economics[3]. No previous study, to our knowledge, has done so. Second, it addresses the issue of public financing in Islamic economics. Third, it analyzes the welfare effects of inflation and financial innovation. The next section contains a general equilibrium model of growth with *Zakat* and profit sharing features. The monetary authority intervenes in the financial sector to allocate resources, while coordinating its fiscal and monetary policy to finance its budget. Financial institutions use capital-augmented technologies to transform resources into output. The following two sections investigate the welfare effects of financial innovation and inflation respectively. The main result here is that, at a given level of capital stock, financial innovation improves welfare, while inflation reduces both long-run growth and welfare. The final section concludes the study.

The model

We begin with an economy inhabited by infinitely lived identical agents, financial institutions known as banks (firms) and the government (monetary authority). Agents, who are endowed with capital at the beginning of their lives, derive utility from consumption and real money balances, and can hold their savings in terms of deposits or real balances[4]. All deposits are PLS that do not guarantee a fixed return, nor do banks guarantee the nominal value of these deposits. Each bank has access to an investment project, which requires specialized evaluation and monitoring technology with a large fixed cost. The government issues and distributes high-powered money at the beginning of the period, and usually intervenes in the market to direct monetary policy toward specific goals. Specifically, the monetary authority alters the profit-sharing ratios between banks and their depositors, as well as the reserve ratios on PLS deposits (Khan and Mirakhor, 1987). We assume that the marginal utility of money is decreasing in the level of government intervention in the financial markets. Building on Sidrauski (1967), and closely following Roubini and Sala-i-Martin (1992), preferences are modeled over per capita consumption and real balances by:

$$U = \int_0^\infty e^{-(\rho-n)t} u(c_t, m_t) dt \tag{1}$$

where $\rho > 0$ is the rate of time preference, and n is the exogenous rate of growth of population.

Both consumption and real balances are assumed to be normal goods and so the per capita utility function $u(c_t, m_t)$ is strictly concave. To achieve a closed form solution, we assume that the utility function is separable in consumption and real money balances:

$$u(c_t, m_t) = \alpha \ln c_t + \beta(\theta) \ln m_t \tag{2}$$

where θ, $0 < \theta < 1$ is a policy variable (e.g. profit-sharing ratios between the financial institution and its depositors), while α and β are elasticities of consumption and money respectively. $\beta'(\theta) < 0$ indicates that higher values for θ reduce the marginal utility of holding money[5]. We assume that the monetary authority alters θ, a monetary policy tool, to allocate resources in the economy. Strict regulation of the financial system will give the monetary authority a better control over the money supply. Since the policy variable θ represents an instrument by which the government can regulate the financial system, then, without loss of generality, θ becomes an index of how an individual can be induced to invest (Persson and Tabellini, 1991)[6]. Denoting household wealth as $K + M/P$, consumers are assumed to maximize the lifetime utility function, Equation (1), subject to the budget constraint:

$$\dot{K} + \frac{\dot{M}}{P} = [(1 + r - z)]K - C \tag{3}$$

where K is capital (PLS deposits), M is money stock, P is the price level, and N is the total number of persons in the economy. The rate of return per unit of investment r (defined below) is endogenously determined, and z is the rate of

Zakat on capital[7]. Because the economy may be growing over time, it is convenient to focus on capital stock per person $k = \frac{K}{N}$ rather than the capital stock, K.

Rewriting Equation (3) in per capita terms, we have:

$$\frac{K}{N} + \frac{M}{NP} = k + nk + m + mn + \pi m = (1 + r - z)k - c. \quad (4)$$

Equation (4) states that per capita saving equals per capita investment plus money accumulation. Note that the households can hold either money or capital (deposits at banks and capital are the same) or both. Denoting the per capita asset-holding by $x_t = k_t + m_t$, the budget constraint, Equation (3) can be rewritten in terms of an asset accumulation equation of the form:

