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STOCK MARKETS, GROWTH, AND POLICY

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ABSTRACT

In a model that emphasizes technological progress and human capital creation as essential features of economic development, this paper establishes a theoretical link between the financial system and per capita output growth. More specifically, it demonstrates that stock markets - by facilitating the ability to trade ownership of firms without disrupting the productive processes occurring within firms - naturally encourage technological innovation and economic growth. Along with recent studies of the role played by financial institutions other than stock markets in promoting growth, this paper contributes to a theoretical foundation upon which financial policy recommendations may more confidently rest.

The paper finds that direct and indirect taxes associated with stock market transactions slow real per capita output growth. Thus, given different policies toward financial markets, this paper helps to explain simultaneously the observed differences in growth rates across countries, the inability of measured factor inputs to explain these differences, and the close empirical association between the size of financial markets and the rate of economic growth.

STOCK MARKETS, GROWTH, AND POLICY

Ross Levine[1]

An extensive literature documents and discusses the role of financial markets in economic development.[2] In an exhaustive study of three dozen developed and developing countries over the period 1860-1963, Goldsmith (1969) provides evidence of a positive relationship between the ratio of financial institutions' assets to GNP and output per person. Goldsmith also presents data showing "that periods of more rapid economic growth have been accompanied, though not without exception, by an above-average rate of financial development." (p.48) This correlation between growth and the size of the financial system is also supported by more recent evidence [World Bank 1989]. Although it is appealing to conclude that financial markets foster growth, two cautionary statements by Goldsmith should be heeded: (1) It is difficult to establish "whether financial factors were responsible for the acceleration of economic development or whether financial development reflected economic growth whose mainsprings must be sought elsewhere" (p. 48); and (2) "there does not as yet exist a theory of financial structure and development as an integral part of modern economic theory" (p. 5).

This paper constructs a general equilibrium optimizing model that establishes a theoretical link between the financial system and economic

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2. See: Goldsmith 1969; McKinnon 1973; Shaw 1973; and the World Bank 1989.

development. More specifically, it demonstrates that stock markets - by facilitating the ability to trade ownership of firms without disrupting the productive processes occurring within firms - naturally encourage technological innovation and economic growth. Along with work by Bencivenga and Smith (1988), Jovanovic and Greenwood (1989), Greenwald and Stiglitz (1989), and Levine (1990), who study the role played by financial institutions other than stock markets in promoting growth, this study contributes to a theoretical foundation upon which financial policy recommendations may more confidently rest.[3] Unfortunately, this paper does not have a channel through which economic growth can encourage financial market development. Nonetheless, taking policies such as income taxes, corporate taxes, capital gains taxes, and financial market regulations as given exogenously, this paper reconciles three empirical regularities:[4]

(1) across countries and time there exist startling differences in real per capita growth rates with little tendency for convergence;

(2) it is difficult to explain these differences with measurable factor inputs; and

(3) across countries and time there is a positive correlation between the size of the financial system as a fraction of GNP and per capita growth rates.

3. Bencivenga and Smith (1988) construct a bank that allows investors to pool liquidity risk, which fosters a more efficient allocation of resources between illiquid, high-return projects and liquid, low-return projects. In Greenwood and Jovanovic (1989), growth increases investor participation in the financial intermediary. The intermediary is a research agency that, for a fee, provides information on the economy's aggregate shock. In Greenwald and Stiglitz (1989), financial markets allow managers to diversify the risk associated with individual projects by selling shares. Levine (1990) studies how banks, mutual funds, and investment banks in overcoming liquidity risk and informational externalities promote growth.

4. For evidence on (1) see: Summers and Heston 1984; Romer 1988, 1989; Barro 1989; and the World Bank 1989; regarding (2) see: Norsworthy 1984; the World Bank 1989; and Benhabib and Jovanovic 1989; and on (3) see: Goldsmith 1969; Cameron 1967; McKinnon 1973; Shaw 1973; and the World Bank 1989.

In order to explain these regularities, I examine one link between two growing literatures: the literature on endogenous growth and the literature on financial services. The endogenous growth literature, associated with the work of Romer (1986, 1990), Lucas (1988), and Becker, Murphy, and Tamura (1990), constructs a new set of economic models in which agents make investment decisions that fully determine the steady state growth rate of per capita output.[5] In studying the sources of economic growth, the endogenous growth literature typically abstracts from physical factor accumulation and instead focuses on the augmentation of technology and human capital. This paper maintains this focus: per capita growth only occurs if agents make investment decisions that lead to sufficiently high rates of human capital accumulation and technological innovation. Although the literature typically uses the terms "technology" and "human capital" interchangeably, Romer (1990) distinguishes technology - the instructions for combining raw materials into goods - from human capital - the ability to follow instructions and create new instructions. This distinction is unimportant in this paper because of the specific production processes that I study.

I also follow the literature in assuming that group interactions are the quintessential element of individual productivity growth. Human capital is produced in "firms", groups of people that invent, innovate, and produce together. Furthermore, as in Prescott and Boyd (1987), it takes "time" before individuals learn how to exploit fully the expertise of other group members. Thus, individuals must work with others for a long time before receiving the benefits of those interactions: higher levels of human capital and larger firm profits. In addition, the more physical resources an individual invests in a

5. This "new" literature is necessary because in the standard growth model (Solow 1956), steady state growth is given exogenously by technology.

firm the more skills he acquires. Finally, and unique to this paper, I consider potential externalities associated with physical resources in the creation of human capital. In particular, I assume that the average amount of resources invested by the firm positively affects the human capital of each individual independently of that individual's own investment. One can think of this externality as representing the public good aspect of physical resources within firms as well as other mechanisms discussed in the body of the paper. It is imperative to recognize that an individual who prematurely removes his resources from a firm reduces the rate of human capital accumulation of remaining members because of this externality in human capital production.

As in Diamond and Dybvig (1983), risk enters the model because individuals face privately observed shocks that lead to a demand for liquidity.[6] In particular, agents must decide how much to invest in firms that take a long-time to produce and distribute profits and how much to invest in a less profitable but more liquid asset that pays off in the short-run. After making investment decisions, some individuals discover that they want to have all of their wealth available before firms create new technologies, sell goods, and distribute profits. Agents receiving these shocks remove their resources and leave the firm, even if the "salvage" value of prematurely removing one's resources is small. Consequently, individuals may be reluctant to invest in firms; investment decisions will depend on agents' degree of risk aversion and expected relative rates of return between the high return, illiquid firm and the low return, liquid asset.

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6. There is no production risk: for a given level of inputs there is a given level of output.

Stock markets reduce liquidity risk by allowing those entrepreneurs receiving liquidity shocks to sell "shares" in their firms to other investors. Agents who do not receive a liquidity shock will want to purchase shares with their liquid assets because firms enjoy a higher rate of return than liquid assets. In an unrestricted environment, a market will form to allow agents to conduct mutually beneficial equity transactions. One result is that physical resources are not prematurely removed from firms to satisfy short-run liquidity requirements. Consequently, remaining firm members enjoy a higher rate of human capital accumulation. This efficiency effect is a product of the externality in human capital production. Even in the absence of this externality, however, stock markets may expand output. By increasing the liquidity of long-run projects, stock markets increase the quantity of resources devoted to productive firms.

Although "banking systems" have typically been proposed as endogenous institutional reactions to the liquidity problem modelled in this paper [Diamond and Dybvig 1983], the banking equilibrium is not incentive compatible unless severe restrictions are imposed on private asset transactions [Jacklin 1987; and Levine 1990]. Although the stock market equilibrium of this paper yields a lower level of expected utility for the representative agent than in the banking system case, the stock market equilibrium imposes significantly fewer restrictions on trading.

The paper goes on to examine the implications of consumption, income, corporate, and capital gains taxes. The most important finding from this study is that the more restrictive are the direct or indirect taxes associated with financial market transactions the smaller is the fraction of resources devoted to firms, the lower is the rate of human capital accumulation, and the slower is real per capita growth. Thus, given different policies toward financial markets, this paper simultaneously explains cross-country and intertemporal differences in growth rates; the inability of measured factor inputs to explain these differences; and the close association between the relative size of the financial market and economic growth.

I. The Basic Endogenous Growth Model

This section presents an overlapping generations endogenous growth model without a stock market and describes the economy's equilibrium. Growth is endogenous in the sense that given preferences and production functions agents make decisions that fully determine the steady state growth rate of per capita output. This section presents the model's structure and assumptions so that the effects of stock markets and policy can be studied in Sections II and III.

