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The Spirit of Capitalism, Social Status, Money, and Accumulation

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This paper demonstrates the unambiguous existence of the Tobin portfolio-shift effect in the wealth-is-status and the spirit-of-capitalism models of growth. Namely, higher inflation leads to higher capital stock in the long run, and inflation increases the endogenous-growth rate of the economy.

Keywords: spirit of capitalism, social status, money, growth.

JEL classification: E1, E31, O42.

1 Introduction

Recently, Cole et al. (1992, 1995), Robson (1992), Fershtman and Weiss (1993), Bakshi and Chen (1996), and Zou (1994, 1995) have developed the wealth-is-status and the spirit-of-capitalism models of savings, growth, and asset pricing. The salient feature of these models is to define social status and wealth directly or indirectly in the representative agent's utility function. Including wealth in the preferences is an explicit way to model people's quest for social status as in Rae (1964), Veblen (1973), Duesenberry (1949), Spence (1974) and Frank (1985); it also reflects the spirit of capitalism in the sense of Max Weber (1958): individuals accumulate wealth not only for consumption, but also for its own sake.[1]

All these studies have considered the effects of social status and the spirit of capitalism on savings and growth in a real economy. This paper extends this new approach to a monetary economy and examines the effect of inflation on capital accumulation and growth. It is found that there exists unambiguously the Tobin (1965) portfolio-shift effect.

1 For detailed justifications, see Cole et al. (1992, 1995) and Zou (1994, 1995).

Specifically, in Sect. 2, we demonstrate that, for a perfect-foresight equilibrium and even with a separable utility function on consumption and real balances, higher inflation leads to a higher capital stock in the long run. In Sect. 3, still with a simple, separable utility function and with the same assumption on the production technology as in Rebelo (1987) and Barro (1990), we show that inflation increases the long-run balanced-growth rate. If the desire for social status and the spirit of capitalism are dropped from the model, the balanced-growth rate is independent of the growth rate of money. These findings stand in sharp contrast to the superneutrality result in the Sidrauski model, the negative effect of inflation on growth in the Stockman (1981) model, and many ambiguities regarding the connection between inflation and growth in other related studies.

2 The Model and Analysis

Here we first present the monetary extension of the wealth-is-status and the spirit-of-capitalism models. A representative agent maximizes a discounted utility defined on both consumption and wealth over an infinite time horizon subject to a dynamic constraint of wealth accumulation[2]:

$$\int_0^{\infty} (U(c, m) + \beta v(a))e^{-\rho t}\, dt \;, \tag{1}$$

where c is consumption, m is real balances, β is a nonnegative parameter, which measures the desire for social status and the intensity of the spirit of capitalism, ρ is the time discount rate ($0 < \rho < 1$), $U(c, m)$ is the utility from consumption and liquidity services as in the Sidrauski model, a is total wealth, namely, the sum of capital, k, and real balances:

$$a = k + m \;, \tag{2}$$

and $\beta v(a)$ is the utility[3] derived from wealth accumulation (the spirit of capitalism). It also represents the idea that absolute wealth is status as in Kurz (1968), Bakshi and Chen (1996), and Zou (1994, 1995).

2 Defining the utility function on both consumption and wealth or asset has also been done in Bardhan (1967), Kurz (1968), and Blanchard (1983) in modeling growth and foreign borrowing.

3 We need to point out that all the results obtained in this paper also apply to the alternative definition of the utility function $U(c, m) + \beta v(k)$ instead of $U(c, m) + \beta v(a)$.

A more sophisticated approach will consider the ratio of one's own wealth to the social-wealth index as the determinant of social status; see Duesenberry (1949), Spence (1974), Robson (1992), Bakshi and Chen (1996), and Rauscher (1997), among many others. That would be an interesting extension of the model considered here.

The dynamic constraint is given by:

$$\dot{a} = f(k) + x - c - \pi m - g \ , \tag{3}$$

and

$$\dot{a} = \dot{k} + \dot{m} \ , \tag{4}$$

where x is the lump-sum transfer from the government, π is the expected inflation rate, g is government spending, and $f(k)$ is the net output (equal to gross output minus capital depreciation). A dot over a variable denotes a time derivative. The utility function is increasing, concave, and differentiable in c, m, and a. The production function is neoclassical.