$$\dot{x}_t = [(1 + r - z) - n]x_t - R_t m_t - c_t \quad (5)$$

where $R_t = (1 + r - z) + \pi$ is the nominal rate of return per unit of investment, π is the inflation rate, x_t is assets per person, n is the growth rate of population, m_t is per capita real balances, and the dot denotes the time derivative[8]. Equation (5) is the key equation of the Solow model. It gives the rate of change of total wealth per capita as the difference between income and consumption, where consumption is now the sum of two terms, c and $R_t m_t$. The last term ($R_t m_t$) equals the rate of return forgone by holding money instead of PLS deposits. Since it is equal to the nominal rate of return times real money balances, it therefore measures the implicit consumption of money services (Blanchard and Fischer, 1996). The maximization problem is now given by the current value Hamiltonian:

$$H = e^{-(\rho+n)t}[\alpha \ln c + \beta(\theta) \ln m] + \lambda_t[(1 + r - z)x - nx - c - Rm]. \quad (6)$$

The optimal allocation optimizes Equation (6) at each date t, provided that the implicit price λ_t is correctly chosen. Maximizing with respect to c_t and m_t Equation (6) gives the money demand function:

$$m_t^d = \frac{\beta(\theta)\, c_t}{\alpha R_t}. \quad (7)$$

The money demand function depends negatively on the nominal rate of return (i.e. the opportunity cost of holding money), and positively on the level of per capita consumption. The accumulation Equation (5) and the first order conditions imply that the per capita rate of growth of consumption equals

$$\gamma_c = \frac{\dot{c}}{c} = (1 + r - z) - \rho. \quad (8)$$

The first term in the right-hand side of Equation (8) is the after *Zakat* (real) rate of return of investment, while the second term is the rate of time preference. Given z and assuming a certain parameter value for ρ, θ can be chosen such that $\gamma_c > 0$, indicating that sustained per capita growth is feasible. The striking aspect of Equation (8) is that consumption growth does not depend on the stock of asset holding, x. If the level of consumption per capita at time 0 is c (0), then consumption per capita at time t is $c(t) = c(0)e^{((1+r)(1+z)-\rho)t}$.

On the other hand, the rate of growth of the money supply is defined as:

$$\gamma_m = \frac{\dot{m}}{m} = (1 + r - z) - \rho - \frac{\dot{R}}{R} = \gamma_c - \gamma_R. \tag{9}$$

Equation (9) indicates that the rate of growth of consumption is equal to the rate of growth of the money stock plus the rate of growth of profits, i.e. $\gamma_c = \gamma_m + \gamma_R$. In general, r is variable and so is Π^*, the level of profit in the economy. However, competition between firms and the government control over θ will tend to equalize profits and rates of return across firms. Only then would the nominal rate of return be constant. A necessary condition for balanced growth is that the rate of growth consumption and money growth rate will be equalized, i.e. $\gamma_c = \gamma_m = \gamma$.

The firm

To close the model and capture some stylized facts about banks' behavior, we introduce banks into the model. We assume that banks operate production technologies that are linear in a broad measure of capital, i.e. include physical and human capital (Barro, 1991). Although there might be decreasing returns in either type of capital when applied separately, constant returns will persist when both types of capital are applied together (see Ireland, 1994). To achieve tractability, we assume that the following process governs production:

$$y = \frac{Y}{N} = F\left(\theta, \frac{K}{N}\right) = \phi(\theta)k \tag{10}$$

where Y is the level of output, and $\phi(\theta)$ is an intermediation technology (or the state of knowledge)[9]. The intermediation technology is increasing in the profit sharing ratio, i.e. $\phi'(\theta) > 0$. The linearity of the production function in Equation (10) is rationalized by the fact that K is regarded as a composite of human capital, knowledge, public infrastructure, and so on. Under such conditions, a constant rate of investment can result in an ever-growing capital stock, and thus steady-state growth. Hence, any policy that raises saving would be sufficient to raise the rate of growth. This certainly rationalizes government intervention in the production process to raise the marginal product of private capital. There are assumed here only government actions that influence private production and enhance property rights (i.e. enforcing the Islamic laws of contracts).

To show that the model has no transitional dynamics, it suffices to show that the growth rates γ_m and γ_y are constant and equal the growth rate γ_c shown in Equation (8). Since $y = \phi(\theta)k$, it follows that $\gamma_y = \gamma_k = \gamma_c = \gamma$. Thus the variables k (t), c (t), and y (t) begin at the values k (0), c (0), and y (0) respectively, where $y(0) = \phi(\theta)$k (0). Hence, all three variables grow at the constant rate $(1 + r)(1 + z) - \rho$.

