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ENDOGENOUS DEBT-EQUITY RATIO AND BALANCE-SHEET CHANNEL: IMPLICATIONS FOR GROWTH AND WELFARE

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ABSTRACT

This paper endogenizes the debt-equity ratio and embodies financial leverage in a cash-in-advance model of endogenous growth. Our analysis finds that the debt-equity ratio is positively related to the balanced-growth rate, since it serves as a ‘financial accelerator’ to stimulate investment projects. Compared to previous studies, this positive relationship gives rise to an additional balance-sheet effect, which substantially affects the macroeconomic consequences of monetary and taxation policies. Due to the existence of the balance-sheet effect, we also find that the Friedman rule is not necessarily optimal.

Keywords: agency cost, balance-sheet channel, capital structure, growth and welfare, monetary and tax policies

JEL Classification: O42, O16, E52, E63, G32

I. INTRODUCTION

What is the role played by firms’ capital (financial) structures in economic growth? This is an old, but important, question. Modigliani and Miller (1958) propose that the average cost of capital for any firm only reflects the capitalization rate of a pure equity stream of its class and that the capital structure does not matter to the firm’s market value. This implies that capital accumulation is completely independent of firms’ capital structures and financial policies are separated from firms’ investment decisions. Due to the ‘irrelevance of the capital structure’, the early literature on macroeconomics and monetary economics has mostly overlooked the related issue and conducted the growth analysis by simply taking the firms’ capital structure as exogenously given (e.g., Lucas, 1967; Tobin, 1969; Sidrauski, 1967; Lucas, 1980; Kimbrough, 1986; Wang and Yip, 1992; Gomme, 1993; and Mino, 1997). While ‘finance is a veil’ has become widely accepted in the macroeconomics literature, it has not been supported by empirical studies. Long and Malitz (1985) provide direct empirical evidence to show that investment and financing

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decisions are not independent and that the firm's choice between debt and equity depends in part on the magnitude of the potential agency costs of debt. A large body of empirical research has by now pointed out that the firms' financing structure plays a crucial role in terms of affecting their investment projects, profitabilities and market values (see, e.g., Myers, 1974; Bradley *et al.*, 1984; Titman and Wessels, 1988; and Hubbard, 1998). Recently, some empirical studies have further shown the limitation of the Modigliani-Miller Theorem by shedding light on the relationship between the financial market and macroeconomic conditions (see, Levine, 1991; Levine and Zervos, 1998; Booth et al., 2001; Korajczyk and Levy, 2003; Beck and Levine, 2004; Caporale *et al.*, 2005 and Hanousek and Shamshur, 2011, among others).

In response to its empirical importance, this paper is a theoretical attempt to explore the macroeconomic implications of financial leverage for growth and welfare. To this end, we develop a monetary model of endogenous growth, embodying *an endogenously-determined debt-equity ratio* and a cash-in-advance (CIA) constraint on consumption.[1] In the model both corporate bonds and equities are allowed to be issued in order to gather investment funds and firms rationally decide the optimal debt-equity ratio by taking into account the tax shield effect and the agency costs. While the tax shield effect captures the idea of Modigliani and Miller (1963), Kim (1982), and Bradley *et al.* (1984), the agency costs are inclusive of both debt issues and equity issues. The agency costs of debt issues are associated with contractual restrictions intended to control the conflict between bondholders and stockholders (see Jensen and Meckling, 1976 and Myers, 1977).[2] The agency costs of equity issues arise because of the difference in interests and the existence of information asymmetry between the shareholders and management (see Jensen and Meckling, 1976; Grossman and Hart, 1980 and Jensen, 1986). The difference implies that debt and equity issues are not equivalent in terms of the informational agency costs (see Leland and Pyle, 1977 and Myers and Majluf, 1984). Of particular note, this *flexible* debt-equity ratio is commonly ignored by the conventional macroeconomics studies, while it plays a crucial role in terms of governing the effects of monetary and tax policies on employment, growth, inflation, and welfare. It then enables us to provide new and insightful implications for the existing literature.

Our analysis does not support the argument of *the irrelevance of the capital structure*, raised by Modigliani and Miller (1958); the balanced-growth rate is independent of the debt-equity ratio *only* under a perfect financial market in which there is no distortion caused by agency costs and government intervention. The debt-equity ratio, in general, serves as a *financial accelerator*, which stimulates investment projects and boosts economic growth. Thus, higher financial leverage is associated with a higher balanced-growth rate. This provides theoretical explanation for the empirical evidence of Booth *et al.* (2001), Korajczyk and Levy (2003) and Hanousek and Shamshur (2011).

By shedding light on the endogenous debt-equity ratio, our model creates an additional monetary transmission mechanism, namely, the balance-sheet channel, relative to the conventional interest rate channel emphasized by the previous monetary studies. The balance-sheet channel has been shown empirically to match the firms' dynamic behaviors on sales, short-term debt and other financing choices well (see, e.g., Bernanke *et al.*, 1996 and Olivero and Rudebusch, 1996). Given this additional balance-sheet channel, we show that an increase in the nominal interest rate has a mixed effect on the steady-state debt-equity ratio, employment, inflation, and growth. This result differs from the prediction of a CIA growth model, such as in Wang and Yip

[1] The CIA model has been one of the most popular methods used to introduce money into macro-optimizing models.

[2] From a wider aspect, the agency cost includes the induced costs of negotiation, monitoring and enforcement of contracts. See Jensen and Meckling (1976) or Section II.2 of our context for more detailed illustrations.

(1992). Of particular interest, it is found that a higher nominal interest rate can be associated with a lower inflation rate, implying that the prediction of the Fisher equation may also be invalid, either. This ambiguity, however, is consistent with the empirical evidence; as stressed by Malliaropulos (2000) and Lanne (2006), even though the Fisher prediction is widely accepted in macroeconomic theory, a stable one-for-one relationship between nominal interest rates and inflation has proved difficult to establish empirically.

Regarding the effects of taxation, we show that a rise in the tax rate on either firms' profits or stockholders' yield incomes unambiguously raises the debt-equity ratio, while having an ambiguous effect on the steady-state employment, inflation, and growth. This result sharply contradicts that of existing studies, such as Turnovsky (1990), who refer to a negative effect, based on a *real* model without a monetary consideration. Moreover, we show that an increase in the tax rate on bondholders decreases the debt-equity ratio, employment and growth, but raises inflation. It seems that taxing equity yields may result in the worst consequence for the economy among the three types of taxes on corporate finance.

Finally, our welfare analysis points out that the Friedman rule is not necessarily optimal in the presence of the balance-sheet channel. If the corporate income tax on firms is larger than the yield tax on bondholders, the firm is inclined to raise the debt-equity ratio in order to decrease its tax burden. This consideration of a *tax shield* decreases the cost of capital and, therefore, capital formation becomes more rewarding than money holding for achieving the social optimum. As a result, a positive nominal interest rate is desirable for a society to tax money and hence promote capital accumulation.

I.1 Related Literature

A substantial volume of research has been devoted to the relevance of the capital structure (the validity of Modigliani and Miller's (1958) theorem). For example, the role of taxes (Modigliani and Miller, 1963 and Miller, 1977) and bankruptcy cost (Kim, 1978; Bradley *et al.*, 1984; and Fischer *et al.*, 1989) as well as the problems of information asymmetry (Myers, 1984; Myers and Majluf, 1984 and Krasker, 1986), agency cost (Jensen and Meckling, 1976 and Smith and Warner, 1979) and managerial entrenchment (Stulz, 1988 and 1990; Harris and Raviv, 1991; Israel, 1991 and Berger *et al.*, 1997) are addressed to link the capital structures to firms' performance. These papers exclusively restrict attention to the firm-level analysis in a partial equilibrium model, which is unable to explore the macroeconomic growth and welfare effects and the relevant policy implications regardless of monetary policy or fiscal (tax) policy.

Of importance, empirical studies have referred to a linkage between capital (financial) structure and economic growth. On the one hand, Booth *et al.* (2001), Korajczyk and Levy (2003) and Hanousek and Shamshur (2011) provide evidence of a positive relationship between the long-term debt ratio and the economic growth rate. Gajurel (2006) echoes this positive relationship, showing that economic growth tends to induce firms to use more debt. On the other hand, Levine (1991), Levine and Zervos (1998), Beck and Levine (2004), and Caporale *et al.* (2005) refer to a positive relationship between equity issues and economic growth. By shedding light on the information asymmetry of equity and debt issues, Blackburn *et al.* (2005) and Capasso (2008) explain the late emergence of stock markets in emerging and developing countries.