A representative agent maximizes (1) subject to the constraints (2) and (3). Following Calvo (1979), let λ_1 be the costate variable associated with the budget constraint (3) and λ_2 be the multiplier associated with the wealth definition (2). The Hamiltonian is given as follows:

$$\begin{aligned} H = \{&U(c, m) + \beta v(a) + \lambda_1[f(k) + x - c - \pi m - g\} \\ &+ \lambda_2(a - k - m)\}e^{-\rho t} \ . \end{aligned} \tag{5}$$

It is well-known that in the Sidrauski model, a separable utility function in consumption and real balances results in not only short-run, but also long-run superneutrality. To show how the wealth-is-status model differs from the Sidrauski model, we assume that $U(c, m)$ is separable in c and m:

$$U(c, m) = u(c) + l(m) \ . \tag{6}$$

The conditions necessary for a maximum are

$$u'(c) = \lambda_1 \ , \tag{7}$$

$$l'(m) = u'(c)(f'(k) + \pi) \ , \tag{8}$$

$$\beta v'(a) + u'(c)(f'(k) - \rho) = -u''(c)\dot{c} \ , \tag{9}$$

$$\lim a\lambda_1 e^{-\rho t} = 0, \quad t \to \infty \ , \tag{10}$$

plus the dynamic budget constraint:

$$\dot{k} + \dot{m} = f(k) + x - c - \pi m - g \; . \tag{3'}$$

By definition,

$$\dot{m} = (\theta - \dot{p}/p)m \; , \tag{11}$$

where θ is the constant rate of money growth, and p is the price level. On the perfect-foresight path, the expected inflation rate is equal to the actual one:

$$\dot{p}/p = \pi \; . \tag{12}$$

We also note that government transfer, x, is equal to the net increase in money supply:

$$x = \theta m \; . \tag{13}$$

Substituting (11), (12), and (13) into conditions (8) and (3′), and rewriting condition (9), we have:

$$\beta v'(a) + u'(c)(f'(k) - \rho) = -u''(c)\dot{c} \; , \tag{9}$$

$$[f'(k) + \theta - l'(m)/u'(c)]m = \dot{m} \; , \tag{14}$$

$$f(k) - c - g = \dot{k} \; . \tag{15}$$

In the steady state $\dot{c} = \dot{k} = \dot{m} = 0$. Two points about the steady-state equation (9) are worth noting here. First, as $\beta v'(\cdot)$ is positive, $(f'(k) - \rho)$ has to be negative in the steady state, namely, the steady-state capital is larger than the modified-golden-rule level of capital. Second, if β is zero in (9), we are back to the Sidrauski model, and capital accumulation is independent of monetary growth in both the short run and long run; because β is positive in our model, capital accumulation will in general depend on inflation.

As in the real-sector Kurz (1968) model, there often exist multiple equilibria in our monetary model. That is to say, depending on the initial conditions, different economies can have very different long-run steady states. Thus the convergence theorem in the standard neoclassical growth model such as Cass (1965) does not hold in our monetary growth model with social status and the spirit of capitalism. But in this paper we focus on an equilibrium with only one negative characteristic root; or stated differently, we focus on a perfect-foresight equilibrium. Denoting the steady-state capital, consumption, and real balances as k^*,

c^*, and m^*, and linearizing the dynamic system around them, we have:

$$\begin{bmatrix} \dot{c} \\ \dot{m} \\ \dot{k} \end{bmatrix} = \begin{bmatrix} -(f'(k^*) - \rho) & \dfrac{\beta v''(\cdot)}{-u''(c^*)} & \dfrac{\beta v''(\cdot) + u'(c^*) f''(k^*)}{-u''(c^*)} \\ \dfrac{l'(m^*) u''(c^*) m^*}{u'(c^*)^2} & \dfrac{l''(m^*) m^*}{-u'(c^*)} & f''(k^*) m^* \\ -1 & 0 & f'(k^*) \end{bmatrix} \cdot \begin{bmatrix} c - c^* \\ m - m^* \\ k - k^* \end{bmatrix} . \tag{16}$$

Call the 3×3 matrix in (16) as T. The trace of matrix T is positive:

$$\operatorname{tr} T = \rho - \frac{l''(m^*) m^*}{u'(c^*)} > 0 . \tag{17}$$

Since the trace is the sum of the three characteristic roots in our dynamic system, a positive trace implies that at least one characteristic root is positive. The determinant of matrix T, which we denote as Δ, does not possess a definite sign,

$$\begin{aligned} \Delta = {} & (f'(k^*) - \rho) f'(k^*) \frac{l''(m^*) m^*}{u'(c^*)} + f''(k^*) \frac{\beta v''(a^*) m^*}{u''(c^*)} \\ & + \frac{\beta v''(\cdot) + u'(c^*) f''(k^*)}{u''(c^*)} \frac{l''(m^*) m^*}{u'(c^*)} \\ & + \frac{\beta v''(\cdot)}{u''(c^*)} \frac{l'(m^*) u''(c^*) m^*}{u'(c^*)^2} f'(k^*) , \end{aligned}$$

where the second, third, and fourth terms are always negative, but the first term is positive.