I.A. Preferences, Technology, and Trading

The economy consists of agents that live for three periods with the same large number of agents, N, born each period. Agents maximize utility:

$$(1) \quad u(c_1,c_2,c_3) = -\frac{[c_2 + \phi c_3]^{-\gamma}}{\gamma},$$

where $\gamma > -1$, $\gamma + 1$ is the coefficient of relative risk aversion, and c_t

is consumption in the t-th period of life. The agent-specific random variable ϕ becomes known at the start of the second period of life, and is distributed:

$$\phi = \begin{cases} 0 & \text{with probability} \quad 1-\pi \\ 1 & \text{with probability} \quad \pi. \end{cases}$$

As in Diamond and Dybvig (1983), agents care about the ability to consume all of their wealth at age two if $\phi=0$. This is the "desire for liquidity." Since an individual's type is not publicly observable, however, it is impossible to write standard, optimal insurance contracts.

Since no utility is gained from age one consumption, all age one income is saved. Consequently, neither the financial system nor policy can alter the savings rate, they can only alter the composition of savings.

There are three types of goods: a consumption good, a capital good, and human capital. Human capital is a non-tradable productive factor representing "knowledge" or technical skills embodied in individuals. Each agent is endowed with one unit of time in each period of life.

The consumption good is produced using capital, labor and human capital. As will be discussed below, only the old generation (the age three agents) has capital and human capital so that the firms producing consumption goods are owned by the old generation. Firms hire the unskilled labor of age 1 individuals and produce consumption goods with the following function:

(2) $y_t = h_t L_t^{1-\theta}, \quad 0 < \theta < 1$

where h_t is a composite input representing the level of human capital and physical capital of a representative entrepreneur in period t. One could think of h_t as representing the fixed factor of production in period t, e.g., the physical firm, the available expertise, knowledge, and patents of the entrepreneurs.[7] L_t is the number of labor units (of age 1 individuals) hired per entrepreneur in the firm in period t. The term y_t is the production of consumption goods per entrepreneur in period t. There is no production risk: for a given quantity of inputs there is a given amount of output. Each worker in period t is paid the wage rate w_t.

Assuming a competitive labor market in which labor is supplied perfectly inelastically, each unit of labor receives a wage rate equal to the marginal product of labor at time t,

(3) $w_t = (1-\theta) h_t L_t^{-\theta}$.

The total earnings of the age 1 labor force (per entrepreneur) in period t is $w_t L_t = (1-\theta) h_t L_t^{1-\theta}$, and the reward to each period t entrepreneur is

(4) $r_t = \theta h_t L_t^{1-\theta}$.

7. One can also think of this term as the endogenous growth version of "technology" in the standard neoclassical growth model.

Empirical evidence suggests that changes in measurable factor inputs such as capital and labor are able to account for considerably less than half of the observed growth rates in per capita output over the past one hundred years [Maddison 1987]. While physical factor accumulation is undeniably important for economic development, this paper focuses on the accumulation of knowledge and expertise.[8] Physical resources will, however, play a key role in producing human capital. In addition, this paper does not make a useful distinction between technology - the instructions for combining raw materials to make goods - and human capital - the ability to follow instructions and create new instructions. I assume that due to legal or technical considerations, newly invented technologies are only useful to the firms that created those new plans. Using Romer's (1990) terminology, firm created technology is perfectly excludable and therefore economically indistinguishable from rival goods such as human capital. Thus, I will simply refer to h_t as the level of human capital.

By explicitly modelling the production of human capital and the other production opportunities faced by individuals, this paper exemplifies one potential incentive behind the emergence of stock markets and one mechanism by which stock markets naturally promote economic growth. As in Prescott and Boyd (1988), human capital is produced using a technology that requires a group of agents working together for two periods and uses consumption goods as physical inputs. Agents joining human-capital-producing firms receive human capital only if they invest consumption goods and remain in the same firm for two periods. More specifically, an individual's accumulation of human capital depends positively on (1) interactions with other individuals; (2) the amount

8. It is straightforward to extend this model so that capital goods are produced using human capital and consumption goods.

of resources invested by the individual; and (3) the average amount of physical resources invested and maintained in the firm for two periods.

The first input represents the belief that people need to interact with other people in order to increase their own level of skills. This phenomenon has been stressed by Romer (1986), Lucas (1988), and others. The second input states that the more resources devoted to the accumulation of human capital by an individual the greater the amount of human capital received by the individual. Rebelo (1988) and King and Rebelo (1988) similarly model the importance of physical resources in the creation of technological skills. This paper also considers the potential externalities associated with physical resources in the creation of human capital as given by input (3): the average amount of resources invested by the firm positively affects the human capital of each individual member independently of that individual's own investment.

One can think of the physical resource externality associated with human capital production in a number of ways. For example, the purchase of a more powerful computer by one group member may aid other members via a public good externality, i.e., the computer is available to all firm members. Another avenue through which the average amount of resource maintained in a firm may positively influence individual human capital accumulation is via a joint human capital production function. A member who contributes a better computer to the firm will increase her own human capital, which, via her interactions with other members, will positively influence the human capital of others. Finally there may be a time-savings effect contributing to the positive external effects associated with physical resource investment in the coalition. By contributing a computer, an individual may have more time with which to interact with other members, increasing the rate of human capital accumulation of members who did not contribute the computer.

Formally, the two period human capital production function for the representative firm member is:

$$(5) \quad h_{t+2} = H\bar{W}^{\delta}_{t+2}(qw_t)^{\epsilon}, \qquad 1 < \delta, \epsilon < 0$$

where H is a constant, qw_t is the quantity of resources invested by the representative individual, and $\bar{W}_{t+2}$ represents the average quantity of physical resources per firm member maintained in the firm between periods t and t+2. More specifically, $\bar{W}_{t+2} = (1-\bar{\alpha}^i)(\bar{q}\bar{w}_t)/\pi$, where $\bar{\alpha}^i$ is the average fraction of physical resources removed from the firm at t+1, $\bar{q}\bar{w}_t$ is the average quantity of resources per entrepreneur invested in the firm in period t, and π is the fraction of initial entrepreneurs that remain in period t+2.

Agents who receive $\phi=0$ at age two and who therefore do not value period three consumption leave the firm prematurely at t+1. They remove their physical investment from the firm and receive x consumption goods per initial investment (qw_t). This "salvage" value is very small relative to the return that can be earned from remaining in the firm through period t+2.

Period t consumption goods may also be invested in a more liquid project that permits consumption in either period t+1 or t+2. There is no penalty for early withdrawal from this liquid project. The rate of return to this liquid-storage technology is equal to n, where n > x, but less than the return from remaining in the firm through period t+2. After receiving the wage rate (w) in the first period of life agents choose to invest the proportion q in the illiquid, human-capital-producing firm and (1-q) in the liquid storage technology.

I.B. Equilibrium without a Stock Market

Consider first a situation with a very limited financial market. Agents receiving $\phi=0$ at the beginning of their second period of life remove all of their physical investment from firms in order to consume their wealth at age two, so that $(1-\bar{\alpha}^{i}) = \pi$. This reduces the amount of physical resources available to other firm members, lowering $\bar{W}_{t+2}$, and thereby reducing the rate of human capital accumulation.