In the macroeconomics literature, some theoretical studies also explore the relationship between financial structure and growth/aggregate output. By focusing on the literature on endogenous financial structures, Turnovsky (1990) and Osterberg (1989) investigate the capital and output effects of the taxes on firms' profits and households' dividend yields in neoclassical models.[3] With sustained growth rates, Strulik (2003, 2008) and Strulik and Trimborn (2010) numerically explore the growth effect of the taxes in both the AK and Lucas (human capital) models. These studies, in general, propose a negative effect of corporate taxes on output growth.[4] While these studies contribute a good understanding of taxation on corporate finance to the macroeconomics literature, they all focus on fiscal policy, ignoring monetary policy. Instead, the central purpose of our paper is to (i) examine the relationship between the endogenous debt-equity ratio (financial structure) and the long-run growth and social welfare through a more generalized agency cost (inclusive of both debt issue and equity issue) as well as (ii) provide new insights into the macroeconomic policy implications via the balance sheet channel.

To be more specific, we pursue a different object of investigation – the *monetary* implications of an endogenous debt-equity ratio on *long-run* growth and welfare. Based on a CIA monetary model of endogenous growth, we, on the one hand, examine the relationship between the debt-equity ratio and the balanced-growth rate and, on the other hand, shed light on the importance of the balance-sheet channel of monetary policy, which is ignored in the conventional monetary transmission mechanism. Of particular note, to make up for the lack of the aforementioned studies on corporate taxation, we not only uncover the macroeconomic consequences of monetary policy, but also examine the optimal rule of monetary policy (the validity of Friedman's rule) in the presence of the balance-sheet effect.

II. THE ANALYTICAL FRAMEWORK

The economy we consider consists of households, firms, and a government (solely represented by the monetary authority). Households derive utility from consumption and leisure and make portfolio choices among various assets: money, equities, corporate bonds and government bonds. Firms produce a single good by using capital and labor in a perfectly competitive market. To collect funding for investment, in addition to using retained earnings, firms can issue equities and corporate bonds to households, and the debt-equity ratio is thereby determined optimally. The government (the monetary authority) runs a balanced budget and implements a nominal interest rate peg. Money is introduced into this model through a cash-in-advance (CIA) constraint. In line with Lucas (1980), real money balances are required prior to purchasing the consumption good. Focusing the CIA constraint only on consumption will make our point (the balance sheet channel) more striking. Time t is continuous. For compact notation, the time index is suppressed throughout the paper.

II.1 Households

The economy is populated by a unit measure of identical infinitely-lived households. Each household, in facing its budget constraint, maximizes the discounted sum of future instantaneous utilities $u = \ln c - \chi \frac{n^{1+\varepsilon}}{1+\varepsilon}$. To be specific, it optimally chooses consumption c and working hours n, and also makes an asset portfolio allocation among nominal money balances M, outstanding equities issued by firms E, corporate bonds B^F, and government bonds B^G, taking the general price P, wage offers W, market price for the firm's share S, the (after-tax) yield rates of equities $(1 - \tau_E)\phi$, government bonds $\bar{i}$, and corporate bonds $(1 - \tau_B)i^F$, as well as the government's

[3] In the absence of an endogenous debt-equity ratio, Bernanke and Gertler (1989), Fuerst (1995), and Carlstrom and Fuerst (1997, 2001) show that agency costs propagate the impact of various shocks on the economy and hence generate a realistic pattern of short-run business cycles.

[4] Arnold and Walz (2000) endogenize the firm's capital structure by *ad hoc* assuming that the probability of success of R&D is increasing in the external funds for firms to engage in investment.

lump-sum transfers TR, as given. Thus, a representative household's optimization problem can be expressed as:

$$\max \int_0^\infty \left(\ln c - \chi \frac{n^{1+\varepsilon}}{1+\varepsilon} \right) \cdot e^{-\rho t} dt, \qquad \text{with } 0 < \chi < \infty, \tag{1}$$

subject to the following budget constraint and CIA constraint,

$$\frac{\dot{M}}{P} + \frac{\dot{B}^G}{P} + \frac{\dot{B}^F}{P} + \frac{S\dot{E}}{P} = \frac{W}{P}n + \bar{i}\frac{B^G}{P} + (1-\tau_E)\phi\frac{SE}{P} + (1-\tau_B)i^F\frac{B^F}{P} + \frac{TR}{P} - c, \tag{2}$$

$$\frac{M}{P} \geqq c, \tag{3}$$

where ε is the inverse of the elasticity of the intertemporal substitution of labor, ρ is the constant rate of time preference, $\bar{i}$ is the nominal interest rate for government bonds, τ_E is the tax rate imposed on the dividend yields ϕ of outstanding equities SE, and τ_B is the tax rate imposed on the yield rate i^F of corporate bonds B^F.[5]

Let v be the shadow price associated with the budget constraint (2) and η be the Lagrangian multiplier of the CIA constraint (3). The necessary conditions, in real terms, for this optimization problem are summarized as follows:

$$\chi(1+\bar{i})cn^\varepsilon = w, \tag{4}$$

$$\frac{\eta}{v} = \bar{i}, \tag{5}$$

$$m = c, \tag{6}$$

$$\frac{\dot{c}}{c} = -\frac{\dot{v}}{v} = \bar{i} - \pi - \rho, \tag{7}$$

$$\bar{i} = (1-\tau_B)i^F = (1-\tau_E)\phi + \frac{\dot{S}}{S}, \tag{8}$$

and the transversality conditions

$$\lim_{t\to\infty} vm = \lim_{t\to\infty} vb^G = \lim_{t\to\infty} vb^F = \lim_{t\to\infty} vsE = 0,$$

where $\pi(=\frac{\dot{P}}{P})$ is the inflation rate, $w(=\frac{W}{P})$ is the real wage, $m(=\frac{M}{P})$ are real money balances, $b^G(=\frac{B^G}{P})$ are real government bonds, $s(=\frac{S}{P})$ is the relative price of equities to goods, and $b^F(=\frac{B^F}{P})$ are real corporate bonds. Equation (4) describes how the household trades off consumption and leisure at the real wage w. Equation (5) refers to the optimal condition for real money holdings, which equates the shadow price of real money balances to its opportunity costs, i.e., the yield rate on government bonds $\bar{i}$. While (6) is the CIA constraint, (7) refers to the standard Keynes-Ramsey rule. Equation (8) is a no-arbitrage condition, indicating that all the rates of yields on government bonds $\bar{i}$, on corporate bonds $(1-\tau_B)i^F$, and on stocks $(1-\tau_E)\phi + \frac{\dot{S}}{S}$ must be equal.

[5] In this model without banks, we assume that negotiable certificates of deposit and government bonds are perfect substitutes. The monetary authority implements its monetary policies by purchasing/selling government bonds in the open market.

II.2 Firms

There is a single final good, denoted by y, which can be consumed, accumulated as capital, and paid for as taxes. This good is produced by identical firms, whose production technology takes the prototypical Cobb-Douglas form as follows:

$$y = A(\overline{k}) \cdot n^{\alpha} k^{1-\alpha}, \quad \alpha \in (0, 1), \tag{9}$$

where $A(\cdot)$ is the total factor productivity (TFP), k is capital, n is labor, and $(1 - \alpha)$ and α represent the capital and labor shares, respectively. The Romer (1986)-type production externality governs TFP. Since the average economy-wide stock of capital $\overline{k}$ is assumed to be the index of knowledge available to the individual firm, the spillovers refer to external benefits from interacting with the person who possesses some degree of skills and knowledge. Due to the effect of learning by doing, TFP is increasing in the average capital stock; specifically, $A(\overline{k}) = A_0\overline{k}^{\sigma}$, with $\sigma > 0$. As pointed out by Mulligan and Sala-i-Martin (1993), this is a simple way to eliminate the scale effect as $A(\cdot)$ depends on the economy's average capital, instead of the aggregate capital stock. We then impose:

Assumption 1. (Perpetual Growth) $\sigma = \alpha$.

This assumption leads our model economy to generate perpetual growth.

