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**Entrepreneurship,
Innovation and Growth**

by

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Introduction

The three basic sources of growth in any economy are growth in inputs of production, improvements in the efficiency of allocation of inputs across economic activities, and innovation that generates new products, new uses for existing products and brings about increases in the efficiency of use inputs¹. Solow's (1957) path-breaking analysis of growth in the US economy during the first half of the twentieth century showed that the contribution of growth in inputs of production, namely labour and capital to aggregate growth, was around half, and the remaining half, that is the unexplained Solow residual, is commonly attributed to technical progress or the contribution of innovation in the sense I have used the term. Since by definition the residual growth is the difference between aggregate growth and the contributions of growth in factors of production; it is also called Total Factor Productivity growth or TFP growth. Whether or not TFP growth accounts for a similarly large share of output in East Asian economies of Korea, Singapore, and Taiwan has been debated (Young (1992, 1995) and Lau and Kim(1994)), in part on methodological grounds (for example, the dependence of estimates on essentially arbitrary assumptions about scale economies and functional forms for the aggregate production function) and in part on grounds of possible errors of measurement and biases in the data (Pack, 2001). I do not propose to enter into the debates on the empirics of estimating TFP growth except to note that despite all its problems, it is a useful summary measure of the outcome of innovation (or lack thereof) interpreted broadly. For this reason, I will be using TFP estimates in Section 4 of this paper. I will

¹ According to Webster's New World Dictionary (Second College Edition, 1970), "innovation" means something newly introduced, such as new method, custom device, etc. and changes in the way of doing things. This is the sense in which the term is used in this paper. Traditionally, "innovation" is distinguished from "invention" which, according to the same source, means something thought up or mentally fabricated. In other words, the process of invention generates ideas while innovation implements them or commercializes them. This paper has nothing to say on the process of invention.

simply assume, as seems reasonable, that TFP growth contributes to economic growth and is driven by useful ideas or increases in “the stock of useful knowledge” as Lucas (2002) puts it. Again, as he rightly points out, treating growth in technology or knowledge as exogenous for an economy implies that it originates from activities outside that economy. In other words, what is external to one economy must be internal or endogenous in some other economy. One is thus led to modeling the endogenous process that generates technological change in that economy. Even if one were to assume that for developing economies technical progress comes about through the adoption or imitation of technologies developed elsewhere, still the adoption and imitation processes themselves could be endogenous. It is therefore essential to view processes to innovation as endogenous processes that are influenced by incentives, institutions, as well as political economy.

I will be concerned in this paper with four broad themes. The first is the importance of innovation to economic growth, discussed in Section 2, where I report on the analytics of the contribution of innovation to growth, selectively drawing from the vast recent literature on endogenous growth models². An essential element of these models is that the endogeneity of growth is driven in part by the endogeneity of innovation. There was an earlier literature (Kaldor and Mirrlees (1962), Boserup (1965)) on endogenizing the innovation process. A major strand of this literature goes under the rubric of induced innovation (Ruttan 2001, for a recent treatment). I will not report on this body of work primarily because in the models of this genre the market for innovation (more precisely the process of compensation of

² It is often argued that although innovation is essential to growth in mature economies, developing countries can in part free-ride on innovation undertaken by mature economies, and further, there is much greater scope in developing economies to gain productivity growth out of efficiency gains from reallocation of resources. First of all, free-riding is impossible in reality—even to adapt what is developed elsewhere, and to introduce it, resources and ingenuity are needed. This resource cost is explicit as imitation cost in the Helpman model of Section 2. Besides, such adaptation and introduction are innovations in my definition anyway. Empirical estimates from applied general equilibrium models of efficiency gains from resource reallocation, say, following trade liberalization, are very modest.

innovators in contexts that benefits of innovation have spillover effects) and the link between innovation and growth are not transparent. An alternative to the induced innovation model is the celebrated “learning by doing” model of Arrow (1962). In this model, innovation as reflected in increases in labour productivity was the unintended or serendipitous effect of production. It was external to the firms who did the producing. Thus, strictly speaking, the process of innovation through “learning by doing” in the Arrow model is exogenous. Nordhaus (1969) and Shell (1973) endogenize innovation by modeling the incentives to innovate as arising from the prospect of monopoly rents from patented innovations.

In models of pure learning, sustained growth effects are ruled out if there are diminishing marginal returns to learning in any single activity. For sustaining growth, new activities with learning potentials have to emerge and be adopted all the time, as in the model of Lucas (2002, Chapter 3). The adoption of new products could be endogenous, thus endogenizing learning and hence growth. However there is an inherent ambiguity about learning processes. As Lucas (2002, p. 84) points out:

“Is it the individual worker who is doing the learning? The managers? The organization as a whole? Are the skills being learned specific to the production process on which the learning takes place, or are they more general? Does learning accrue solely to the individual worker, manager, or organization that does the producing, or is some of it readily appropriable by outside observers?”

My second broad theme is the importance of entrepreneurship to innovation. The dictionary meaning of the word “entrepreneur” is a person “who organizes, operates, and assumes the risk for a business venture” (American Heritage Dictionary of the English Language, Fourth Edition, 2000) and “one who undertakes an enterprise; one who owns and manages a business; a person who takes the risk of profit or loss” (Oxford English Dictionary [database online], April 25, 2003). Neither definition includes what economists usually think of

as the essential characteristic of an entrepreneur, namely, as the source of a new, potentially commercially viable idea. The entrepreneur herself or others to whom she licenses or sells the idea, implement it in a productive enterprise. In this sense, it is not so much the generation of ideas, but its implementation in an enterprise, that is the center of attention from the perspective of growth.