Let q equal the fraction of savings devoted to the firm, and (1-q) equal the fraction of savings devoted to the liquid asset. If she receives $\phi=0$ at t+1, then she consumes $qw_t x + (1-q)w_t n$. If she receives $\phi=1$ at age two, then she consumes $(1-q)w_t n + r_{t+2}$, where $r_{t+2} = \theta h_{t+2} L_{t+2}^{1-\theta}$ and where $h_{t+2} = H\bar{W}_{t+2}^{\delta}(qw_t)^{\epsilon}$. Thus, after working and receiving w_t, the representative young agent in period t simply chooses q to maximize expected utility:

$$(6)\quad \max_{q} \; -\frac{(1-\pi)[qw_t x + (1-q)w_t n)]^{-\gamma}}{\gamma} - \left(\frac{\pi}{\gamma}\right)[\theta H\bar{W}_{t+2}^{\delta}(qw_t)^{\epsilon} L_{t+2}^{1-\theta} + (1-q)w_t n]^{-\gamma}.$$

The first order condition is:

$$(7)\quad (1-\pi)(n - x)w_t[xqw_t + n(1-q)w_t]^{-(1+\gamma)} =$$

$$\pi\{\epsilon\theta H\bar{W}_{t+2}^{\delta} q^{\epsilon-1} L_{t+2}^{1-\theta} w_t^{\epsilon} - nw_t)\}[\theta H\bar{W}_{t+2}^{\delta}(qw_t)^{\epsilon} L_{t+2}^{1-\theta} + (1-q)w_t n]^{-(1+\gamma)}$$

This first order condition is easily simplified using a few equilibrium conditions and assuming that $\delta + \epsilon = 1$. Note that only the fraction π of the old agents are entrepreneurs because $1-\pi$ of the old agents liquidate their investment and leave firms at age two. In equilibrium, the total age one labor force (N) is hired by the total age three entrepreneurs (πN). Since L_t represents the units of age one labor per entrepreneur, $L_t = 1/\pi$. Also, since all agents are identical, $\bar{q}$ equals q. Thus, in equilibrium,

$$(8) \quad L_t^{1-\theta} = \psi, \quad \text{where} \quad \psi = \pi^{\theta-1},$$

$$\bar{w}_t = (1-\theta)\pi^{\theta}\bar{h}_t.$$

$$\bar{q} = q$$

$$(1-\bar{\alpha}^i) = \pi,$$

$$\bar{W}_{t+2} = (1-\bar{\alpha}^i)(\bar{q}\bar{w})/\pi = \pi(\bar{q}\bar{w})/\pi = w_t q.$$

Before deriving the investment allocation decision, q, it is worth defining the expected marginal rate of return of firm investment. Since each individual has probability π of remaining in the firm for two periods, the expected marginal return of firm investment is: $(1-\pi)x + \pi\epsilon H\theta\psi\bar{W}_{t+2}^{\delta}(qw)^{\epsilon-1}$. Using (8), the equilibrium expected marginal return to firm investment is:

$$\partial r_{t+2}/\partial(qw) = \epsilon\pi R + (1-\pi)x, \quad R = H\theta\psi.$$

This depends positively on the share of firm output going to entrepreneurs (θ), the size of the labor force available for firm production (ψ), the rate of human capital accumulation (H), the liquidation value of firm investment (x), the probability of being type 1 (π), and the perceived return, in terms of human capital accumulation, to investing in the firm (ϵ). The fraction ϵ

arises in this expression because agents do not internalize the external effects of their physical investment in human-capital-producing firms. A social planner, maximizing utility for a representative agent, would face an expected marginal return from firm investment of $\pi R + (1-\pi)x$.[9]

Substituting (8) into equation (7) the first order condition becomes

$$(7') \quad (1-\pi)(n-x)[xq + n(1-q)]^{-(1+\gamma)} = \pi\{\epsilon R - n\}[Rq + (1-q)n]^{-(1+\gamma)}.$$

Solving (7') for q yields

$$(9) \quad q = \frac{n(\lambda-1)}{(R-n) + \lambda(n-x)}, \quad \text{where} \quad \lambda = \left[\frac{\pi(\epsilon R-n)}{(1-\pi)(n-x)}\right]^{\frac{1}{1+\gamma}}.$$

This is the expression for the proportion of first period wages devoted to the firm. In order to have a solution for q that lies in the unit interval, assume that $R/x \geq \lambda \geq 1$. Given the risk involved in investing in the firm, it is not surprising to find that the greater the degree of relative risk aversion (γ) the lower the amount invested in the firm. Equation (9) also demonstrates that the higher the expected rate of return from human capital accumulation, ϵR, the more resources will be devoted to firms.

9. This model incorporates the notion that individuals perceive diminishing marginal returns to firm investment. If instead individuals see themselves as buying a share of final firm output proportional to their own investments, then the return to firm investment is $r_{t+2} = H\theta\psi\bar{W}_{t+2}(qw/\bar{q}\bar{w})$. The results under this specification can be obtained from this paper by setting ϵ to 1.

Since in equilibrium $y_t = \psi h_t$, the two period growth rate is:

$$g_y = y_{t+2}/y_t = h_{t+2}/h_t = \frac{H\bar{W}^{\delta}_{t+2}(qw_t)^{\epsilon}}{h_t}$$

Substituting the equilibrium values for $\bar{W}^{\delta}_{t+2}$, $\bar{q}$, and $\bar{w}_t$ and letting $\rho = (1-\theta)\pi^{\theta}$, the (two period) equilibrium growth rate of the economy is

$$(10) \quad g_y = H[(1-\theta)\pi^{\theta}]q = H\rho q = H\rho\left[\frac{n(\lambda-1)}{(R-n) + \lambda(n-x)}\right].$$

Per capita growth is inextricably linked to human capital accumulation: the greater the incentives for investment in human capital, the faster will be the rate of human capital accumulation and the higher will be per capita growth.[10]

In general, g_y may be greater or less than one so that per capita real growth may be positive or negative. It is worth noting that after one period when $1-\pi$ of the population receives $\phi=0$ and leaves the firms, they also remove their physical investment from firms. Since removal of physical capital from the human-capital-augmenting process reduces the per capita production of human capital, an institution or market that helps minimize the liquidation of <u>physical</u> investment in these projects may increase the economy's growth rate.

10. Since the aggregate savings rate is trivially set to one, it is the <u>form</u> of savings that is important.

II. Stock Markets and Growth

This section incorporates a "stock market." At the beginning of period two, each agent's ϕ is realized. At this point, type ϕ=1 agents (those who value period three consumption) may wish to purchase shares of firms that produce consumption goods in period three from type ϕ=0 agents (those who want to consume their wealth at age two). These shares are claims on the period three output of consumption goods. In the previous section, this exchange was not feasible so that agents receiving ϕ=0 were forced to withdraw their physical investment from firms to the detriment of all those remaining in firms. With a "stock market", however, agents valuing period three consumption may purchase shares in firms from those who do not value period three consumption. This has two important effects. The first depends importantly on the externality in human capital production. Stock market transactions eliminate the premature withdrawal of physical resources from firms, increasing the rate of human capital accumulation of remaining members, and promoting the growth rate of per capita output. The second effect does not necessarily depend on the externality in human capital creation. By increasing the liquidity of firm investment, stock markets encourage individuals to invest more in firms. This stimulates economy-wide production of human capital and economic growth. Thus, although the stock market does not allow individual entrepreneurs to coordinate and take advantage of the externality associated with the production of human capital, stock market transactions increase the positive role of the externality by providing a mechanism that unintentionally maintains a higher level of physical resources in firms and by encouraging individuals to invest more in firms.[11]

Stock market transactions take place in the first part of each period and other activities occur in the second part of the period. Therefore age one agents create and distribute shares by forming firms. At the beginning of age two agents learn whether their types. The resulting heterogeneity creates an incentive for stock market transactions. Agents who do not value period three consumption will sell their claims to period three consumptions goods as long as they receive a rate of return at least equal to x, the salvage value of their investment in the firm. Agents who value period three consumption will purchase period three consumption goods with their stored consumption goods as long as the price of period three consumption goods in terms of stored consumption goods is less than one.

II.A. Stock Market Equilibrium

Letting P equal the period two stock market price of claims to period three goods, a rational expectations equilibrium involves: (i) finding agents' optimal consumption/investment decisions in period two, given P and period one investment decisions; (ii) finding a P that clears the market in period two, given period one investment decisions; (iii) finding the optimal period one investment allocation decision, given P; and (iv) requiring period one market equilibrium.

11. This type of trading could go on within firms. But, owners would have to engage in the inconvenient and costly process of selling parts of the firm or enter into lengthy negotiations with other owners in order to acquire the necessary funds. By providing a cheaper and less disruptive mechanism for satisfying liquidity requirements, an impersonal stock market improves the ability of owners to cope with shocks. Furthermore, although the incentives for diversification are not modelled here, the stock market would allow individual investors to tailor their own portfolios.

Before characterizing the equilibrium it is worth establishing an important result. Let

α^n = the proportion of liquid assets consumed by agents valuing only period two consumption, and

α^i = the proportion of physical investment in firms removed prematurely in period two.

Then the following proposition holds:

<u>Proposition 1</u>: If $\epsilon\pi R^s > n > x$, then $\alpha^i = 0$ and $\alpha^n = 1$, where $R^s = \theta\psi H\pi^{-\delta}$.

If the equilibrium expected return from investing an extra unit in the firm is greater than the expected storage return which in turn is greater than salvage return of firm assets, then no resources are prematurely liquidated and all stored goods are consumed by agents valuing only age two consumption.