The firm's before-tax gross profit is defined as:

$$\Pi' = Py - Wn - i^F B^F.$$

In our model the firm can optimally choose the debt-equity ratio, denoted by $\lambda(=\frac{B^F}{SE})$, which factors in the agency costs. To capture the agency costs in a generalized manner, we assume that there is a deduction from pay for agency costs induced by issuing both debt B^F and equity E. To be specific, we have:[6]

Assumption 2. (Agency costs) *The agency cost of debt is given by: $a_B B^F$, where the agency cost of issuing unit corporate bond (debt) a_B is increasing and convex in the debt-equity ratio $\lambda(=\frac{B^F}{SE})$, i.e., $a'_B(=\frac{\partial a_B}{\partial \lambda}) > 0$ and $a''_B(=\frac{\partial a'_B}{\partial \lambda}) > 0$. By contrast, the agency cost of equity is given by: $a_E SE$, where the agency cost of issuing unit equity a_E is increasing and convex in the inverse of the debt-equity ratio $\frac{1}{\lambda}(=\frac{SE}{B^F})$, i.e., $a'_E(=\frac{\partial a_E}{\partial(1/\lambda)}) > 0$ and $a''_E(=\frac{\partial a'_E}{\partial(1/\lambda)}) > 0$.*

In Assumption 2, we resemble Osterberg's (1989) specification, assuming that the agency cost of debt is associated with contractual restrictions intended to control the conflict between bondholders and stockholders. In the literature on financial contracting (such as Jensen and Meckling, 1976), the firm is viewed as a 'contracting arena' in which the conflicting interests of bondholders and stockholders are negotiated. According to the 'costly contracting hypothesis' of Smith and Warner (1979), the presence of bond covenants can be viewed as a method of controlling the conflict between bondholders and stockholders, and bond covenants are negotiated to restrict the level of debt for a given value of equity. Thus, the higher the debt-equity ratio $\lambda(=\frac{B^F}{SE})$, the more likely it is that the covenant will be violated, resulting in restrictions on investment activities and a decrease in firm value.

The agency cost of equity arises because of the difference in interests and existence of information asymmetry between the shareholders and management. Due to these distortions, management may be tempted to make suboptimal decisions that do not maximize the objective value for shareholders. Any measures implemented to oversee and prevent this will have a cost associated with them. Hence, the agency costs of equity will include the cost stemming from

[6]The generalized agency costs were pointed out to us by an anonymous referee, to whom we are grateful.

the suboptimal decision and the cost incurred in monitoring the management to prevent them from taking these decisions, both being similar to Jensen and Meckling's (1976) monitoring and residual costs. As proposed by Jensen and Meckling (1976), Grossman and Hart (1980), Jensen (1986) and Berger *et al.* (1997), these agency costs can be reduced by increasing the debt financing because it increases the monitoring intensity over managers. Alternatively, decreasing the outstanding equities through an increase in the proportion of the managers' shareholding can also reduce the agency costs, because it reconciles the conflicting interests between the shareholders and the management.[7] Note that the specification of the agency costs in Assumption 2 is more general than that of Osterberg (1989). We account for not only the agency cost of debt but also the agency cost of equity. This generalization echoes the argument of Leland and Pyle (1977) and Myers and Majluf (1984): in terms of the informational agency costs, debt and equity issues are not equivalent and, hence, the debt-equity choice will affect the firm's external valuation and its investment opportunities.

With these costs, the gross profits go to the government as taxes (at the rate of profit tax τ_Π), to stockholders as dividends Ω, or become the internal funds of the firm as retained earnings RE. Thus, the after-tax firm's gross profit Π is:

$$\Pi = (1-\tau_\Pi)\Pi' = \Omega + RE + a_B(\lambda)B^F + a_E\left(\frac{1}{\lambda}\right)SE. \tag{10}$$

By following Turnovsky (1990), we assume that firms offer a dividend yield to stockholders on their equity according to the fixed dividend payout rule, i.e., $\phi = \frac{\Omega}{SE}$. This fixed dividend rules out the possible effect of a financial constraint on the firm's investment decisions (see, e.g., Myers and Majluf, 1984), which allows us to place more attention on the investment effect of an endogenous debt-equity ratio.

In addition to internal funds (retained earnings RE), there are two sources of external funds for firms to engage in investment: they can borrow from households by issuing corporate bonds $\dot{B}^F$ and by issuing new equity $S\dot{E}$. By defining I as investment, the financing constraint facing a firm is expressed as:

$$PI = RE + \dot{B}^F + S\dot{E}. \tag{11}$$

Moreover, by letting δ be the depreciation rate of capital, the law of motion of capital is given by:

$$\dot{k} = I - \delta k. \tag{12}$$

We define the firm's market value of total assets as $V = SE + B^F$. Differentiating V with respect to time and utilizing (8), (10), and (11) yield:

$$\dot{V} = \Gamma V - \omega. \tag{13}$$

Similar to Osterberg (1989), we define

$$\omega = (1-\tau_\Pi)(PA_0\bar{k}^{\sigma}k^{1-\alpha}n^{\alpha} - Wn) - PI, \tag{14}$$

as the firm's cash flow and the weighted average cost of capital (WACC) is given by:

$$\Gamma = i^E\frac{1}{1+\lambda} + i^B\frac{\lambda}{1+\lambda} = \bar{i} + (i^E - \bar{i})\frac{1}{1+\lambda} + (i^B - \bar{i})\frac{\lambda}{1+\lambda}, \tag{15}$$

[7]The studies by Stein (1997) and Scharfstein and Stein (2000) show that an increase in the shareholding for managers can help to reconcile the interests of the shareholders and management.

where $i^E = \bar{i} + \tau_E\phi + a_E(\frac{1}{\lambda})$ and $i^B = \frac{(1-\tau_\Pi)\bar{i}}{1-\tau_B} + a_B(\lambda)$ represent the cost of equity capital and the cost of debt capital, respectively.[8] The cash flow net of profit tax (14) is only related to the real production factors, such as labor n, investment I, and capital k, while the WACC is mainly related to the firm's capital structure λ. To be more specific, the WACC is a weighted average of the cost of issuing equity (reflecting the opportunity cost $\bar{i}$, the tax burden on dividends $\tau_E\phi$, and the agency cost of unit equity $a_E(\frac{1}{\lambda})$) and the cost of issuing corporate bonds (reflecting the opportunity cost $\frac{(1-\tau_\Pi)\bar{i}}{1-\tau_B}$ and the agency cost of unit debt $a_B(\lambda)$), with the weights being given by their relative structures $\frac{1}{1+\lambda}$ and $\frac{\lambda}{1+\lambda}$, respectively. To convey Bernanke and Gertler's (1995) point of view, the WACC can be alternatively expressed as: $\Gamma = \bar{i} + (i^E - \bar{i})\frac{1}{1+\lambda} + (i^B - \bar{i})\frac{\lambda}{1+\lambda}$, indicating that the firm's cost of capital consists of the riskless interest rate $\bar{i}$ and the weighted wedges between the costs of external and internal finance, stemming from the usage of equity capital $(i^E - \bar{i})$ and of debt capital $(i^B - \bar{i})$. Thus, a higher $\bar{i}$ may reduce the wedges $(i^B - \bar{i})$ and $(i^E - \bar{i})$, which, due to the firm's financial leverage, trigger the financial accelerator, stimulating investment. In the absence of issuing any corporate bonds ($\lambda = 0$), the agency cost of equity ($a_E = 0$), and of dividends (ϕ), the WACC reduces to $\Gamma = i^E = \bar{i}$, which essentially recovers the situation in a conventional macro model. By contrast, in the presence of corporate bonds ($\lambda > 0$) with distinct agency costs, the firm's financial structure plays a prominent role in terms of governing the firm's cost of capital and in turn the economy's growth. Most notably, the government's monetary $(\bar{i})$ and tax $(\tau_E, \tau_B, \tau_\Pi)$ policies will influence economic growth via the balance-sheet channel (or the financial channel).

It is easy to solve (13) for $V(t)$. By following Osterberg (1989) and Turnovsky (1990), the firm's objective is assumed to be its initial market value of $V(0)$:

$$V(0) = \int_0^\infty \omega(\tau)e^{-\int_0^\tau \Gamma d\xi}d\tau. \tag{16}$$

As mentioned above, ω is solely a function of 'real' variables, whereas Γ is a function of only 'financial' variables summarized by λ. Thus, as noted by Osterberg (1989), the firm can optimize based on the following sequential procedure. Subject to the evolution of capital (12) and given the initial values of $k(0)$, $B^F(0)$, $E(0)$, the firm first chooses n, I, and k to maximize (16) and then chooses λ to minimize the WACC of (15).[9]

The optimal conditions necessary for the firm's optimization problem are as follows:

$$\alpha A_0\bar{k}^\sigma k^{(1-\alpha)}n^{(\alpha-1)} = w, \tag{17}$$

$$(1-\tau_\Pi)(1-\alpha)A_0\bar{k}^\sigma k^{-\alpha}n^\alpha - \delta = \Gamma - \pi, \tag{18}$$

$$\tau_E\phi + \bar{i}\left(1 - \frac{1-\tau_\Pi}{1-\tau_B}\right) = \left[a_B(\lambda) + a_B^{'}\cdot\lambda(1+\lambda)\right] - \left[a_E\left(\frac{1}{\lambda}\right) + a_E^{'}\cdot\frac{1+\lambda}{\lambda^2}\right], \tag{19}$$

and the transversality conditions

$$\lim_{\tau\to\infty} b^F e^{-\int_0^\tau \Gamma d\xi} = \lim_{\tau\to\infty} sEe^{-\int_0^\tau \Gamma d\xi} = 0,$$

where $s(=S/P)$ is the real equity price. Equation (17) is the firm's demand for labor. Equation (18) equates the after-tax marginal productivity of capital (net of the capital depreciation rate) to the real WACC (net of the inflation rate). The optimal debt-equity ratio is pinned down by (19), which indicates that the advantages of debt financing stemming from the tax shield (the

[8]The complete derivation is also available from Osterberg (1989).