As noted by Brock (1974), Calvo (1979), and Fischer (1979), a unique perfect-foresight path is crucial for the assumption of rational expectation in a monetary economy. In our model, this assumption amounts to a negative Δ. To see this point, we know that Δ is equal to the product of the three characteristic roots. Hence, a negative Δ implies that there are either one or three negative roots. Since the trace of matrix T is positive as shown in (17), at least one of the roots is positive. Therefore the dynamic system has one negative root and two positive roots. Since we have one state variable (capital stock) and two jumping variables (consumption and price) in our model, there exists a unique perfect-foresight path converging to the steady state.[4]

Proposition 1: Along the unique perfect-foresight path, a higher growth rate of money leads to more capital accumulation in the long run.

Totally differentiating Eqs. (9), (14), and (15) yields:

$$T\begin{bmatrix} \mathrm{d}c \\ \mathrm{d}m \\ \mathrm{d}k \end{bmatrix} = \begin{bmatrix} v'(\cdot)/u''(c^*)\,\mathrm{d}\beta \\ -m^*\,\mathrm{d}\theta \\ \mathrm{d}g \end{bmatrix}. \tag{18}$$

By Cramer's rule (and note that the determinant of T, Δ, is negative),

$$\frac{\mathrm{d}k}{\mathrm{d}\theta} = \frac{-\beta v''(\cdot)m^*}{\Delta u''(c^*)} > 0 . \tag{19}$$

We can offer some intuitions for this result. As the growth rate of money rises, inflation goes up and the cost of money holdings increases. In terms of utility from wealth accumulation, it is relatively cheaper to save more in the form of capital accumulation than real-balance holdings. Thus, the representative agent reduces his money stock. This is similar to the explanation of the Tobin portfolio-shift effect in an ad hoc monetary-growth model (see Tobin, 1965; also Sidrauski, 1967b). Of course, the result here is derived from an infinite-horizon model with the optimal choice of the representative agent instead of with some ad hoc equations of money demand and asset accumulation.

Consumption also increases as a result of higher inflation:

$$\mathrm{d}c/\mathrm{d}\theta = f'(k^*)\,\mathrm{d}k/\mathrm{d}\theta > 0 . \tag{20}$$

The effects of inflation on money demand are not clear-cut. To see this, use Cramer's rule in linear system (18),

$$\frac{\mathrm{d}m}{\mathrm{d}\theta} = \frac{1}{\Delta}(f'(k^*) - \rho)m^* f'(k^*) + \frac{\beta v''(\cdot) + u'(c^*)f''(k^*)m^*}{\Delta u''(c^*)} , \tag{21}$$

4 If Δ is positive, the dynamic system will have either three positive eigenvalues or two negative eigenvalues. The former case is a critical equilibrium point in the situation of multiple equilibria. The latter case gives rise to multiple converging paths, which are not admissible by the definition of the perfect-foresight equilibrium.

where the second term on the right-hand side is always negative, which represents the substitution effect of money demand, but the first term is positive, which represents the income effect of money demand since inflation leads to more capital accumulation, more output, and more consumption.

Proposition 2: The stronger the desire for social status and the capitalist spirit, the higher the steady-state capital. The higher the government spending, the lower the steady-state consumption and real balances. The effect of government spending on the steady-state capital is ambiguous.

Recall that in our model parameter β measures the desire for social status and the intensity of the spirit of capitalism. From (18), it is easy to show the positive effect of the capitalist spirit on long-run capital accumulation:

$$\frac{\mathrm{d}k}{\mathrm{d}\beta} = \frac{-l''(m^*)m^*v'(\cdot)}{\Delta u'(c^*)u''(c^*)} > 0 \,. \tag{22}$$

Zou (1994, 1995) offers both theoretical and empirical discussions of the spirit of capitalism for economic growth over time and across countries in a real-sector model. The rich implications of this proposition are also derived by Cole et al. (1992, 1995), Fershtman and Weiss (1993), and Bakshi and Chen (1996). In particular, this proposition provides a potential explanation for the divergent growth performance across countries. We refer interested readers to the above papers and evidence therein.