Equation (8) above reveals an important result of the endogenous growth model. The long-run growth rate is determined by the parameters that determine saving and investment decisions of private agents or, equivalently, by factors that influence saving and investment (see Barro, 1991). These include the rate of return on investment (or equivalently the profit sharing ratio θ) and the *Zakat* rate. A higher value of θ, which raises the willingness to save, implies a higher rate of return, r, and higher per capita growth rate. Alternatively, higher profit-sharing ratios offered to the customers (depositors) will enable the banks to mobilize more funds. The more funds they mobilize, the more they invest on R&D, and the more intermediation knowledge and techniques they acquire. If this learning process spills over in the economy, banks will be able to collect and analyze information that will allow investors' resources to flow to their most profitable uses. The high incomes generated through risk pooling and efficient resource allocation will feed back and promote economic growth. In an equilibrium with an active R&D activity, the expected rate of return for R&D must reflect the opportunity cost of capital (see Grossman and Helpman, 1990). If we assume that the rate of depreciation of capital is zero, then profit maximization will yield the usual condition equating marginal productivity to the rate of return of capital:

$$1 + r - z = \phi(\theta). \tag{11}$$

Substituting Equation (11) in Equation (9) yields:

$$\gamma = \phi(\theta) - \rho. \tag{12}$$

Equation (12) implies the superneutrality result derived by Sidrauski (1967). Furthermore, Equation (12) shows that changes in the policy variable θ can permanently increase the rate of growth of the economy. That is, a higher sharing ratio and/or an improvement in the level of financial innovation will raise average and marginal productivity of capital and also raises the growth rate of the economy.

The monetary authority

To make sure that the government has a role to play, we assume that the monetary authority controls the supply of high-powered money by setting the nominal rate of growth of the money supply $\mu = \frac{\dot{M}}{M}$, and follows a time-consistent monetary policy that prevents price-level jumps.

The monetary authority relies on two revenue sources to finance its expenditures, seigniorage and *Zakat* revenue. The consolidated government budget constraint is $g_t = \frac{\dot{M}}{P} + Z$, where $\frac{\dot{M}}{P}$ is the revenue from seigniorage and $Z = (1 + r - z)k$, the proceeds from *Zakat*. Since the issuing of interest-bearing securities is not allowed, and no transfers are assumed, the government's budget constraint can be rewritten as:

$$g_t = \dot{m} + m(\Pi + n) + (1 + r - z)k. \tag{13}$$

Rearranging and using the agent's budget constraint (5) and the government's budget Equation (13), the Equation for capital accumulation can be written as:

$$\dot{k} = (\phi(\theta) - n)k - c - g. \tag{14}$$

Note that we are assuming that there is no depreciation, break-even investment is nk, and actual investment is $\phi(\theta)k - c - g$. That is, capital stock accumulates, as the difference between net per capita real output and private and public consumption gets larger (i.e. the larger the saving). Given the government budget constraint (13), Equation (14) shows that the rate of capital accumulation varies with the rate of inflation. Specifically, it shows that inflation would slow the rate of capital accumulation. Using the nominal rate of growth of money supply $\mu = \frac{\dot{M}}{M}$, and substituting for the per capita demand for real balances, the government budget Equation becomes:

$$g_t = \frac{\beta(\theta)\, c_t}{\alpha R_t} \mu + \phi(\theta) z k_t. \tag{15}$$

Substituting Equation (8) in Equation (15) reduces the budget equation to $gt = m_t\mu + \phi(\theta)zk_t$. The first term in the right-hand side of Equation (15) shows the amount of seigniorage that the government can collect from inflation tax, which equals the consumer's cost of holding money. The second term in Equation (15) is the proceeds from imposing *Zakat* on output. The results further show that, by adhering to the optimum quantity of money rule, the government can raise the revenue it requires at a lower tax rate. When the government adopts the optimum quantity of money rule, it can with any combination of monetary and fiscal policies satisfy its budget constraint. This is possible if θ is chosen such that the expected revenue is equal to the expected expenditure[10]. However, given the marginal utility of holding money, any government action to increase θ would decrease the demand for real money balances and reduce the revenue collected from inflation tax. On the other hand, since the revenue generated from *Zakat* is increasing in income, any government action to reduce θ (i.e. the profit-sharing ratios) would decrease output and, hence, the *Zakat* revenue. Thus, a trade-off exists between the welfare cost of inflation and the welfare cost that can be ascribed to decreasing income. To balance these two effects out, the monetary authority should adjust its instrument to control the amount of revenue generated from both sources.