[9]We assume that $\lim_{t\to\infty}\int_0^t \Gamma d\tau = \infty$ in order to have a convergent value for the solution.

LHS of (19)) should be balanced by the disadvantage stemming from the *relative* agency cost of debt to equity (the RHS of (19)). The "tax shield effect" captures the idea of Modigliani and Miller (1963), which will be discussed later.

Since the debt-equity ratio λ plays a central role in the analysis, we then more delicately examine (19). We now impose

Assumption 3. (Interior solution for the optimal debt-equity ratio) $\tau_E \phi + \bar{i}(1 - \frac{1-\tau_\Pi}{1-\tau_B}) > 0$.

By shedding light on the tax shield effect of debt financing, Assumption 3 guarantees the existence of a positive, optimal ratio of debt to equity. Given a corporate income tax τ_Π, Assumption 3 introduces the so-called tax shield effect to our model in the sense that the firm can decrease its tax burden by raising the higher debt-equity ratio. Intuitively, the LHS of (19) refers to the marginal benefit of raising the debt-equity ratio, which is related to the government's monetary and tax policies, while the RHS is the net marginal cost of raising the debt-equity ratio which stems from both agency costs of debt and equity. A higher tax rate τ_Π on the corporate income increases the marginal benefit of raising the debt-equity ratio λ because a higher profit tax induces the firm to decrease its flow of profit via an increase in the debt-equity ratio. It follows from Assumption 3 that the tax shield effect (the tax ratio $\frac{1-\tau_\Pi}{1-\tau_B}$ is smaller than one) must be substantially large so that firms are willing to use relatively costly debt ($\lambda > 0$) as their external funds to engage in investment (see Strulik (2003, 2008) for a similar specification).[10] This assumption is also supported by empirical studies, such as Kim (1982), Bradley *et al.* (1984), Long and Malitz (1985), Buser and Hess (1986), and Booth *et al.* (2001).

Based on (19), Assumption 3 also implies that $a_B(\lambda) + a_B^{'} \cdot \lambda(1+\lambda) > a_E(\frac{1}{\lambda}) + a_E^{'} \cdot \frac{1+\lambda}{\lambda^2}$ holds, i.e., the net marginal cost of raising the debt-equity ratio which stems from both the agency costs of debt and equity is positive. Otherwise, an unlimited use of debt issue to decrease the WACC (because of $\partial\Gamma/\partial\lambda < 0$) will lead firms to choose a maximum debt-equity ratio, i.e., the optimal debt-equity ratio is $\lambda \to \infty$. This case provides an interesting implication: in developing or emerging countries with relatively high agency costs of equity, firms are inclined to issue debt, instead of equity, to engage in investment. This results in a late emergence of the stock market in the developing and emerging countries which is consistent with the observation of Blackburn *et al.* (2005). Notice that in this generalized agent cost specification, the unit agency cost of debt issue a_B could be higher or lower than the unit agency cost of equity issue a_E. It is easy to see from (19) that $a_E(\frac{1}{\lambda}) - a_B(\lambda) \gtrless 0$ if $\tau_E\phi + \bar{i}(1 - \frac{1-\tau_\Pi}{1-\tau_B}) \lesseqgtr a_B^{'}\lambda(1+\lambda) - a_E^{'}\frac{1+\lambda}{\lambda^2}$. This implies that $a_E(\frac{1}{\lambda}) > a_B(\lambda)$ can be true if the tax shield effect is not too strong, i.e., $\tau_E\phi + \bar{i}(1 - \frac{1-\tau_\Pi}{1-\tau_B}) < a_B^{'}\lambda(1+\lambda) - a_E^{'}\frac{1+\lambda}{\lambda^2}$. This ambiguity between $a_B(\lambda)$ and $a_E(\frac{1}{\lambda})$ is general enough for us to examine the role of financial leverage in economic growth.

By the implicit-function theorem, we can use (19) with Assumption 3 to obtain:

$$\widetilde{\lambda} = \lambda\left(\underset{\pm}{\bar{i}}, \underset{-}{\tau_B}, \underset{+}{\tau_\Pi}, \underset{+}{\tau_E}\right). \tag{20}$$

where $\lambda_{\bar{i}} = \frac{\tau_\Pi - \tau_B}{\Lambda(1-\tau_B)} \lesseqgtr 0$, $\lambda_{\tau_B} = -\frac{(1-\tau_\Pi)\bar{i}}{\Lambda(1-\tau_B)^2} < 0$, $\lambda_{\tau_\Pi} = \frac{\bar{i}}{\Lambda(1-\tau_B)} > 0$, $\lambda_{\tau_E} = \frac{\phi}{\Lambda} > 0$, and $\Lambda = [(a_B^{''}\lambda + 2a_B^{'}) + (a_E^{''}\frac{1}{\lambda} + 2a_E^{'})\frac{1}{\lambda^3}](1+\lambda) > 0$. It is clear that the capital cost of issuing equity i^E increases with the dividend income tax τ_E, while the capital cost of issuing corporate bonds i^B increases with the tax rates on the corporate bond yields τ_B, but decreases with the corporate income tax τ_Π. Therefore, to minimize the WACC, the firm optimally chooses a higher

[10]For example, Strulik and Trimborn (2010) and Gourio and Miao (2011) estimate that the average corporate income tax rate is 35 percent while the interest rate income tax is about 25 percent in the USA. Thus, $\frac{1-\tau_\Pi}{1-\tau_B} < 1$ is true.

debt-equity ratio λ if τ_E and τ_Π are higher or τ_B is lower. Of particular interest, a rise in the nominal interest rate does not necessarily lower the firm's debt-equity ratio, depending on the relative magnitude of τ_B to τ_Π. If $\tau_\Pi > \tau_B$, the tax shield effect indicates that in response to a rise in the nominal interest rate it is optimal for the firm to choose a higher debt-equity ratio so as to decrease its tax burden. Otherwise, if $\tau_\Pi < \tau_B$, a higher nominal interest rate increases the WACC, which induces the firm to lower its debt-equity ratio.

By substituting (20) into (15) and (19), we can obtain the optimal WACC as follows:

$$\widetilde{\Gamma} = \bar{i} + \tau_E \phi - a_B^{'}(\widetilde{\lambda}) \cdot \widetilde{\lambda}^2 + a_E(\widetilde{\lambda}) + \frac{a_E^{'}(\widetilde{\lambda})}{\widetilde{\lambda}}. \tag{21}$$

This indicates that the optimal average cost of capital $\widetilde{\Gamma}$ is negatively related to the optimal debt-equity ratio (i.e., $\partial\widetilde{\Gamma}/\partial\widetilde{\lambda} < 0$). In other words, given a substantially strong tax shield effect (i.e., Assumption 3), the firms can lower their capital costs $\widetilde{\Gamma}$ through higher financial leverage $\widetilde{\lambda}$.

II.3 Monetary Authority

The monetary authority implements a nominal interest rate peg by targeting the nominal level of the interest rate on government bonds $\bar{i}$. By letting the growth rate of money be $\mu = \dot{M}/M$, the evolution of real money balances is: $\frac{\dot{m}}{m} = \mu - \pi$. The monetary authority will endogenously adjust the money growth rate μ to whatever level is needed for the targeted interest rate $\bar{i}$ to prevail.

In addition, the government (solely represented by the monetary authority) runs a balanced budget. It provides transfers TR to households in a lump-sum manner and pays the interest rate to government-bond holders $\bar{i}B^G$. To finance these expenditures, the government taxes households on the interest rate of corporate bonds (bondholders) and the dividend yields of outstanding equities (stockholders), and firms on their gross profits as well as by issuing government bonds and money. Thus, the flow government budget constraint is given by:

$$TR + \bar{i}B^G = \left(\tau_B i^F B^F + \tau_E \phi SE + \tau_\Pi \Pi'\right) + \dot{B}^G + \dot{M}. \tag{22}$$

III. MACROECONOMIC EQUILIBRIUM

This model economy defines a competitive *equilibrium* by a sequence of prices $\{w, i^F, s, \pi\}_{t=0}^{\infty}$, real allocations $\{c, n, k, I\}_{t=0}^{\infty}$, the stocks of assets $\{b^G, b^F, m, E)\}_{t=0}^{\infty}$, the capital structure $\{\lambda\}_{t=0}^{\infty}$, and policy variables $\{\bar{i}, \mu, \tau_E, \tau_B, \tau_\Pi, TR\}_{t=0}^{\infty}$ such that:

- the representative household maximizes its lifetime utility (1), subject to the budget constraint (2), i.e., the optimizing conditions (4)-(8) hold;
- the representative firm maximizes its initial market value (16), i.e., the optimizing conditions (17)-(19) hold;
- the budget constraints of households (2) and the government (22) as well as the financing constraints of firms (11) with the evolution of capital (12) are met.