As for the effect of government spending on various variables in our model, we can show that, again from (18),

$$\frac{\mathrm{d}k}{\mathrm{d}g} = \frac{(f'(k^*)-\rho)l''(m^*)m^*}{\Delta u'(c^*)} + \frac{\beta v''(\cdot)l'(m^*)m^*u''(c^*)}{\Delta u''(c^*)u'(c^*)^2} \gtrless 0 \,, \tag{23}$$

$$\frac{\mathrm{d}m}{\mathrm{d}g} = \frac{-l'(m^*)u''(c^*)m^*[\beta v''(\cdot)+u'(c^*)f''(k^*)]}{\Delta u''(c^*)u'(c^*)^2} + \frac{1}{\Delta}(f'(k^*)-\rho)f''(k^*)m^* < 0 \,, \tag{24}$$

$$\frac{\mathrm{d}c}{\mathrm{d}g} = -\left\{\frac{\beta v''(\cdot)f''(k^*)m^*}{u''(c^*)} + \frac{[\beta v''(\cdot)+u'(c^*)f''(k^*)]l''(m^*)m^*}{u'(c^*)u''(c^*)}\right\}\frac{1}{\Delta} < 0 \,. \tag{25}$$

Therefore, an increase in government spending crowds out private consumption and real-balance holdings. To see the effect of government spending on capital accumulation, we look to the magnitude of its effect on consumption. From Eq. (25), the two terms in the parentheses are two of the three negative terms in Δ. But Δ also has one positive term. Hence, we do not know whether these two negative terms in (25) are larger or smaller than Δ (note that Δ is also negative by assumption). Differentiate equilibrium condition (15) with respect to g,

$$\mathrm{d}k/\mathrm{d}g = (1 + \mathrm{d}c/\mathrm{d}g)/f'(k^*) \ . \tag{26}$$

$\mathrm{d}k/\mathrm{d}g$ will be positive if $\mathrm{d}c/\mathrm{d}g$ is larger than minus one and negative if $\mathrm{d}c/\mathrm{d}g$ is smaller than minus one. That is to say, if government spending crowds out private consumption by more than a one-to-one ratio, then government spending can increase long-run capital accumulation. This result is also interesting when compared to the Sidrauski model, where government spending fully crowds out private consumption and exerts no effect on capital accumulation in the long run.

3 Inflation and Endogenous Growth

Even though recent studies on endogenous growth have reformulated many growth models, e.g., Romer's (1986) and Lucas' (1988) revisions of the traditional real-sector optimal-growth model and Barro's (1990) extension of the new model to include government spending, the monetary model, e.g., the Sidrauski model, has received little attention thus far. This is not strange considering we will show that in the Sidrauski model the balanced rate of growth is independent of the rate of monetary growth.

To derive an explicit solution to the endogenous-growth rate, we follow Barro (1990) and use a linear production function defined on the stock of capital:

$$f(k) = Ak \ , \tag{27}$$

where $A > 0$ is the constant net marginal product of capital.

The utility function is assumed to be of the simple form:

$$u(c) = \log c, \quad l(m) = \log m, \quad \beta v(a) = \beta \log a \ . \tag{28}$$

The equation of motion for asset accumulation is modified to be:

$$\dot{a} = Ak + x - c - \pi m \ , \tag{29}$$

$$a = k + m \ . \tag{30}$$

In writing Eq. (29), we have set government spending, g, equal to zero.

The representative agent maximizes a discounted logarithmic utility function defined in (28) subject to constraints (29) and (30). The optimal conditions are (λ is the costate variable):

$$\lambda = c^{-1} \ , \tag{31}$$

$$\lambda(A + \pi) = m^{-1} \ , \tag{32}$$

$$\beta(k + m)^{-1} + \lambda(A - \rho) = -\dot{\lambda} \ , \tag{33}$$

$$Ak + x - c - \pi m = \dot{k} + \dot{m} \ . \tag{34}$$

Again, by definition,

$$\dot{m} = (\theta - \dot{p}/p)m \ . \tag{11}$$

On the perfect-foresight path, the expected inflation rate equals the actual one:

$$\pi = \dot{p}/p \ . \tag{12}$$

In addition, government transfer, x, is just the revenue from inflation in our model without any other taxes:

$$x = \theta m \ . \tag{13}$$

Substituting (11), (12), and (13) into (32), (33), and (34), we obtain:

$$\lambda = c^{-1} \ , \tag{31}$$

$$m/c = (A + \theta - \dot{m}/m)^{-1} \ , \tag{35}$$

$$(m + k)/c = \beta(\rho - A - \dot{\lambda}/\lambda)^{-1} \ , \tag{36}$$

$$\dot{k} = Ak - c \ . \tag{37}$$

In the rest of this section, we focus on a particular solution to the dynamic system: the balanced-growth path. Along this path, all real variables grow at a constant rate. Let γ be the growth rate of consumption, $\gamma = \dot{c}/c = \dot{\lambda}/\lambda$. Differentiate (35) on both sides with respect to time and note that $\dot{m}/m$ is a constant: $\dot{m}/m = \dot{c}/c = \gamma$. Similarly from (37), $\dot{k}/k = \dot{c}/c = \gamma$. Therefore, on the balanced-growth path, consumption, real balances, and capital stock all grow at the same rate, γ.

Next we want to solve the balanced-growth rate, γ, in terms of the technology, the parameters of the preference, and the money growth rate. In (35), (36), and (37), substitute all the growth rates with the common variable λ:

$$m/c = (A + \theta - \gamma)^{-1} , \tag{38}$$

$$k/c = (A - \gamma)^{-1} , \tag{39}$$

$$(m + k)/c = \beta[\rho - (A - \gamma)]^{-1} . \tag{40}$$

Equation (38) plus (39) equals (40), $(A + \theta - \gamma)^{-1} + (A - \gamma)^{-1} = \beta[\rho - (A - \gamma)]^{-1}$. Simple algebra leads to

$$A - \gamma = \frac{-[(\beta + 1)\theta - 2\rho] \pm \sqrt{[(\beta + 1)\theta - 2\rho]^2 + 4(2 + \beta)\theta\rho}}{2(2 + \beta)} .$$

From (39), $(A - \gamma)$ has to be positive. Thus, the endogenous-growth rate is given by:

$$\gamma = A + \frac{[(\beta + 1)\theta - 2\rho] - \sqrt{[(\beta + 1)\theta - 2\rho]^2 + 4(2 + \beta)\theta\rho}}{2(2 + \beta)} . \tag{41}$$

In passing we note that, if the spirit of capitalism is not present in the model, in other words, if $\beta = 0$, the utility function is $(\log c + \log m)$ and the unique balanced-growth rate is directly given by Eqs. (31) and (33): $\gamma = A - \rho$, which is exactly the same as the case of the real economy and is independent of inflation. In this case, to generate positive growth, the net marginal product of capital has to be larger than the time discount rate.

In (41), we can show:

Proposition 3: The higher the monetary growth rate, the higher the endogenous-growth rate.

Proof: Differentiate γ with respect to θ in (41):

$$\frac{d\gamma}{d\theta} = \frac{1}{2(2 + \beta)} \left\{ (\beta + 1) - \frac{[(\beta + 1)\theta - 2\rho](\beta + 1) + 2(2 + \beta)\rho}{\sqrt{[(\beta + 1)\theta - 2\rho]^2 + 4(2 + \beta)\theta\rho}} \right\} , \tag{42}$$

which is shown to be positive in the appendix. □

The intuition for this result is as follows: with a higher rate of money supply and higher inflation, the representative agent tends to substitute real-balance holdings with capital. This stimulates the rate of investment and capital accumulation, which in turn raises the balanced-growth rate of the economy. In the end, as the balanced-growth rate goes up, the rise in the growth rate of money does not bring about a proportional rise in the inflation rate. To see this, just look at the following identity: $\dot{m}/m = \theta - \pi$. On the balanced-growth paths, $\gamma = \theta - \pi$. Differentiate this equation with respect to the growth rate of money: $\mathrm{d}\pi/\mathrm{d}\theta = 1 - \mathrm{d}\gamma/\mathrm{d}\theta < 1$. Therefore, inflation falls short of the growth rate of money.

Proposition 3 is a very strong result. It says that inflation not only stimulates long-run capital accumulation, but also increases the long-run economic growth rate. Accordingly, this result significantly extends the Tobin portfolio-shift effect in the context of endogenous growth.

Proposition 4: The stronger the desire for social status, the higher the balanced-growth rate.