<u>Proof</u>: See Appendix A.

The condition for this proposition to hold: $\epsilon\pi R^s > n > x$ simply requires that in equilibrium the expected return from marginally increasing investment in the firm ($\epsilon\pi R^s$). is larger than the return from marginally increasing investment in the liquid asset (n) which is in turn larger than the "salvage" return (x) from the firm. If, in equilibrium, the return from investing in the liquid asset were higher than the return from investing in human capital, then no agent would invest in firm. If, on the other hand, the salvage return from the human capital project were higher than the return from the liquid asset, no agent would invest in the liquid asset. Thus, if $\epsilon\pi R^s > n > x$ does not hold, a relatively uninteresting corner solution results.

In this subsection on the stock market, q and $\bar{W}$ should be superscripted with an "s" to indicate that they correspond to an economy with a stock market. These superscripts are omitted for convenience until the end.

It is interesting to note that in the economy with a stock market, agents voluntarily relinquish their ability to salvage their physical investment in firms at rate x when they form firms and issue shares. This equilibrium result is demonstrated in Appendix A. Thus, over the relevant set of stock prices, these agents have a vertical supply curve of claims to period three consumption goods in period two.

Noting that at the start of period two each agent has a claim to $\pi\theta\psi H\bar{W}^{\delta}_{t+2}(qw_t)^{\epsilon}$ units of period three goods given period one investment decisions, and assuming that $\epsilon\pi R^{s} > n > x$, agents choose q to maximize expected utility after working and receiving wage w_t:

$$(11)\quad \max_{q} \; -\left(\frac{1-\pi}{\gamma}\right)\left[(1-q)nw_t + P\pi\theta\psi H\bar{W}^{\delta}_{t+2}(qw_t)^{\epsilon}\right]^{-\gamma} - \left(\frac{\pi}{\gamma}\right)\left[\pi\theta\psi H\bar{W}^{\delta}_{t+2}(qw_t)^{\epsilon} + \frac{(1-q)nw_t}{P}\right]^{-\gamma}$$

The first order condition for this problem is

$$(12)\quad (1-\pi)[\epsilon P\pi\theta\psi H\bar{W}^{\delta}_{t+2}w_t q^{\epsilon-1} - nw_t]\left[(1-q)nw_t + P\pi\theta\psi H\bar{W}^{\delta}_{t+2}(qw_t)^{\epsilon}\right]^{-\gamma-1} + (\pi/P)[\epsilon P\pi\theta\psi H\bar{W}^{\delta}_{t+2}w_t q^{\epsilon-1} - nw_t]\left[\pi\theta\psi H\bar{W}^{\delta}_{t+2}(qw_t)^{\epsilon} + \frac{(1-q)nw_t}{P}\right]^{-\gamma-1} = 0.$$

A little simplifying yields

$$(12') \quad \epsilon P\pi\theta\psi H\bar{W}^{\delta}_{t+2}\ w^{\epsilon}_{t}q^{\epsilon-1} = nw_t.$$

Re-introducing the superscript "s" to designate the stock market equilibrium, the following equilibrium conditions hold:

$$(13) \quad \bar{q}^s = q^s,$$

$$(1-\bar{\alpha}^i) = 1, \text{ (see Appendix A)},$$

$$\bar{W}^s_{t+2} = w_t\bar{q}^s/\pi, \text{ and}$$

$$\bar{w}_t = (1-\theta)\pi^{\theta}\bar{h}_t.$$

Imposing these equilibrium conditions and recalling that $R^s = \theta\psi H\pi^{-\delta}$ yields:

$$(14) \quad \epsilon\pi R^s P = n.$$

Now, conjecture that $P = \dfrac{(1-\bar{q}^s)n}{(1-\pi)R^s\bar{q}^s}$, substitute into (14) and solve for q^s,

$$(15) \quad q^s = \frac{\epsilon\pi}{1-\pi+\epsilon\pi}.$$

It is trivial to show that this q clears the market in period one. Also, since in period two the total equilibrium market supply of claims to period three consumption goods is $N(1-\pi)\pi R^s q^s w_t$, and the total market demand is

$N(1-q^s)\pi n w_t$, a rational equilibrium requires that the conjectured P and the q^s in (15) clear the market in period two, i.e., that $P(1-\pi)\pi R^s q^s w_t = (1-q^s)\pi n w_t$. Substitution demonstrates this result. Furthermore, given equilibrium q^s, the conjectured P equals $n/\epsilon\pi R^s$. Since $1 > n/\epsilon\pi R^s > x/\pi R^s$, this P is consistent with the requirements for a rational expectations equilibrium described in the appendix.

It is worth noting that the period one investment decision q^s does not depend on agent's degree of relative risk aversion. This arises because with stock markets, individuals face a fixed price for claims on period three consumption goods. Consequently, individuals perceive a constant unchangeable difference between consumption when $\phi = 0$ or consumption when $\phi = 1$. A marginal change in q by any single individual does not affect the proportion of consumption in the two states.[12]

In comparing the investment allocation decision in an economy with a stock market (15) with the investment allocation decision in an economy without a stock market (9), it is apparent that there exist parameterizations of the model such that without a stock market there is no investment in firms but the mere addition of stock market trading changes incentives sufficiently so that individuals do invest in firms. Investment in firms permits technological innovation and growth. Thus, financial policies that prohibit the formation of capital markets may severely discourage technological progress and economic development.

12. Banks, however, that pool and invest the savings of individuals recognize that alterations in q change the value of period three goods [Levine 1990].

II.B. The Growth Rate with a Stock Market

The (two period) equilibrium growth rate of the economy with a stock market, $y^s_{t+2}/y^s_t = h_{t+2}/h_t$, is

$$(16)\quad g^s_y \;=\; H\pi^{-\delta}\rho q^s \;=\; H\pi^{-\delta}\rho\,\frac{\epsilon\pi}{1-\pi+\epsilon\pi}\,.$$

Recall that the growth rate of the economy without a stock market is:

$$(10)\quad g_y \;=\; H\rho q \;=\; H\rho\left[\frac{n(\lambda-1)}{(R-n)+\lambda(n-x)}\right].$$

In comparing the growth rate of the economy with a stock market, with the growth rate of the economy without a stock market, there are two important factors to notice. First, even if the the investment allocation decisions q and q^s are equal, the growth rate of the economy with a stock market is greater than that of the economy without a stock market because $H\pi^{-\delta}\rho > H\rho$. This occurs because in the stock market economy, socially productive resources are not prematurely removed from firms when some agents experience a preference shock for period two consumption. Instead, these agents sell their shares to agents who value consumption in period three. The stock market thus fosters a more efficient use of resources by permitting a higher level of resources to be maintained in firms for any given first period investment decision. In particular, $\tilde{W}$, the externality associated with physical resources in the production of human capital, rises from an equilibrium value of qw in the non-stock market economy to a value of qw/π in the stock market economy. This increase in $\tilde{W}$ is a result of the natural functioning of the stock market. It does not imply that individual agents in the stock market economy perceive themselves as being able to influence the externality in human capital production. The rise in $\bar{W}$ accelerates the rate of human capital accumulation and increases the economy's per capita growth rate.

The second difference between the two economies is the investment allocation decision:

$$(17) \qquad q^S = \frac{\epsilon\pi}{1-\pi+\epsilon\pi}, \text{ and } q = \left[\frac{n(\lambda-1)}{(R-n) + \lambda(n-x)}\right]$$

If agents are sufficiently risk averse, $q^S > q$; the proportion of resources devoted to firms is higher with a stock market than without. Agents will seek to invest more in firms because the stock market increases the expected return from investing in firms in two ways. First, in the "bad" state, agents who ultimately leave firms can sell their shares in the stock market at a higher rate than they would receive from salvaging their physical investment in the firm. Second, in the "good" state, agents who remain in firms receive more human capital at age three because the stock market eliminates the premature liquidation of physical resources in the firm. As the growth equations indicate, the higher the proportion of the economy's resources invested in firms the greater will be the economy's growth rate. It follows that stock markets may foster growth by encouraging a larger proportion on an economy's resources to be invested in human-capital-producing firms.

Thus, the stock market may help promote long run growth by increasing the efficiency with which a given quantity of resources are used and by increasing the allocation of resources devoted to human capital production. This coincides with the data presented in the World Bank (1989) that suggests a positive relationship between the efficiency of investment - the change in GNP divided by investment - and financial market activity.