The welfare effects of financial innovation

This section analyzes the welfare effects of varying θ on consumption, money demand, and government spending at the steady state equilibrium. As shown by De Gregorio (1991), there are multiple equilibrium paths for such an economy, but the only (Bubleless) equilibrium is where $k = 0$. Then, for a given k, the steady-state level of consumption is given by:

$$c = (\phi(\theta) - n)k - g. \tag{16}$$

Equations (8), (15) and (16) will characterize the steady state general equilibrium. In particular, the goods market equilibrium requires $c + g = y - nk$, where nk is the amount of capital needed for the new generation. The asset market equilibrium has already been implicitly assumed in the preceding discussion. Since the economy is always in the steady state and both c and m enter the utility function, we need to analyze the effects of θ on both consumption and real balances in order to understand its effects (θs) on welfare.

P1. For a given capital stock and inflation, the welfare effect of increasing θ on consumption is positive.

Proof: see Appendix 1.

That is, other things being equal, an increase in θ will increase welfare.

The effects of increasing θ on money demand are apparent from the following equation:

$$\frac{\partial m}{\partial \theta} = \frac{1}{(1 + \frac{\mu\beta}{\alpha R})}\left[\frac{\beta' m}{\beta} - (1-z)\mu\phi'\frac{m}{R} + \frac{\beta}{\alpha R}(1-z)\phi' k\right]. \tag{17}$$

The first two terms in square brackets on the right-hand side of Equation (17) are negative, while the third term is positive, indicating the ambiguous effect of θ on money demand.

P2. For a given level of consumption c, increases in θ reduce the demand for real balances.

Proof: Straightforward from Appendix 1.

The intuition here is that an increase in θ is interpreted as financial innovation, which allows people to require lower money balances to carry the same amount of transactions.

P3. Given the steady state levels of consumption and capital stock, increasing θ has an ambiguous effect on g.

Proof. Assuming a given k, then from Equation (15) we have:

$$\frac{\partial g}{\partial \theta} = \mu\frac{\partial m}{\partial \theta} + \phi'(\theta)zk. \tag{18}$$

Given c, the first term on the right-hand side of Equation (18) reduces to $\mu[(\beta'\beta)\ m - (1-z)\phi' m/R] < 0$. Since $\phi'(\theta) > 0$, the second term is positive. The overall effect of θ on g depends on whether the decline on seigniorage dominates the increase in *Zakat* revenue. A government that prefers levying an inflation tax (to finance its deficit) will increase the per capita demand for money by reducing θ, thus reducing the incentives to invest (i.e. hold a PLS deposit). Such behavior will certainly reduce the level of output and hence hampers growth. Moreover, since the economy will grow at a lower rate, both the revenue from *Zakat* and the revenue from money creation will decline. In contrast, a forward-looking government will increase θ to mobilize more resources and increase the level of income. By doing so, it can lure the nonproductive resources to the financial system and promote growth. In short, one would say that a government that prefers to collect inflation tax to finance its deficit would tend to reduce the profit-sharing ratio, and hence depresses the incentives to hold PLS deposits. Financial institutions would then spend less in R&D activities and become less innovative in attracting and disposing of funds. Since holding money is a close substitute for holding PLS deposits, the per capita demand for money increases. Such behavior will be inflationary, and eventually hampers growth.

The welfare effects of inflation

To investigate the welfare costs of inflation, we need first to characterize the effect of inflation on the policy variable θ. Note that the steady state Equation (7) can be rewritten as a function of θ and π. Specifically, $\beta(\theta)c/\alpha m = R^*$, where R^* is the optimal rate defined above.

P4. For a given nominal rate of return R, an increase in the rate of inflation reduces θ.