Proof: In (41), differentiate γ with respect to parameter β, and rearrange terms,

$$\frac{\mathrm{d}\gamma}{\mathrm{d}\beta} = \frac{1}{2(2+\beta)^2}\left\{(\theta + 2\rho) + \sqrt{[(\beta+1)\theta - 2\rho]^2 + 4(2+\beta)\theta\rho} - \frac{(2+\beta)(\beta+1)\theta^2}{\sqrt{[(\beta+1)\theta - 2\rho]^2 + 4(2+\beta)\theta\rho}}\right\}, \tag{43}$$

which is shown to be positive in the appendix. □

As in the case of Proposition 2, Proposition 4 illustrates another implication of the cultural-economic approach in examining capital accumulation and economic growth. For a similar result in an economy without money, see Rauscher (1997).

4 Conclusion

In an infinite-horizon model of economic growth with social status and the spirit of capitalism, we have demonstrated that the Tobin portfolio-shift effect holds unambiguously: in the long run, inflation stimulates capital accumulation and increases the endogenous-growth rate. Our results overturn the superneutrality result in the Sidrauski model and the negative association between inflation and growth in the money-in-production model and the cash-in-advance model (Stockman, 1981). It also avoids the ambiguity in the leisure-in-utility model (Brock, 1974).

Appendix

Here we prove Propositions 3 and 4.

For Proposition 3, we only need to show that the terms in the parentheses of Eq. (42) are positive. Suppose not, then:

$$(\beta+1) < \frac{[(\beta+1)\theta-2\rho](\beta+1)+2(2+\beta)\rho}{\sqrt{[(\beta+1)\theta-2\rho]^2+4(2+\beta)\theta\rho}}\ . \tag{A.1}$$

For $\theta > 0$, the numerator on the right-hand side of (A.1) is positive, so both sides are positive. Take the square on both sides and cross multiply:

$$\begin{aligned}&(\beta+1)^2\{[(\beta+1)\theta-2\rho]^2+4(2+\beta)\theta\rho\}\\&<\{[(\beta+1)\theta-2\rho](\beta+1)+2(2+\beta)\rho\}^2\ .\end{aligned} \tag{A.2}$$

Expand the expression:

$$\begin{aligned}&(\beta+1)^2[(\beta+1)\theta-2\rho]^2+(\beta+1)^2(2+\beta)4\theta\rho\\&<(\beta+1)^2[(\beta+1)\theta-2\rho]^2+(\beta+1)^2(2+\beta)4\theta\rho\\&\quad-8\rho^2(\beta+1)(2+\beta)+4\rho^2(2+\beta)^2\ ,\end{aligned} \tag{A.3}$$

namely,

$$0 < -8\rho^2(\beta+1)(2+\beta)+4\rho^2(2+\beta)^2\ , \tag{A.4}$$

or,

$$0 < 4\rho^2(2+\beta)(2+\beta-2\beta-2)\ , \tag{A.5}$$

$$0 < -4\beta\rho^2(2+\beta)\ , \tag{A.6}$$

which is a contradiction, for both β and ρ are positive, and the right-hand side is negative. Hence the right-hand side of Eq. (42) is positive.

Next we show that the terms in the parentheses of Eq. (43) are positive, which is the same as:

$$(\theta + 2\rho) + \sqrt{[(\beta+1)\theta - 2\rho]^2 + 4(2+\beta)\theta\rho} > \frac{(2+\beta)(\beta+1)\theta^2}{\sqrt{[(\beta+1)\theta - 2\rho]^2 + 4(2+\beta)\theta\rho}} \,. \tag{A.7}$$

Multiply both sides by the positive number $([(\beta+1)\theta - 2\rho]^2 + 4(2+\beta)\cdot \theta\rho)^{1/2}$, and simplify:

$$(\theta + 2\rho)\sqrt{[(\beta+1)\theta - 2\rho]^2 + 4(2+\beta)\theta\rho} + 4\rho^2 + 4\theta\rho > (\beta+1)\theta^2 \,. \tag{A.8}$$

But the left-hand side of inequality (A.8) is the same as:

$$\begin{aligned}
&(\theta + 2\rho)\sqrt{(\beta+1)^2\theta^2 + 4\rho^2 + 4\theta\rho} + 4\rho^2 + 4\theta\rho \\
&> (\theta + 2\rho)(\beta+1)\theta + 4\rho^2 + 4\theta\rho \\
&> (\beta+1)\theta^2 \,,
\end{aligned} \tag{A.9}$$

which is just what we need to prove.

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