III. Tax Policy, The Stock Market, and Growth

This section examines the growth and resource allocation effects of various tax policies in the stock market economy. I consider four marginal taxes: a consumption tax (τ^c), a tax on wage earnings (τ^w), a corporate or firm tax (τ^f), and a capital gains tax (τ^g). That is, when agents sell their shares in the firm, the earnings they receive are taxed at the rate τ^g. The marginal taxes are assumed to be bounded by [0,1].

A. Formal Inclusion of Taxes

The marginal taxes alter equations (1), (3), and (4):

(1′) $$u(c_1,c_2,c_3) = \frac{[(1-\tau^c)c_2 + \phi(1-\tau^c)c_3 + T]^{-\gamma}}{\gamma}$$, T is government transfers,

(3′) $$w_t = (1-\tau^f)(1-\tau^w)(1-\theta)\ \pi^\theta h_t,$$

(4′) $$r = (1-\tau^f)\theta h_t\ \psi.$$

Equation (3′) is obtained by a representative entrepreneur maximizing profits by choosing L_t,

(18) $$L_t = \text{argmax}\ \{\ (1-\tau^f)h_t L_t^{1-\theta} - w_t^b L_t\ \}$$

where w_t^b is the wage rate before labor pays taxes.

Agents perceive themselves as having no influence over the level of transfers (T) from the government. Equation (1′) models the government as transforming tax revenues into private consumption goods and provides no avenue for the government to invest. (see Barro 1990 for a different perspective)

Given the revised structure, Proposition 1 becomes:

Proposition 2: $\alpha^{i} = 0$ and $\alpha^{n} = 1$, if $(1-\tau^{g})(1-\tau^{f})\epsilon\pi R^{s} > n > x$.

Proof: Straightforward given Appendix A.

Intuitively, the proposition indicates that as long as the tax system does not alter the fundamental structure of the model, no firm resources are prematurely liquidated and all of the economy's liquid assets are "paid" to agents that attach no utility to period three consumption in exchange for their claims to period three consumption. Furthermore, this implies that π of the liquid assets are taxed at rate τ^{g} since π of the agents remain in firms and purchase the shares of the agents that leave prematurely.

Thus, assuming that $(1-\tau^{g})(1-\tau^{f})\epsilon\pi R^{s} > n > x$, agents choose q to maximize expected utility:

$$(19)\quad \max_{q} \; -\left(\frac{1-\pi}{\gamma}\right)\left[(1-\tau^{c})(1-q)nw_{t} + (1-\tau^{c})(1-\tau^{g})(1-\tau^{f})P\pi\theta\psi H\bar{W}^{\delta}_{t+2}(qw_{t})^{\epsilon}\right]^{-\gamma}$$

$$-\left(\frac{\pi}{\gamma}\right)\left[(1-\tau^{c})(1-\tau^{f})\pi\theta\psi H\bar{W}^{\delta}_{t+2}(qw_{t})^{\epsilon} + \frac{(1-\tau^{c})(1-q)nw_{t}}{P}\right]^{-\gamma}$$

The first order condition for this problem after substituting the equilibrium conditions given in equation (13) is:

$$(20) \qquad \frac{(1-\pi)[(1-\tau^{g})(1-\tau^{f})P\epsilon\pi R^{s} - n]}{\left[(1-q)n + (1-\tau^{g})(1-\tau^{f})P\pi R^{s}q \right]^{1+\gamma}} = \frac{\pi[n - (1-\tau^{f})P\epsilon\pi R^{s}]}{\left[(1-q)n + (1-\tau^{f})P\pi R^{s}q \right]^{1+\gamma}} .$$

The first policy result is immediate. The consumption tax does not appear in the first order condition. Thus, it does not affect the choice of q, or the growth rate of the economy. This result emerges because the consumption tax affects all elements of the specified utility function equally. If leisure is valued and not taxed, or partially taxed, then a rise in the marginal consumption tax would probably induce a substitution into leisure and a reduction in the economy's growth rate.

In order to solve for a rational expectations equilibrium, conjecture that $P = \dfrac{(1-\bar{q}^{s})n}{(1-\tau^{f})(1-\pi)R^{s}\bar{q}^{s}}$ and solve for q:[13]

$$(21) \qquad q^{s\tau} = \frac{\{\pi/(1-\pi)\}\ \epsilon\pi\left[1-\pi+(1-\tau^{g})\pi\right]^{1+\gamma} + (1-\tau^{g})\epsilon\pi}{\{\pi/(1-\pi)\}\ [1-\pi+\epsilon\pi]\left[1-\pi+(1-\tau^{g})\pi\right]^{1+\gamma} + [1-\pi+(1-\tau^{g})]\epsilon\pi} < 1.$$

where the superscript "$s\tau$" has been added to distinguish this q, the proportion of resources invested in the firm, as the q chosen by maximizing agents in an economy with a stock market <u>and</u> marginal taxes. Also, note risk aversion reduces the resources invested in the firm: $\partial q^{s\tau}/\partial\gamma < 0$.

13. Appendix B derives (21). Furthermore, it is trivial to verify that this is a rational expectations equilibrium given the definition in Section II.

The per capita growth rate of this economy with a stock market and marginal taxes on wages, firms, and capital gains is:

$$(22)\quad g_y^{s\tau} = h_{t+2}/h_t = (1-\tau^f)(1-\tau^w)H\pi^{-\delta}\rho q^{s\tau}$$

$$= (1-\tau^f)(1-\tau^w)H\pi^{-\delta}\rho \frac{\{\pi/(1-\pi)\}AC + B}{\{\pi/(1-\pi)\}aC + b} .$$

where:

$a = 1-\pi+\epsilon\pi$, $A = \epsilon\pi$, $b = 1-\pi+(1-\tau^g)\epsilon\pi$, $B = (1-\tau^g)\epsilon\pi$, and $C = \left[1-\pi+(1-\tau^g)\pi\right]^{1+\gamma}$,

Equation (22) indicates that wage and corporate taxes directly lower the economy's per capita growth rate by reducing the quantity of resources available for future production. The capital gains tax only affects growth indirectly by altering the first period investment allocation decision. The effect on $q^{s\tau}$ of a marginal increase in the capital gains tax is:

$$(23)\quad \frac{\partial q^{s\tau}}{\partial \tau^g} = \frac{\left[\left(\frac{\pi}{1-\pi}\right)A\,\frac{\partial C}{\partial \tau^g} - A\right]\left[\left(\frac{\pi}{1-\pi}\right)aC + b\right] - \left[\left(\frac{\pi}{1-\pi}\right)a\,\frac{\partial C}{\partial \tau^g} - A\right]\left[\left(\frac{\pi}{1-\pi}\right)AC + B\right]}{D} < 0.$$

where $D = \left[\left(\frac{\pi}{1-\pi}\right)aC + b\right]^2$.

Equation (23) is derived in Appendix B, where I also demonstrate that $\partial q^{s\tau}/\partial \tau^g$

is negative.[14] That is, an increase in the capital gains tax reduces the fraction of resources invested in the firm. A sufficiently large tax on stock market transactions could actually induce agents not to transact in the stock market at all. If the impediments to stock market transactions are large enough to cause financial dis-intermediation, the economy resorts back to the slower growth financial structure of an economy without a stock market.

Thus, capital gains taxes reduce the per capita growth rate of the economy

$$(24)\quad \partial g_y^{s\tau}/\partial\tau^g \;=\; (1-\tau^f)(1-\tau^w)H\pi^{-\delta}\rho\,\frac{\partial q^{s\tau}}{\partial\tau^g} \;<\; 0.$$

B. Discussion of Tax Policy

The source of growth in this model economy is human capital creation. Since the rate of human capital accumulation is positively related to the quantity of resources invested and maintained in firms, taxes that lower investment in firms, ceteris paribus, lower per capita growth rates. Therefore, either a reduction in the fraction of an economy's resources devoted to human capital augmenting firms or a reduction in the total quantity of resources available for investment will lower the economy's growth rate. The consumption tax in this model does not affect the fraction of resources

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14. The capital gains tax reduces equilibrium q and therefore increases equilibrium P. The increase in P partially counteracts the disincentives for firm investment. But, individual investors do not perceive themselves as influencing the market determined level of P through individual choices of q. Thus, the effect of a change in P on the investment allocation decision q turns out to be a secondary effect in an environment where individuals transact in the stock market. See Levine 1990 for a discussion of the effects of capital gains taxation when large mutual funds conduct stock market transactions.

devoted to human capital accumulation or the total amount of resources available for productive investment. Therefore the consumption tax does not alter the economy's per capita growth rate. This result occurs because the consumption tax affects all elements of the utility function equally. If some elements of the utility function are taxed differentially there would be some substitution and this severe result would not emerge.