Proof. Rewriting the steady-state Equation (7) and differentiating with respect to π we get:

$$\frac{d\theta}{d\pi} = \frac{1}{\frac{\beta'}{\beta}R^* - \phi'(\theta)(1-z)}. \tag{19}$$

The right-hand side of Equation (19) is negative (since $\beta' < 0$ and $\phi' > 0$). This result indicates that inflation is harmful to innovation and/or to government regulation, since it adversely affects θ.

The next step is to use this result to investigate the effects of inflation on consumption, money demand, government spending and growth. To do this, we use equilibrium equation (7) and the following propositions:

P5. (i) For a given capital stock, inflation affects consumption negatively.
(ii) For a given capital stock, increases in the rate of inflation affect money demand negatively.

Proof: See Appendix 2.

The utility function $u(c, m)$ can now be used to show how higher rates of inflation reduce consumers' welfare. To see this, note that $\frac{\partial u}{\partial \pi} = u_c \frac{\partial c}{\partial \pi} + u_m \frac{\partial m}{\partial \pi}$ < 0, since, and $\frac{\partial m}{\partial \pi} < 0$.

P6. Given the levels of consumption, real money balances and capital stock, higher inflation rates reduce growth.

Proof. Differentiating Equation (12) with respect to π to get

$$\frac{\partial \gamma}{\partial \pi} = \phi'(1-z)\frac{d\theta}{d\pi}. \tag{20}$$

Using Equation (19) and $\phi'(\theta) > 0$ proves the result.

This result shows the traditional trade-off between inflation and output growth. More specifically, policy measures that are set to finance government spending by seigniorage may end up hampering growth. Countries that use seigniorage to finance their deficits have no easy job of targeting output growth and financing government spending, using inflation tax at the same time.

Concluding remarks

We have constructed a simple neoclassical growth model in which financial factors play an important role. The model demonstrates that the injunction against fixed interest payments induces the monetary authority in the Islamic economy to develop and innovate alternative financial instruments that do not have fixed nominal values and do not bear predetermined rates of return[11]. The model also proves that financial innovation is welfare enhancing, while inflation reduces welfare and hampers growth. Furthermore, our model proves that the government in an Islamic economy can effectively implement fiscal policy using the *Zakat*. The fact that the *Zakat* rate is fixed reduces the distortion created by variations in the tax rate[12]. Revenues from *Zakat* and from money creation can be used to finance public sector programs and/or finance the budget deficit. To boost growth, monetary and fiscal policies should be closely coordinated. However, our model is a special case, since it assumes a pure profit-sharing environment. Our model would probably work better as a description of a smaller, closed economy. The conclusions should, therefore, be interpreted carefully.

Notes

1. See the *Proceedings* of "Policies for long-run economic growth", a symposium sponsored by The Federal Reserve Bank of Kansas City, Jackson Hole, WY, 1992.
2. *Zakat* is a 2.5 per cent annual wealth tax paid on non-working capital, profits, saving, and all types of wealth in excess of an exempt minimum known as *Nisab*. Although *Zakat* is supposed to be given to a designated group in the society, it can also be spent in public programs.
3. See Arif (1982): *Monetary and Fiscal Economics of Islam*, and the papers cited there.
4. Real balances enter the utility function, because money reduces transaction costs.
5. If θ is interpreted as reserve ratio against bank deposits, then $\beta'(\theta) > 0$.
6. Although many Islamic economists argue against the legality of holding reserves against PLS deposits, we are assuming here that banks are required to keep reserves with the central banks for regulatory purposes. Since these reserves are guaranteed, the central bank can invest these resources on the basis of PLS and later uses its discretion to remunerate the banks owning these reserves. Alternatively, we can think of these reserves as "permits" which are required to be held by each bank in order to accept a unit of capital in real terms (see Bashir and Darrat, 1992).
7. The rate of return per unit invested is calculated using the formula $r = \theta(F(K^*) - K^*)/K^* = \theta\Pi^*/K^*$, where K^* is the optimal level of investment, and $\Pi^* = F(K^*) - K^*$ is the optimal profit at that level of investment.
8. We assume perfect foresight equilibrium paths where $\frac{\dot{p}}{p} = \pi$. On such paths, the expected and the actual inflation rates coincide.