In the competitive equilibrium, these conditions will clear all markets. By putting (2), (9), (10), (11), and (22) together, we have the economy-wide resource constraint:

$$A_0 k n^{\alpha} = c + I + a_B(\widetilde{\lambda}) b^F + a_E\left(\frac{1}{\widetilde{\lambda}}\right) sE, \tag{23}$$

which is also the good-market clearing condition. Notice that in deriving (23) we have used Assumption 1 and the condition of the symmetric equilibrium $\overline{k} = k$. Moreover, from (4) and (17), the clearing condition for the labor market is:

$$\chi(1+\bar{i})cn^{\varepsilon} = \alpha A_0 k n^{\alpha-1}, \tag{24}$$

under the symmetric equilibrium. By analogy, we can obtain the money-market equilibrium by combining the demand for money (equations (6) and (7)) with the supply of money ($\mu = \dot{M}/M$). Finally, (8), (18), and (19) with conditions (10)-(15) jointly construct the equilibria of the equity and bond markets.

III.1 Balanced-Growth Path Equilibrium

A non-degenerate balanced-growth path (BGP) equilibrium is a tuple of paths such that each of the quantity variables c, k, m, b^G, and b^F grows at a positively constant common rate, while each of the financial-structure variable λ, the price variables π, i^F and working time n is a positive constant.

To solve the common balanced growth rate, we define the transformed variable: $z = \frac{c}{k}$. With this definition, under symmetric equilibrium we can rewrite the inflation rate from (18)

$$\pi = \widetilde{\Gamma} + \delta - (1-\tau_{\Pi})(1-\alpha)A_0 n^{\alpha}, \tag{25}$$

and, accordingly, the consumption growth rate, denoted by γ_c, from (7):

$$\gamma_c = \frac{\dot{c}}{c} = \bar{i} - \widetilde{\Gamma} - \delta + (1-\tau_{\Pi})(1-\alpha)A_0 n^{\alpha} - \rho. \tag{26}$$

Moreover, from (12) and (23), we obtain the capital growth rate, denoted by γ_k:

$$\gamma_k = \frac{\dot{k}}{k} = A_0 n^{\alpha} - z - \delta - \Sigma(\widetilde{\lambda}), \tag{27}$$

where $\Sigma(\widetilde{\lambda}) = a_B(\widetilde{\lambda})\frac{\widetilde{\lambda}}{1+\widetilde{\lambda}} + a_E(\frac{1}{\widetilde{\lambda}})\frac{1}{1+\widetilde{\lambda}}$. Note that, as shown in Turnovsky (2000, Ch. 8), in equilibrium the firm's market value of total assets V must equal its replacement cost of capital, i.e., $V = SE + B^F = Pk$, which is essentially the firm's balance sheet. Thus, from the definition of $\lambda = \frac{B^F}{SE} = \frac{b^F}{sE}$, we can obtain $\frac{b^F}{k} = \frac{\lambda}{1+\lambda}$.

Besides, the consumption-capital ratio z can be obtained by (24):

$$z = \frac{\alpha A_0 n^{-(1+\varepsilon-\alpha)}}{\chi(1+\bar{i})}. \tag{28}$$

By differentiating (28) with respect to time and substituting (26) and (27) into the resulting equation, the dynamic system of our model can be reduced to the following equation in terms of only n:

$$\frac{\dot{n}}{n} = \frac{-1}{1+\varepsilon-\alpha}\left\{\bar{i} - \widetilde{\Gamma} - \left[1-(1-\tau_{\Pi})(1-\alpha)\right]A_0 n^{\alpha} - \rho + \frac{\alpha A_0 n^{-(1+\varepsilon-\alpha)}}{\chi(1+\bar{i})} + \Sigma(\widetilde{\lambda})\right\}, \tag{29}$$

recalling that $\widetilde{\lambda}$ is reported in (20), and $\widetilde{\Gamma}$ is reported in (21). In the steady state, $\dot{n} = 0$ holds true in (29) and the stationary values for all steady-state variables are denoted by a '*hat*'. Thus, (28) implies that $\hat{\gamma}_c = \hat{\gamma}_k$ and (3) implies that the growth rates of consumption and money are also the same, i.e., $\hat{\gamma}_c = \hat{\gamma}_m$, along the BGP equilibrium. Since the debt-equity ratio λ is constant under the BGP equilibrium, the relationships of $\lambda = \frac{b^F}{sE}$ and $\frac{b^F}{k} = \frac{\lambda}{1+\lambda}$ imply that the growth rates of stockholders' equities and corporate bonds are the same as that of capital, $\hat{\gamma}_k = \hat{\gamma}_{sE} = \hat{\gamma}_{b^F}$. [11]

[11] We can see from the firm's balance sheet that $\hat{\gamma}_k = \hat{\gamma}_s + \hat{\gamma}_E$, where $\hat{\gamma}_s = \hat{\gamma}_S - \hat{\pi}$.

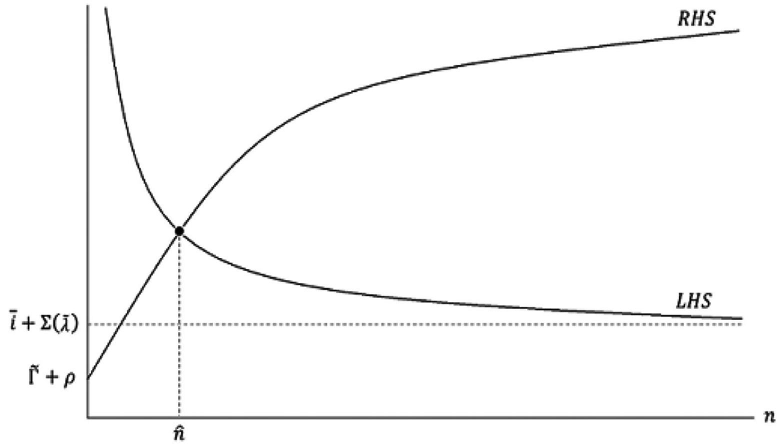

Fig. 1. Existence and uniquencess of the equilibrium.

The common growth between physical capital and equity capital is in line with the theoretical models of Levine (1991), Boyd and Smith (1998), Blackburn *et al.* (2005), Bose (2005) and Capasso (2008) and supported by the empirical studies of Levine and Zervos (1998), Beck and Levine (2004) and Caporale *et al.* (2005).[12] In the model, the monetary policy is to adjust the money growth rate μ by means of purchasing/selling government bonds b^G in order to peg the targeted interest rate $\bar{i}$. Therefore, $\hat{\gamma}_m = \hat{\gamma}_{b^G}$. To sum up, under the BGP equilibrium the quantity variables c, k, m, b^F, and sE all grow at a common rate, denoted by $\hat{\gamma}$.

Accordingly, we arrive at:

Theorem 1. (Existence and Uniqueness of the Equilibrium) *Under Assumptions 1-3, there exists a nondegenerate, unique balanced-growth equilibrium of the dynamic model with the endogenous debt-equity ratio.*

Proof. Along the BGP equilibrium, $\dot{n} = 0$ and $\hat{\gamma}_c = \hat{\gamma}_k$ hold true. Given (21), it follows from (29) with $\dot{n} = 0$ that the BGP equilibrium must satisfy the following condition:

$$\frac{\alpha A_0}{\chi(1+\bar{i})}\hat{n}^{-(1+\varepsilon-\alpha)} + \bar{i} + \Sigma(\widetilde{\lambda}) = [1 - (1-\tau_\Pi)(1-\alpha)]A_0\hat{n}^\alpha + \widetilde{\Gamma} + \rho. \qquad (30)$$

As shown in Figure 1, the LHS of this equation is a downward-sloping locus, while the RHS is an upward-sloping one. When $n \to 0$, the value of the LHS approaches ∞, while the value of the RHS intersects the vertical coordinate at $\widetilde{\Gamma} + \rho > 0$. These guarantee that the BGP equilibrium exists and is unique, as demonstrated in Figure 1. ■

As steady-state employment is determined, the inflation rate can be determined by (25) with (21). Furthermore, the balanced-growth rate can easily be obtained from (26):

$$\hat{\gamma} = \bar{i} - \hat{\pi} - \rho = A_0\hat{n}^\alpha - \frac{\alpha A_0\hat{n}^{-(1+\varepsilon-\alpha)}}{\chi(1+\bar{i})} - \delta - \Sigma(\widetilde{\lambda}). \qquad (31)$$

[12]In a way that differs from the agency cost, we shed light on, the aforementioned studies focus on the relationship between economic growth and the function of financial markets and intermediaries and financial frictions, such as funds pooling, diversifying risk, increasing liqudity, reducing monitoring cost, and constructing financial contracts and institution, the role of agency costs in policy and welfare effects.