The wage and corporate taxes reduce growth by directly reducing the quantity of resources available for investment. In the current model, wage earnings equal savings. Thus, a wage tax is a direct tax on savings that lowers the total quantity of resources available for productive investment. Since people typically consume some of their wages, this model probably exaggerates the effect of a wage tax on growth. Similarly, the corporate tax shifts-back the demand curve for labor and reduces the equilibrium wage rate. The implied reduction in savings lowers investment in human capital production and thereby lowers the economy's per capita growth rate. The corporate tax will generally not alter q. But, if the corporate tax is large enough, investment in human capital will end, along with economic growth.

Capital gains taxes, or in this model taxes on stock market transactions, also affect per capita growth rates. The capital gains tax may be broadly interpreted as official regulations and impediments to financial market transactions as well as direct taxation of stock market activities. These "taxes" do not directly lower the quantity of resources available to agents making investment decisions. Rather, capital gains taxes alter the investment allocation decision. The capital gains tax lowers each individual's expected return from investing in firms because the tax lowers the expected re-sale value of the individual's ownership claims. This reduces the fraction of resources invested in human capital production and thereby lowers steady state per capita growth. Thus, cross-country differences in policies toward financial markets may help explain the observed differences in per capita growth rates without requiring differences in the accumulation of more easily measured factor inputs.

The relative size of the financial system as a fraction of gross domestic product is a commonly used measure of the significance of the financial system. In the current model, this may be approximated by taking the ratio of stock market transactions of generation t (the transactions in period t+1) to the output generated by generation t (production in period t+2). If we consider an economy with only a corporate tax, for example, this ratio is given by $(1-\pi)\pi(1-\tau^f)\theta$. Since the growth rate of the economy in the case with only a corporate tax is $g_y^{s\tau} = (1-\tau^f)H\pi^{-\delta}\rho q^{s\tau}$ and $q^{s\tau}$ is independent of τ^f, the relative size of the financial system will be positively correlated with the economy's growth rate; the relative size of the financial system and growth are both negatively correlated with the corporate tax rate. Thus, given different tax policies, the model is capable of explaining the positive correlation between measures of the relative size of financial markets and real per capita growth rates found in the data.

In this model there exist many avenues through which public policy can positively influence welfare. Appropriate financial market policies will promote the creation and efficient functioning of firms that produce new technologies and promote economic welfare. In addition, by recognizing even partially the externality associated with human capital investment, the government could perform the revenue neutral policy of raising consumption taxes and reducing corporate taxes, which would increase the growth rate of the economy. Similarly, one could extend the model along the lines of Barro (1990) to study the growth effects of specific types of public expenditures.

In this admittedly over-simplified environment, it is possible to ask the question: given the choice of marginally reducing the wage tax, the corporate tax, or the capital gains tax, which tax reduction would induce the greatest improvement in per capita growth? As demonstrated in Appendix B, reductions in the wage and corporate taxes are more potent than the capital gains tax when evaluated at small marginal tax rates. Since the corporate and wage taxes directly tax savings in this model, their effects are probably exaggerated. Therefore, this result should not be taken too seriously but instead stimulate further inquiry in the relationship between public policy and per capita growth rates.

IV. Conclusion

This paper addressed the question: how do stock markets and public policy affect the growth rate of real per capita output? Although the profession has assumed that well-functioning financial markets contribute to growth, it has failed to provide strong theoretical underpinnings for this presumption. Along with work by Bencivenga and Smith (1988), Jovanovic and Greenwood (1988), Greenwald and Stiglitz (1989), and Levine (1990), this paper provides support for the intuitively appealing notion that financial markets and policies toward financial institutions affect growth.

The model has two key elements: human capital production and privately observed liquidity shocks. Economic growth only occurs if agents make investment decisions that lead to a sufficiently high rate of human capital accumulation. This accumulation occurs in firms where a physical resource externality operates. The average amount of resources invested and maintained

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Appendix A

This appendix proves proposition 1, derives the equilibrium value of $\bar{W}$ when stock market transactions are permitted, and demonstrates that individuals will voluntarily relinquish the option of salvaging their physical stake in the firm if a stock market exists.

At the start of period 2 each agent has a claim to $\pi\theta\psi H\bar{W}^{\delta}_{t+2}(qw_t)^{\epsilon}$ units of period 3 goods given period 1 investment decisions. Each individual could turn these claims into xqw consumption goods in period 2 by salvaging his investment in the firm. Recall that $\pi\theta\psi H\bar{W}^{\delta}_{t+2}(qw_t)^{\epsilon} > xqw$. Let P equal the number of stored goods one has pay for a claim on a unit of period 3 goods (period 2 goods per period 3 goods).

I now examine the supply and demand curves in the stock market at the beginning of period 2, which is a market for claims to period 3 consumption goods. The supply curve is easily derived. If $P > x/[\pi\theta\psi H\bar{W}^{\delta}_{t+2}(qw_t)^{\epsilon-1}]$, $\phi=0$ agents sell their claims to period 3 goods instead of salvaging their shares in the firm. Set $\underline{P} = x/[\pi\theta\psi H\bar{W}^{\delta}_{t+2}(qw_t)^{\epsilon-1}]$. If $P > 1$, <u>all</u> agents would sell their claims on period 3 consumption goods. At $P = 1$, $\phi=1$ agents are indifferent between selling or not selling their claims to period 3 consumption. At $\underline{P} < P < 1$, $\phi=1$ agents will not sell their claims to period 3 consumption while $\phi=0$ agents are willing to sell all of their claims to period 3 consumption. If $P = \underline{P}$, $\phi=0$ agents are indifferent between salvaging their stake in the firm and selling their claims to period 3 consumption goods. And, for $P < \underline{P}$, $\phi=0$ agents salvage their stake in the firm, and so there is no supply of claims to period 3 consumption goods. This gives rise to the period 2 stock market supply curve for period 3 consumption goods depicted in Figure 1 as $\bar{a}\bar{b}\bar{c}\bar{d}\bar{e}\bar{f}$.

in firms is assumed to influence positively the human capital of each firm member independently of that individuals own investment. The liquidity shock that plagues some individuals creates two sets of agents: those who want to buy more shares in firms and those that want to sell their shares. In an unrestricted environment, a stock market emerges to facilitate mutually beneficial asset transactions. The stock market eliminates the premature removal of physical resources from firms and thereby increases the externality associated with human capital creation. In addition, stock markets improve the liquidity associated with investing in firms. This helps increase the fraction of resources devoted to firms irrespective of externalities. Each of these effects expedites technological progress and economic growth.

I show that taxing or impeding financial market activity lowers per capita growth rates. If we take policies toward financial markets as given exogenously, policy can explain the three stylized facts discussed in the Introduction. That is, different policies toward financial markets can lead to vastly different long-run per capita growth rates; they can lead to these differences without relying on variations in capital and labor; and these policy differences will induce the observed positive correlation between financial market activity and growth.

The current model investigates one financial arrangement - the ability to exchange ownership claims - that may arise in response to one economic condition - liquidity risk. Other financial arrangements may emerge in response to liquidity risk. Furthermore, financial markets and intermediaries may arise because they are efficient processors of information, inexpensive monitors of projects, and low cost coordinators of resources. Incorporating these characteristics into endogenous growth models would enhance our understanding of the role of financial markets in economic development.