9. The knowledge here is about financial intermediation techniques, which accumulates as a by-product of government intervention to correct market imperfections (effective enforcement of contractual agreements), or by private firms investing in R&D to introduce new mechanisms to raise and disperse funds (see Grossman and Helpman, 1990; Romer, 1990).
10. The budget deficit is equal to the difference between real government expenditures and real *Zakat* revenue at time *t*.
11. The monetary policy tools available to the monetary authority in an Islamic economy include the reserve ratio against bank deposits, and the profit-sharing ratios between banks and their depositors and/or borrowers (Khan and Mirakhor, 1987). Variations in these rates will enable the monetary authority to control the amount of funds channeled into the investment process. The central bank in an Islamic economy can also issue and regulate high-powered money.
12. King *et al.* (1988) showed that raising income tax rate from 20 per cent to 30 per cent results in welfare loss in excess of 60 per cent of consumption.

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Appendix 1. Proof of *P1*

Differentiating Equations (15), (14), and (6) with respect to θ:

$$\frac{\partial c}{\partial \theta} = \phi'(\theta)k + (\phi(\theta) - n)\frac{\partial k}{\partial \theta} - \frac{\partial g}{\partial \theta} \tag{A1}$$

$$\frac{\partial g}{\partial \theta} = \mu\frac{\partial m}{\partial \theta} + \phi\_(\theta)zk + \phi(\theta)z\frac{\partial k}{\partial \theta} \tag{A2}$$

$$\frac{\partial m}{\partial \theta} = \frac{\beta'(\theta)}{\beta}m + \frac{\beta(\theta)}{\alpha R}\frac{\partial c}{\partial \theta} - \frac{\beta c}{\alpha R^{*2}}\frac{\partial R^*}{\partial \theta} \tag{A3}$$

where $R^* = \phi(\theta)(1-z)+\pi$ is the optimal nominal rate of return per unit of investment. Assuming that the government will choose θ to determine the optimal demand for real balances, Equation (A3) can be rewritten as:

$$\frac{\partial m}{\partial \theta}\frac{\theta}{m} = \frac{\theta}{m}\left[\frac{\beta'}{\beta}m + \frac{m}{c}\frac{\partial c}{\partial \theta} - \frac{m^*}{R}\frac{\partial R^*}{\partial \theta}\right]. \tag{A3$'$}$$

The expression in (A3) reduces to $\eta_{m\theta} = \eta_{\beta\theta} + \eta_{c\theta} - \eta_{R^*\theta}$, which are gross elasticities that take into account the total effect of changing θ on the demand for real balances.

Substitute Equations (A1) and (A2) in Equation (A3) to get:

$$\frac{\partial c}{\partial \theta} = \left(\frac{1}{1+\frac{\mu\beta}{\alpha R}}\right)\left[(1-z)\phi'k + \frac{(1-z)\mu\phi' m}{R} - \frac{\beta'(\theta)m}{\beta}\right]. \tag{A4}$$

Given the assumptions on the marginal productivity of capital and the marginal utility of holding money, the right-hand side of Equation (A4) indicates the positive externalities of increasing θ.

Appendix 2. Proof of *P5*

- Differentiating the steady state Equations (7), (15), and (16) and using the envelope theorem:

$$\frac{\partial c}{\partial \Pi} = \left(\frac{1}{1+\mu\beta/\alpha R}\right)\left[\left(\phi' k(1-z) - \mu\beta'\frac{m}{\beta}\right) + \mu\phi'\left(1-z\right)\frac{m}{R}\right]\frac{d\theta}{d\Pi}. \tag{B1}$$

  Using Equation (19), and the fact that $(\mu\beta' m/\beta) < 0$ proves the result. The model also predicts an inverse relationship between inflation and output, as can be seen from production function (10) and Equation (19).

- Differentiating Equation (7) with respect to π we get:

$$\frac{\partial m}{\partial \Pi} = \left[\frac{\beta' c}{\alpha m}\frac{m}{R} - \phi'(1-z)\frac{m}{R}\right]\frac{d\theta}{d\Pi} + \frac{\beta}{\alpha R}\frac{\partial c}{\partial \Pi} - \frac{m}{R}. \tag{B2}$$

Given Equation (23), the first term in Equation (B2) (in the square brackets) and the third term cancel out. Applying Equation (B1) proves the negative effects of inflation on the demand for real balances.

This article has been cited by:

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