With Theorem 1, we further examine the dynamic property of this model, which is summarized in the following lemma:

Lemma 1 (Dynamic Property). *Under Assumptions 1-3, the steady-state equilibrium is locally determinate.*

Proof. From (29), we have:

$$\frac{\partial\left(\frac{\dot{n}}{n}\right)}{\partial n}=\frac{\Delta}{1+\varepsilon-\alpha}>0.$$

where $\Delta=\Psi\alpha A_0\hat{n}^{\alpha-1}>0$ and $\Psi=1-(1-\tau_\Pi)(1-\alpha)+\frac{1+\varepsilon-\alpha}{\chi(1+\bar{i})}\hat{n}^{-(1+\varepsilon)}>0.$ ■

Since the dynamic system can reduce to one in terms of the jump variable n, $\frac{\partial(\frac{\dot{n}}{n})}{\partial n}>0$ implies that the steady-state equilibrium is characterized by local determinacy.

III.2 Financial Leverage (Debt-Equity Ratio) and Balanced Growth

As is evident, it is important to investigate the relationship between the debt-equity ratio and the balanced-growth rate.

Proposition 1. (Financial Structure and Economic Growth) *Under Assumptions 1-3,*

(i) in the presence of a positive agency cost ($a_B(\widetilde{\lambda})>0$ and $a_E(\frac{1}{\widetilde{\lambda}})>0$), there is a positive relationship between the debt-equity ratio and the balanced-growth rate;

(ii) the balanced-growth rate is independent of the debt-equity ratio under a perfect financial market in which there is no distortion caused by agency cost ($a_B(\widetilde{\lambda})=a_E(\frac{1}{\widetilde{\lambda}})=0$) and the government's tax interventions ($\tau_E=\tau_B=\tau_\Pi=0$).

Proof. Differentiating (30) with respect to $\widetilde{\lambda}$ yields:

$$\frac{\partial\hat{n}}{\partial\widetilde{\lambda}}=\frac{1}{\Delta}\left(\frac{\widetilde{\lambda}\Lambda}{1+\widetilde{\lambda}}+\Sigma_{\widetilde{\lambda}}\right)>0, \tag{32}$$

where $\Sigma_{\widetilde{\lambda}}=\frac{a_B-a_E}{(1+\widetilde{\lambda})^2}+[a_B^{'}\cdot\frac{\widetilde{\lambda}}{1+\widetilde{\lambda}}-(a_E^{'}\cdot\frac{1}{\widetilde{\lambda}^2})\frac{1}{1+\widetilde{\lambda}}]>0$. With this, from (31), we further have:

$$\frac{\partial\hat{\gamma}}{\partial\widetilde{\lambda}}=\frac{\widetilde{\lambda}\Lambda}{1+\widetilde{\lambda}}+(1-\tau_\Pi)(1-\alpha)\alpha A_0\hat{n}^{\alpha-1}\cdot\frac{\partial\hat{n}}{\partial\widetilde{\lambda}}>0. \tag{33}$$

However, when $a_B(\widetilde{\lambda})=a_E(\frac{1}{\widetilde{\lambda}})=\tau_E=\tau_B=\tau_\Pi=0$, (19) always holds regardless of the value of λ. Under such a situation, the firm's WACC reduces to $\Gamma=\bar{i}$. Since the WACC is not related to the debt-equity ratio λ, the balanced-growth rate is independent of the debt-equity ratio, as shown in (30) and (31). ■

Equation (21) reveals that due to the financial leverage a higher optimal debt-equity ratio decreases the firm's optimal WACC (i.e., $\frac{\partial\widetilde{\Gamma}}{\partial\widetilde{\lambda}}=-\frac{\widetilde{\lambda}\Lambda}{1+\widetilde{\lambda}}<0$), which leads firms to have more cheap funds to support their investment. This potentially indicates that if corporate governance can effectively control the agency costs arising from asymmetric information, a higher debt-equity ratio will boost investment, employment, and economic growth. That is, there is a 'financial accelerator', as argued by Bernanke and Gertler (1995), in the sense that higher financial leverage can stimulate more investment projects and in turn boost economic growth. A further implication is that equipped with equations (20), (32), and (33), any policy which alters the firm's debt-equity ratio will give rise to an impact on the firm's investment decision and hence the economy's growth. By contrast, under a perfect financial market without any distortion caused by agency cost ($a_B(\lambda) = a_E(\frac{1}{\lambda}) = 0$) and the government's taxation ($\tau_E = \tau_B = \tau_\Pi = 0$), there is an identical cost for the firm to issue equities and corporate bonds, i.e., $i^E = i^B = \bar{i}$. Given the fact that the WACC $\Gamma = \bar{i}$ regardless of the value of λ, the balanced-growth rate is independent of the debt-equity ratio. This case of a perfect financial market vividly conveys the argument of the irrelevance of capital structure, as in Modigliani and Miller (1958).

IV. COMPARATIVE STATICS

In this section, we will examine the macro effects of both monetary (changing $\bar{i}$) and tax (changing τ_E, τ_B, and τ_Π) policies.

IV.1 Effects of Monetary Policy

First of all, we discuss the impacts of raising the nominal interest rate on employment, inflation, the debt-equity ratio, and economic growth:

Proposition 2. (Effects of Raising the Nominal Interest Rate) *Under Assumptions 1-3, an increase in the nominal interest rate has an ambiguous effect on the steady-state employment $\hat{n}$, inflation $\hat{\pi}$, the debt-equity ratio $\widetilde{\lambda}$, and growth $\hat{\gamma}$.*

Proof. From (20), (25), (30), and (31), we obtain:

$$\frac{\partial \hat{n}}{\partial \bar{i}} = \underbrace{-\frac{1}{\Psi}\frac{\hat{n}^{-\varepsilon}}{\chi(1+\bar{i})^2}}_{interest-rate\ channel\ (-)} + \underbrace{\frac{\partial \hat{n}}{\partial \widetilde{\lambda}} \cdot \frac{\partial \widetilde{\lambda}}{\partial \bar{i}}}_{balance-sheet\ channel\ (\pm)},$$

$$\frac{\partial \hat{\gamma}}{\partial \bar{i}} = \underbrace{-\frac{(1-\tau_\Pi)(1-\alpha)}{\Psi}\frac{\alpha A_0 \hat{n}^{-(1+\varepsilon-\alpha)}}{\chi(1+\bar{i})^2}}_{interest-rate\ channel\ (-)} + \underbrace{\frac{\partial \hat{\gamma}}{\partial \widetilde{\lambda}} \cdot \frac{\partial \widetilde{\lambda}}{\partial \bar{i}}}_{balance-sheet\ channel\ (\pm)},$$

$$\frac{\partial \hat{\pi}}{\partial \bar{i}} = 1 - \frac{\partial \hat{\gamma}}{\partial \bar{i}} = \frac{1}{1+\lambda}\left(1 + \lambda\frac{1-\tau_\Pi}{1-\tau_B}\right) - (1-\alpha)(1-\tau_\Pi)\alpha A_0 \hat{n}^{\alpha-1} \cdot \frac{\partial \hat{n}}{\partial \bar{i}}, \quad \text{and}$$

$$\frac{\partial \widetilde{\lambda}}{\partial \bar{i}} = \frac{\tau_\Pi - \tau_B}{(1-\tau_B)\Lambda} \lesseqgtr 0,$$

where $\frac{\partial \hat{n}}{\partial \widetilde{\lambda}}$ and $\frac{\partial \hat{\gamma}}{\partial \widetilde{\lambda}}$ are reported in (32) and (33), respectively. ■

Proposition 2 clearly indicates that the monetary transmission mechanism includes not only the interest-rate channel, but also the balance-sheet channel. The conventional interest-rate channel indicates that a higher nominal interest rate $\bar{i}$ raises the yields on government bonds and this opportunity cost discourages households from holding money. Under the CIA constraint, as households decrease their holdings of money balances, consumption decreases as well. Since, as shown in (4), consumption is substituted by leisure, households decrease their labour supply. As a result of the decrease in employment, the marginal product of physical capital decreases and the growth rate thereby falls.[13]

The balance-sheet channel, however, may give rise to an opposite effect on employment and growth in the presence of an endogenous debt-equity ratio. As shown in (15), a higher nominal

[13] Alternatively, (15) shows that a higher nominal interest rate pushes up the firms' user cost of capital WACC and this then leads to a deterioration in the balanced-growth rate.

interest rate increases the user cost of issuing equities and corporate bonds. As mentioned previously, if $\tau_\Pi > \tau_B$, the tax shield effect indicates that a higher nominal interest rate induces the firm to choose a higher debt-equity ratio λ so as to decrease its tax burden. By acting as a financial accelerator, the rise in the debt-equity ratio stimulates more investment and in turn boosts employment and growth. By contrast, if $\tau_\Pi < \tau_B$, the firm lowers its debt-equity ratio in response to a higher nominal interest rate. When the opposite result emerges, a higher nominal interest rate has an unambiguously negative effect on employment and growth. Of particular note, existing studies on CIA constraints refer to a negative growth effect by either shedding light on an endogenous labour-leisure decision (Gomme, 1993) or the liquidity constraint on investment (Marquis and Reffett, 1991; Wang and Yip, 1992 and Mino, 1997). In a way that differs from theirs, we emphasize that the monetary consequence results from not only the interest-rate channel via the labour-leisure decision, but also the balance-sheet channel via the firm's financial decision. The latter balance-sheet channel, which is ignored by the conventional CIA models, may give rise to a positive, rather than negative, effect on the balanced-growth rate.