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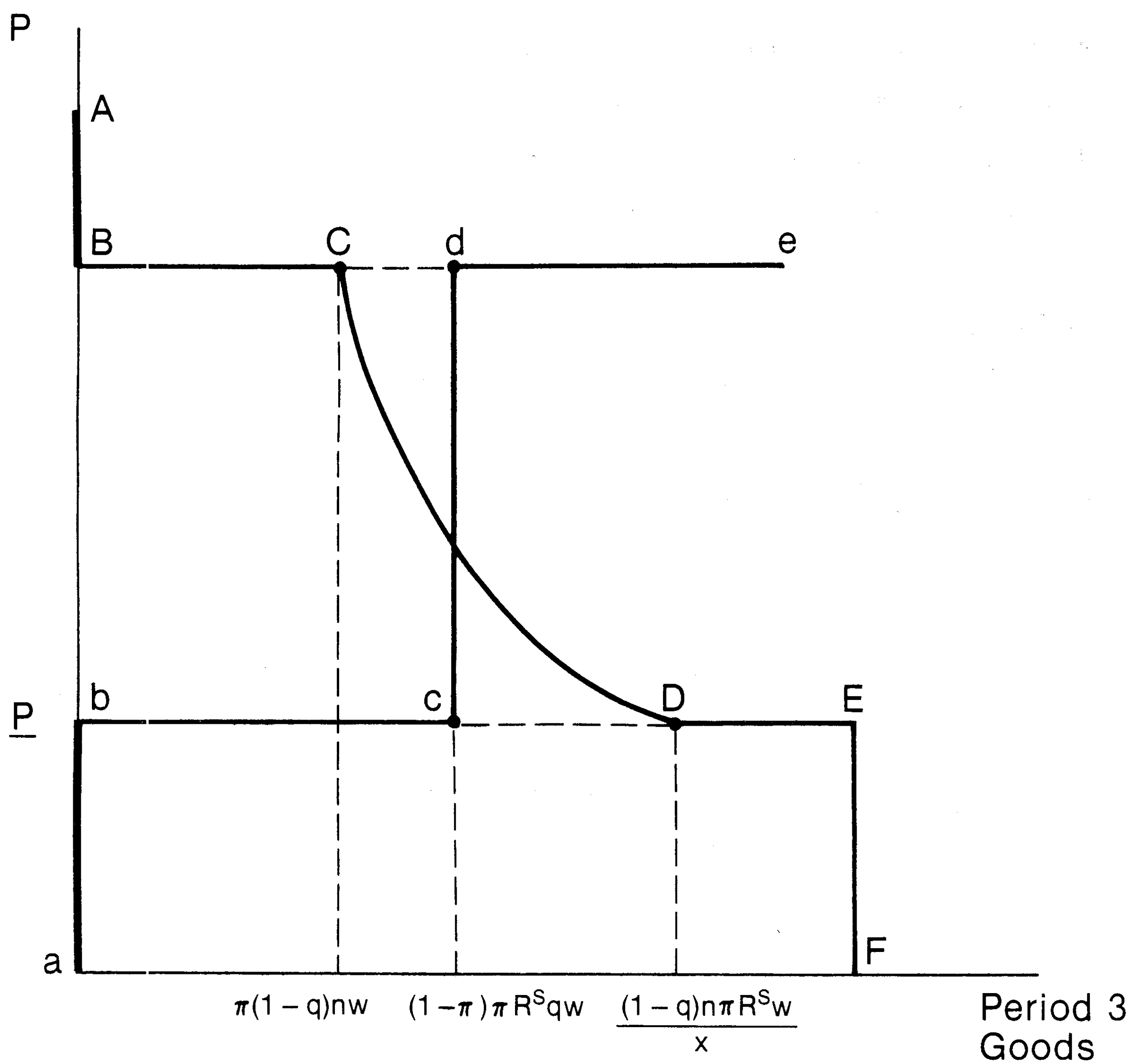
The demand curve for period 3 consumption goods is given in Figure 1 as $\bar{A}\bar{B}\bar{C}\bar{D}\bar{E}\bar{F}$. At $P > 1$, no agent will give-up period 2 goods for period 3 goods. At $P = 1$, $\phi=1$ agents are indifferent between consuming their stored goods in period 2 or using them to purchase period 3 consumption goods. At $\underline{P} < P < 1$, $\phi=1$ agents will use all of their stored goods to purchase period 3 consumption goods. At $P = \underline{P}$, $\phi=1$ agents not only want to purchase period 3 consumption with their stored goods but are also indifferent between salvaging their investment in their own firm and purchasing period 3 consumption goods via the stock market. Finally, at $P < \underline{P}$, $\phi=1$ agents want to use their stored goods <u>and</u> the salvage value of their stake in their firm to purchase period 3 consumption goods in the stock market.

Clearly, a rational expectations equilibrium does not exist at $P \geq 1$ or $P \leq \underline{P}$. At $P \leq \underline{P}$, no equilibrium exists because everyone salvages investment in all firms, there is no period 3 production. Furthermore, everyone - those who receive a $\phi=0$ and those who receive a $\phi=1$ - would alter his period 1 investment decision and store more goods in the liquid asset. Since $r > x$: those who receive $\phi=0$ would have preferred to store more goods because then consumption would be higher in period 2; those who receive $\phi=1$ would have preferred to store more goods because then they would have more period 2 consumption goods with which to purchase period 3 consumption goods at price P in the stock market. Since all agents would increase the proportion of investment in the storage technology if they expect $P \leq \underline{P}$, such a P is not a rational expectations equilibrium. Furthermore, the implied change in the period 1 investment decision will cause the demand curve to shift out and the supply curve to shift back in such way that an intersection will ultimately occur on the $\bar{C}\bar{D}$ part of the demand curve and the $\bar{c}\bar{d}$ part of the supply curve. This implies that no firm resources are salvaged ($\alpha^i=0$) so that in equilibrium $\bar{W}^{\delta} = (\bar{q}w/\pi)^{\delta}$. This also demonstrates that individuals will voluntarily relinquish the option of salvaging their physical stake in the firm if a stock market exists. This implies that in equilibrium the supply curve of claims to period 3 consumption goods is vertical.

Conversely, if $P \geq 1$, everyone would increase his period 1 investment in the firm. Consider, for example, $P = 1$. At this price, agents in period 2 can trade claims on period 3 consumption one-for-one for period 2 consumption goods. Therefore, in period 1, every agent wants to maximize his claims on period 2 or period 3 consumption goods, regardless of ϕ. A marginal increase in the proportion of period 1 wealth allocated to the firm increases claims to period 2 or period 3 consumption goods (at P=1) by $\epsilon\pi\theta\psi H\bar{W}^{\delta}_{t+2}w_t q^{\epsilon-1}$, which in equilibrium equals $\epsilon\pi\theta\psi H\pi^{-\delta}w_t$, and lowers them by nw_t. It follows that, if $\epsilon\pi\theta\psi H\pi^{-\delta} > n$, then at $P \geq 1$, all agents will increase the proportion of their period 1 wealth invested in the firm. Thus, such a P clearly is not a rational expectations equilibrium. Furthermore, the altered period 1 investment decision will cause the demand curve to shift back and the supply curve to shift out until an intersection occurs on the $\bar{C}\bar{D}$ part of the demand curve and the $\bar{c}\bar{d}$ part of the supply curve. This implies that all of the stored goods are consumed by type $\phi=0$ agents ($\alpha^n = 1$).

We have demonstrated that a rational expectations equilibrium can only occur on the $\bar{C}\bar{D}$ part of the demand curve and the $\bar{c}\bar{d}$ part of the supply curve as long as $\epsilon\pi\theta\psi H\pi^{-\delta} > n > x$. This implies that all of the goods stored in period 1 are consumed by those agents receiving $\phi=0$, and no physical investment in the firms is removed prematurely.

Figure 1.



Appendix B

This appendix (1) derives the investment allocation decision of a representative individual in an economy with a stock market and taxes that satisfy the conditions for a rational expectations equilibrium; (2) derives the effect of a marginal change in the capital gains tax on the investment allocation decision and the per capita growth rate of the economy and demonstrates that this effect is negative in both cases; (3) demonstrates that a marginal reduction in the wage tax or the corporate tax has a more positive impact on growth than a marginal reduction in the capital gains tax.

A. Derivation of $q^{s\tau}$

The maximization problem is given by equation (19) in the text:

$$(19) \quad \max_{q} \; -\left(\frac{1-\pi}{\gamma}\right)\left[(1-\tau^{c})(1-q)nw_{t} + (1-\tau^{c})(1-\tau^{g})(1-\tau^{f})P\pi\theta\psi H\bar{W}^{\delta}_{t+2}(qw_{t})^{\epsilon}\right]^{-\gamma}$$

$$-\left(\frac{\pi}{\gamma}\right)\left[(1-\tau^{c})(1-\tau^{f})\pi\theta\psi H\bar{W}^{\delta}_{t+2}(qw_{t})^{\epsilon} + \frac{(1-\tau^{c})(1-q)nw_{t}}{P}\right]^{-\gamma}$$

The first order condition for this problem after substituting the equilibrium conditions given in equation (13) is:

$$(20) \quad \frac{(1-\pi)[(1-\tau^{g})(1-\tau^{f})P\epsilon\pi R^{s} - n]}{\left[(1-q)n + (1-\tau^{g})(1-\tau^{f})P\pi R^{s}q\right]^{1+\gamma}} = \frac{\pi[n - (1-\tau^{f})P\epsilon\pi R^{s}]}{\left[(1-q)n + (1-\tau^{f})P\pi R^{s}q\right]^{1+\gamma}}.$$

In order to solve for a rational expectations equilibrium, conjecture that $P = \dfrac{(1-\bar{q}^{s})n}{(1-\tau^{f})(1-\pi)R^{s}\bar{q}^{s}}$ and solve for q. Substituting in for P yields:

$$\text{(B1)}\qquad \frac{(1-\pi)\left[(1-\tau^{g})\epsilon\pi(1-q)/(1-\pi)q - 1\right]}{\left[(1-q) + (1-\tau^{g})\pi(1-q)/1-\pi\right]^{1+\gamma}} = \frac{\pi\,[1 - \epsilon\pi(1-q)/(1-\pi)q]}{[\pi(1-q)/(1-\pi) + (1-q)]^{1+\gamma}}$$

A little simplification yields:

$$\text{(B2)}\qquad \frac{(1-\pi)\left[(1-\tau^{g})\epsilon\pi(1-q) - (1-\pi)q\right]}{\left[1 - \pi + (1-\tau^{g})\pi\right]^{1+\gamma}} = \pi\,[(1-\pi)q - \epsilon\pi(1-q]$$

and

$$\text{(B3)}\qquad \frac{q\left[1 - \pi + (1-\tau^{g})\epsilon\pi\right] + (1-\tau^{g})\epsilon\pi}{q\,[1 - \pi + \epsilon\pi] - \epsilon\pi} = \frac{\pi}{(1-\pi)}\left[1 - \pi + (1-\tau^{g})\pi\right]^{1+\gamma}.$$

Now, let:

$$a = 1 - \pi + \epsilon\pi, \qquad A = \epsilon\pi,$$

$$b = 1 - \pi + (1-\tau^{g})\epsilon\pi, \quad B = (1-\tau^{g})\epsilon\pi, \quad \text{and} \quad C = \left[1-\pi + (1-\tau^{g})\pi\right]^{1+\gamma},$$

so that

$$\text{(B4)}\qquad \frac{qb + B}{qa - A} = \frac{\pi C}{1-\pi}$$

where $a > b$, $A > B$, $a > A$, and $b > B$.

Finally, solving for q yields equation (21) in the text:

$$q = \frac{\frac{\pi}{1-\pi} AC + B}{\frac{\pi}{1-\pi} aC + b} \tag{21}$$

B. The Effects of the Capital Gains Tax

In order to determine the sensitivity of the investment allocation decision to marginal changes in the tax rate on capital gains note that

$$\frac{\partial A}{\partial \tau^g} = \frac{\partial a}{\partial \tau^g} = 0, \qquad \frac{\partial B}{\partial \tau^g} = \frac{\partial b}{\partial \tau^g} = - A, \quad \text{and} \tag{B5}$$

$$\frac{\partial C}{\partial \tau^g} = - \pi(1+\gamma) \left[1 - \pi + (1 - \tau^g)\pi\right]^{\gamma} < 0 .$$

Therefore,

$$\frac{\partial q^{S\tau}}{\partial \tau^g} = \frac{\left[\left(\frac{\pi}{1-\pi}\right) A \frac{\partial C}{\partial \tau^g} - A\right]\left[\left(\frac{\pi}{1-\pi}\right) aC + b\right] - \left[\left(\frac{\pi}{1-\pi}\right) a \frac{\partial C}{\partial \tau^g} - A\right]\left[\left(\frac{\pi}{1-\pi}\right) AC + B\right]}{D} \tag{B6}$$

where $D = \left[\left(\frac{\pi}{1-\pi}\right) aC + b\right]^2$.

To sign this derivative consider the numerator of (B6) which equals

$$\text{(B7)} \qquad \left(\frac{\pi}{1-\pi}\right)\left(\frac{\partial C}{\partial \tau^g}\right)[Ab - aB] - \left(\frac{\pi}{1-\pi}\right)AC[a - A] - A[b - B].$$

Since $a > A$ and $b > B$, the last two terms of (B7) are negative. Recall that $\frac{\partial C}{\partial \tau^g} < 0$. If $Ab - aB$ is positive, then the first term of (B7) is negative and $\frac{\partial q}{\partial \pi^g}$ is unambiguously negative.

$$\begin{aligned} Ab - aB &= \epsilon\pi\left[\left(1-\pi + (1-\tau^g)\epsilon\pi\right) - (1-\tau^g)(1 - \pi + \epsilon\pi)\right] \\ &= \epsilon\pi\left[(1-\pi) + (1-\tau^g)\epsilon\pi - (1-\tau^g)(1-\pi) - (1-\tau^g)\epsilon\pi\right] \\ &= \epsilon\pi(1-\pi)\tau^g \quad > 0, \end{aligned}$$

so that $\frac{\partial q}{\partial \tau^g} < 0$, which necessarily implies that $\frac{\partial g^{s\tau}}{\partial \tau^g} < 0$.

C. Tax Rate Comparison

Now compare the growth effects of marginally altering the wage, corporate, and capital gains tax at low marginal tax rates. In particular, evaluate $\left.\frac{\partial g^{s\tau}}{\partial \tau^g}\right|_{\tau^w=\tau^f=\tau^g=0}$, $\left.\frac{\partial g^{s\tau}}{\partial \tau^f}\right|_{\tau^w=\tau^f=\tau^g=0}$, $\left.\frac{\partial g^{s\tau}}{\partial \tau^w}\right|_{\tau^w=\tau^f=\tau^g=0}$.

First note that $\left.\frac{\partial g^{s\tau}}{\partial \tau^f}\right|_{\tau^w=\tau^f=\tau^g=0} = \left.\frac{\partial g^{s\tau}}{\partial \tau^w}\right|_{\tau^w=\tau^f=\tau^g=0} = \left.-H\pi^{-\delta}\rho q\right|_{\tau^w=\tau^f=\tau^g=0}$,

substituting for $\left.q\right|_{\tau^w=\tau^f=\tau^g=0}$ yields

(B8) $$\left.\frac{\partial g^{s\tau}}{\partial \tau^{f}}\right|_{\tau^{w}=\tau^{f}=\tau^{g}=0} = \left.\frac{\partial g^{s\tau}}{\partial \tau^{w}}\right|_{\tau^{w}=\tau^{f}=\tau^{g}=0} = \frac{-H\pi^{-\delta}\rho\epsilon\pi}{1-\pi+\epsilon\pi} .$$

Now consider $\left.\frac{\partial g^{s\tau}}{\partial \tau^{g}}\right|_{\tau^{w}=\tau^{f}=\tau^{g}=0} = H\pi^{-\delta}\rho \left.\frac{\partial q^{s\tau}}{\partial \tau^{g}}\right|_{\tau^{w}=\tau^{f}=\tau^{g}=0}$. Noting that $\left.\frac{\partial C}{\partial \tau^{g}}\right|_{\tau^{w}=\tau^{f}=\tau^{g}=0} = -\pi(1+\gamma)$ and $C\Big|_{\tau^{w}=\tau^{f}=\tau^{g}=0} = 1$, it is easy to show that

(B9) $$\left.\frac{\partial g^{s\tau}}{\partial \tau^{g}}\right|_{\tau^{w}=\tau^{f}=\tau^{g}=0} = \frac{-H\pi^{-\delta}\rho\epsilon\pi(1-\pi)^{2}}{(1-\pi+\epsilon\pi)^{2}} .$$

Now compare (B8) with (B9). Since $1 > \frac{(1-\pi)^{2}}{(1-\pi+\epsilon\pi)}$,

$$\text{Abs} \left.\frac{\partial g^{s\tau}}{\partial \tau^{w}}\right|_{\tau^{w}=\tau^{f}=\tau^{g}=0} = \text{Abs} \left.\frac{\partial g^{s\tau}}{\partial \tau^{f}}\right|_{\tau^{w}=\tau^{f}=\tau^{g}=0} > \text{Abs} \left.\frac{\partial g^{s\tau}}{\partial \tau^{g}}\right|_{\tau^{w}=\tau^{f}=\tau^{g}=0} ,$$

so that a marginal decrease in the wage or corporate tax has a larger positive impact on growth than a marginal decrease in the capital gains tax.

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