Besides, Proposition 2 indicates that a rise in the nominal interest rate has an ambiguous effect on inflation. If the tax shield effect is substantial, leading the balance-sheet channel to dominate the conventional interest-rate channel, the level of employment increases in response to the rise in $\bar{i}$. As indicated in (18), this further increases the marginal product of capital (and hence the real interest rate). Consequently, a higher nominal interest rate can be associated with a lower inflation rate, provided that the employment effect of the balance-sheet channel is substantially strong. That is, the prediction of the Fisher equation may be invalid. This ambiguity is consistent with the empirical findings of Mishkin (1992), Evans and Lewis (1995) and Bierens (2000), who show that the relationship between the nominal interest rate and inflation rate is not at all robust. Even though the Fisher effect is widely accepted in macroeconomic theory, a stable one-for-one relationship between nominal interest rates and inflation has proved difficult to establish empirically (see, for example, Malliaropulos, 2000 and Lanne, 2006). By shedding light on a commonly-neglected channel – the balance-sheet channel – of the monetary transmission mechanism, our study reconciles the discrepancy between theory and practice.

IV.2 Effects of Tax Policy

We now turn to an investigation of the macro effects of three distinct taxes τ_Π, τ_E and τ_B on corporate finance.

Proposition 3. (Effects of a Corporate Income (Profit) Tax) *Under Assumptions 1-3, a rise in the corporate income tax τ_Π has an ambiguous effect on the steady-state employment $\hat{n}$, inflation $\hat{\pi}$, and growth $\hat{\gamma}$, while it unambiguously raises the debt-equity ratio $\hat{\lambda}$.*

Proof. From (20), (25), (30), and (31), we obtain:

$$\frac{\partial \hat{n}}{\partial \tau_\Pi} = -\frac{1}{\Delta}(1-\alpha)A_0\hat{n}^\alpha + \underbrace{\frac{\partial \hat{n}}{\partial \widetilde{\lambda}} \cdot \frac{\partial \widetilde{\lambda}}{\partial \tau_\Pi}}_{balance-sheet\ channel\ (+)} \lesseqgtr 0,$$

$$\frac{\partial \hat{\gamma}}{\partial \tau_\Pi} = -\left[1 + \frac{(1-\tau_\Pi)(1-\alpha)}{\Psi}\right](1-\alpha)A_0\hat{n}^\alpha + \underbrace{\frac{\partial \hat{\gamma}}{\partial \widetilde{\lambda}} \cdot \frac{\partial \widetilde{\lambda}}{\partial \tau_\Pi}}_{balance-sheet\ channel\ (+)} \lesseqgtr 0,$$

$$\frac{\partial \hat{\pi}}{\partial \tau_\Pi} = -\frac{\partial \hat{\gamma}}{\partial \tau_\Pi} \lesseqgtr 0, \quad \text{and} \quad \frac{\partial \widetilde{\lambda}}{\partial \tau_\Pi} = \frac{\bar{i}}{(1-\tau_B)\Lambda} > 0,$$

where $\frac{\partial \hat{n}}{\partial \widetilde{\lambda}}$ and $\frac{\partial \hat{\gamma}}{\partial \widetilde{\lambda}}$ are reported in (32) and (33), respectively. ■

In the presence of the endogenously-determined debt-equity ratio, the corporate income tax could either negatively or positively affect employment, growth, and inflation, depending on the relative magnitude between the tax discouraging effect and the tax shield effect. On the one hand, a higher corporate income (profit) tax rate lowers the after-tax return on capital, which discourages firms from investing. It gives rise to an unfavorable impact on employment, growth, and inflation. On the other hand, a higher profit tax triggers the tax shield effect, inducing firms to raise their debt-equity ratios. As a financial accelerator, a higher debt-equity ratio gives rise to a beneficial impact on employment, growth, and inflation.

This result is different from the conventional wisdom of public economics whereby the firm's decision is immune to the profit tax and, accordingly, profit tax is neutral vis–à-vis the economy's performance. Our result also contradicts the existing findings in the macroeconomics literature, such as Turnovsky (1990) and Strulik (2003). Due to the lack of the consideration of an endogenous debt-equity ratio, their studies ignore the important tax shield effect and financial leverage effect and, accordingly, refer to an unambiguously negative effect of the profit tax on output/growth. [14]

Proposition 4. (Effects of Taxes on Bondholders and Stockholders) *Under Assumptions 1-3,*

(i) an increase in the tax rate imposed on the bondholders τ_B lowers the debt-equity ratio, employment and growth, but raises inflation.
(ii) an increase in the tax rate imposed on the stockholders τ_E raises the debt-equity ratio, while it has mixed effects on employment, growth, and inflation.

Proof. By using (20), (25), (30), and (31), we immediately have:

$$\frac{\partial \hat{n}}{\partial \tau_B} = \underbrace{\frac{\partial \hat{n}}{\partial \widetilde{\lambda}} \cdot \frac{\partial \widetilde{\lambda}}{\partial \tau_B}}_{balance-sheet\ channel\ (-)} < 0,$$

$$\frac{\partial \hat{\gamma}}{\partial \tau_B} = \underbrace{\frac{\partial \hat{\gamma}}{\partial \widetilde{\lambda}} \cdot \frac{\partial \widetilde{\lambda}}{\partial \tau_B}}_{balance-sheet\ channel\ (-)} < 0,$$

$$\frac{\partial \hat{\pi}}{\partial \tau_B} = -\frac{\partial \hat{\gamma}}{\partial \tau_B} > 0, \qquad \frac{\partial \widetilde{\lambda}}{\partial \tau_B} = -\frac{(1-\tau_\Pi)\bar{i}}{(1-\tau_B)^2 \Lambda} < 0,$$

$$\frac{\partial \hat{n}}{\partial \tau_E} = -\frac{1}{\Delta}\phi + \underbrace{\frac{\partial \hat{n}}{\partial \widetilde{\lambda}} \cdot \frac{\partial \widetilde{\lambda}}{\partial \tau_E}}_{balance-sheet\ channel\ (+)} \lesseqgtr 0,$$

$$\frac{\partial \hat{\gamma}}{\partial \tau_E} = -\left[1 + \frac{(1-\tau_\Pi)(1-\alpha)}{\Psi}\right]\phi + \underbrace{\frac{\partial \hat{\gamma}}{\partial \widetilde{\lambda}} \cdot \frac{\partial \widetilde{\lambda}}{\partial \tau_E}}_{balance-sheet\ channel\ (+)} \lesseqgtr 0,$$

$$\frac{\partial \hat{\pi}}{\partial \tau_E} = -\frac{\partial \hat{\gamma}}{\partial \tau_E} \quad \text{and} \quad \frac{\partial \widetilde{\lambda}}{\partial \tau_E} = \frac{\phi}{\Lambda} > 0. \qquad \blacksquare$$

[14] Instead of the endogenous debt-equity ratio, Strulik (2003) endogenizes the debt-capital ratio and rules out the possibility of issuing equity. Given that investment is financed by retained earnings or new debt, his specification implies that the financial leverage is fixed and WACC is simplified as the interest rate on bonds. Thus, he also predicts a negative effect of profit tax on growth. In addition, Strulik (2003) ignores the agency costs of equity, thus violating the intuitive assumption in the sense that an equity issue may involve higher information costs than a debt issue.

Imposing a higher tax on bondholders lowers the after-tax yields on corporate bonds and hence decreases the households' demand for corporate bonds. As shown in (15), this increases the firms' capital costs of issuing bonds $i^B = \frac{(1-\tau_\Pi)\bar{i}}{1-\tau_B} + a_B(\lambda)$ and hence the WACC increases. Moreover, (20) indicates that a higher tax on corporate bonds leads to a deterioration in the tax shield effect, lowering the debt-equity ratio. Since both effects lead firms to cut their investment projects, employment and growth fall and inflation rises in response to an increase in τ_B.

However, the impact of a tax on stockholders τ_E on employment, growth, and inflation is uncertain. A higher τ_E lowers the after-tax yield on equities and then decreases the households' demand for equities. As indicated in (15), this raises the firms' capital costs of issuing equities (and hence the WACC) and gives rise to an unfavorable effect on employment, growth, and inflation. However, when the firms' capital costs of issuing equities rise, firms are motivated to adopt a higher debt-equity ratio by issuing more corporate bonds, as shown in (20). Since the rise in the debt-equity ratio triggers the financial accelerator, employment and growth may rise and inflation may fall. In summarizing the results of Propositions 3 and 4, it seems that taxing equity yields has the worst consequence on the economy among those taxes.

IV.3 Non-optimality of the Friedman Rule

In line with Bailey (1956) and Friedman (1969), this sub-section will examine the optimal monetary policy. Social welfare is measured by the lifetime utility of the representative household specified in (1). Along the common balanced-growth rate $\hat{\gamma}$, the paths of consumption and capital are given by $c_t = c_0 e^{\hat{\gamma} t}$ and $k_t = k_0 e^{\hat{\gamma} t}$, respectively. Equation (28) implies that $c_0 = \hat{z} k_0$. Accordingly, social welfare is assumed to be bounded and can be computed as:

$$\widehat{U} = \frac{1}{\rho}\left[\ln(\hat{z}) + \ln(k_0) + \frac{\hat{\gamma}}{\rho} - \chi\frac{\hat{n}^{1+\varepsilon}}{1+\varepsilon}\right], \tag{34}$$

where $\hat{z} = A_0 \hat{n}^{\alpha} - \hat{\gamma} - \delta - \Sigma(\widetilde{\lambda})$ is obtained from (27) under the BGP equilibrium.

Based on this welfare function, we establish the following proposition:

Proposition 5. (Optimal Monetary Policy) *In the presence of the agency costs of debt and equity, the Friedman rule is not the socially optimal monetary policy.*

Proof. From (34), we can derive:

$$\frac{\partial \widehat{U}}{\partial \bar{i}} = \frac{1}{\rho}\left[\left(\frac{\alpha A_0 \hat{n}^{\alpha-1}}{\hat{z}} - \chi \hat{n}^{\varepsilon}\right)\frac{\partial \hat{n}}{\partial \bar{i}} + \left(\frac{1}{\rho} - \frac{1}{\hat{z}}\right)\frac{\partial \hat{\gamma}}{\partial \bar{i}} + \frac{1}{\hat{z}}\Sigma_{\widetilde{\lambda}}\frac{\partial \widetilde{\lambda}}{\partial \bar{i}}\right].$$

By some simple manipulations, we further have:

$$\frac{\partial \widehat{U}}{\partial \bar{i}} = \underbrace{\frac{-1}{\rho}\left[\frac{\bar{i}}{(1+\bar{i})^2} + \frac{(\hat{z}-\rho)(1-\tau_\Pi)(1-\alpha)}{\rho(1+\bar{i})}\right]\frac{1}{\Psi}}_{interest-rate\ channel\ (-)} + \underbrace{\frac{1}{\rho\hat{z}}\left(\frac{\bar{i}}{1+\bar{i}}\alpha A_0 \hat{n}^{\alpha-1}\frac{\partial \hat{n}}{\partial \widetilde{\lambda}} + \frac{\hat{z}-\rho}{\rho}\frac{\partial \hat{\gamma}}{\partial \widetilde{\lambda}} + \Sigma_{\widetilde{\lambda}}\right)\frac{\partial \widetilde{\lambda}}{\partial \bar{i}}}_{balance-sheet\ channel\ (\pm)},$$

where $\hat{z} - \rho = [1 - (1-\tau_\Pi)(1-\alpha)]A_0\hat{n}^{\alpha} + \tau_E\phi - \widetilde{\lambda}(1+\widetilde{\lambda})\Sigma_{\widetilde{\lambda}} > 0.$[15] ■

We can easily recover the conventional result $\frac{\partial \widehat{U}}{\partial \bar{i}} = -\frac{1}{\rho}\left[\frac{\bar{i}}{(1+\bar{i})^2} + \frac{(\hat{z}-\rho)(1-\tau_\Pi)(1-\alpha)}{\rho(1+\bar{i})}\right]\frac{1}{\Psi} < 0$ with $\hat{z} - \rho = \alpha A_0 \hat{n}^{\alpha}$ under a perfect financial market, by ruling out the distortion caused by agency cost ($a_B(\lambda) = a_E(\frac{1}{\lambda}) = 0$) and the government's interventions ($\tau_E = \tau_B = \tau_\Pi = 0$). Given that a

[15] It is reasonable to assume that the induced agency cost of increasing capital is not so large that the consumption-capital ratio is higher than the time preference rate. This empirically-plausible assumption is merely for ease of exposition without loss of generality.

rise in the nominal interest rate has a negative effect on welfare under the conventional interest-rate channel, the optimal monetary policy follows Friedman's rule and the optimal interest rate is set as zero, corresponding to a zero inflation tax.

However, the Friedman rule is not necessarily optimal, if the financial market is imperfect and the balance-sheet channel is taken into account. Recalling that $sgn(\frac{\partial \hat{\lambda}}{\partial \bar{i}}) = sgn(\tau_\Pi - \tau_B)$, the optimal monetary policy follows the Friedman rule only when the tax shield effect is absent ($\tau_\Pi \leq \tau_B$). Under such a situation, both the interest-rate and balance-sheet channels refer to a negative effect of the nominal interest rate on welfare ($\frac{\partial U}{\partial \bar{i}} < 0$). By contrast, if the profit tax on firms is larger than the yield tax on bondholders ($\tau_\Pi > \tau_B$) and the tax shield effect is substantial, the firm is inclined to raise the debt-equity ratio, which effectively decreases its average cost of capital (WACC is decreasing in λ, i.e., $\frac{\partial \tilde{\Gamma}}{\partial \tilde{\lambda}} < 0$). As such, relative to money, capital formation becomes more rewarding for achieving the social optimum. This generates a wedge between returns to money and returns to capital which leads the social planner to promote more capital and impose a tax on money. As a result, a positive nominal interest rate could be desirable to the society. That is why the Friedman rule is not optimal when the firm's capital structure (the debt-equity ratio) is endogenously determined and the balance sheet channel is taken into account.

V. CONCLUDING REMARKS

By specifying a generalized agency cost function, inclusive of both debt issue and equity issue, this paper has developed a monetary model of endogenous growth with an endogenously-determined debt-equity ratio. This flexible debt-equity ratio has been shown to play a crucial role in terms of governing the effects of monetary and tax policies on employment, growth, inflation, and welfare. Thus, we have provided new and insightful implications to the existing literature. Our analysis has suggested that the balanced-growth rate is independent of the debt-equity ratio *only* under a perfect financial market in which there is no distortion caused by agency cost and the government's taxation intervention. Instead, the debt-equity ratio can serve as a *financial accelerator*, which stimulates investment projects and boosts economic growth. This explains the empirical findings of Booth *et al.* (2001), Korajczyk and Levy (2003), and Hanousek and Shamshur (2011).

Given this additional balance-sheet channel, we have shown that an increase in the nominal interest rate has a mixed effect on the steady-state employment, inflation, the debt-equity ratio, and growth. Of particular interest, we have found that a higher nominal interest rate can be associated with a lower inflation rate; i.e., the prediction of the Fisher equation may be invalid. This is empirically plausible. As noted by Malliaropulos (2000) and Lanne (2006), although the Fisher prediction is widely accepted in macroeconomic theory, a stable one-for-one relationship between nominal interest rates and inflation has proved difficult to establish empirically.

In terms of taxation policy, we have shown that a rise in the tax rate on either firms' profits or stockholders' yield incomes unambiguously raises the debt-equity ratio, while having an ambiguous effect on the steady-state employment, inflation, and growth. This result sharply contradicts the existing findings in the macroeconomics literature, such as Turnovsky (1990) and Strulik (2003, 2008), who examine the corresponding effects under a real model. Moreover, we have found that an increase in the tax rate on bondholders decreases the debt-equity ratio, employment and growth, but raises inflation. By accounting for the balance-sheet channel (stemming from the flexible debt-equity ratio), our welfare analysis has indicated that the optimal nominal interest rate is not zero, thus contradicting the Friedman rule. The Friedman rule is valid only under the assumption of a perfect financial market in which the distortions caused by agency cost and the government's intervention are absent.

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