The importance of resources needed to implement viable ideas leads to my third broad theme, namely, the role of financial intermediaries in fostering entrepreneurship. In particular, the ease of access to capital or finance, and the chances of the idea of the originator being appropriated or stolen if the enterprise is not entirely controlled by the originator are important issues. A particular form of organization, namely venture capital, has proved to be significant in financing high-tech start-up enterprises in the US. Interestingly, in other major industrialized countries, such as Germany and Japan, venture capital is less important. Indeed, the equity market as a source of capital, and a market for corporate control are less developed in those countries as compared to the US. An important dimension of venture capital is that its return is mostly from the sale of equity at the time the start-up firm makes its initial public offering (IPO). Unless there is a deep equity market, venture capitalists will not have an attractive option of exit through IPOs from the start-up firms they finance. The absence of a significantly deep equity market might explain in part why venture capital has not become important in Germany and Japan (Black and Gibson, 1998). Also, the US government, through its Small Business Innovation Research Awards and Small Business Investment Company, has supported start-ups. I will discuss entrepreneurship and the role of venture capital and other forms of financing for entrepreneurs in Section 3.

The facts that innovation is important to growth and, in turn, entrepreneurship is important to innovation, and lastly, finance is crucial for entrepreneurial success, naturally raise the question of policy. Are there specific policies that developing countries can adopt so as to accelerate growth through encouraging innovation? To what extent do other policies that influence the environment for resource allocation and accumulation have an effect on innovation? Should governments themselves undertake and fund research that ultimately produces potentially commercially viable ideas? These policy issues comprise my fourth broad theme. The models of innovation, entrepreneurship and finance, as well as the findings of Sections 2 and 3, have policy implications, and these are discussed in those sections. Section 4 is devoted to publicly funded research systems and to empirical findings on the importance of foreign trade and investment as mechanisms of transfer of innovation-induced productivity gains across countries. Section 5 concludes the paper.

1. Some Illustrative Models of Entrepreneurship, Innovation, Imitation and Growth

The literature on the economics of research, technological change and innovation is vast. For example, just one publisher, Kluwer Academic Publishers, has brought out as many as 28 volumes by various authors and editors between 1994 and 2003 on the theme Economics of Science, Technology, and Innovation. This is not the occasion to survey the vast literature. Let me just focus on a couple of contributions.

Grossman and Helpman (1994) provide an accessible survey of endogenous innovation in the theory of growth drawing on their classic book (Grossman and Helpman, 1992). Although there have been several contributions since then (some of which are included in Aghion and Howitt (1998)), for my expository purposes it is enough to concentrate on the simplest general

equilibrium model of innovation and growth presented in Helpman (1990)³. He considers a model in which there is a continuum of differentiated brands of consumer goods produced only by labour. The products enter symmetrically in consumer's utility function. However, to produce each new brand, the producer has to incur expenditure on product development. Product development or R&D, uses only labour. Once he develops a brand, the entrepreneur enjoys indefinite monopoly power over its production and sale. There is free entry into product development. Then, at each time t , product development costs $c_n[w(t)]$ must equal the present value of future profits $\pi(\tau)$, where $w(t)$ is the wage rate and $n(t)$ is the number of brands in existence at t . Thus,

$$c_n[w(t)] = \int_t^\infty \exp[R(t) - R(\tau)] \pi(\tau) d\tau \quad (1)$$

where the discount factor $R(\tau) = \int_0^\tau r(u) du$, with $r(u)$ being the instantaneous interest rate.

Differentiating both sides of (1) with respect to t and rearranging,

$$\frac{\pi(t)}{c_n} + \frac{\dot{c}_n}{c_n} = \dot{R}(t) \quad (2)$$

Consider a symmetric equilibrium in which the same amount $c_n(t)$ of all $n(t)$ brands available at t are consumed and all brands are sold at the same price $p(t)$. With a constant elasticity σ of substitution among brands in the instantaneous utility function, utility $u(t)$ of the representative consumer (all consumers are identical) would be given by

$$u(t) = \frac{1}{\sigma - 1} \text{Log}n(t) + \text{Log}E(t) - \text{Log}p(t) \text{ where } E(t) \text{ is expenditure on the } n(t) \quad (3)$$

brands available at time t .

The consumer maximizes the discounted present value of $u(t)$, i.e.,

³ My exposition follows closely, almost verbatim in parts, Helpman (1990, pp. 29-31).

$$\int_0^{\infty} u(t) \exp(-\rho t) dt, \text{ subject to the wealth constraint} \quad (4)$$

$$\int_0^{\infty} E(t) \exp(-R(t)) dt = \text{wealth, by choosing } E(t), \text{ taking } n(t), p(t) \text{ as given.} \quad (5)$$

This maximization can be shown to imply

$$\frac{\dot{E}(t)}{E(t)} = \dot{R}(t) - \rho \quad (6)$$

Turning to the supply side, a unit of each brand requires a_{Lx} units of labour to produce, while each new brand of product a_{Ln} / K units of labour per unit for its development where K is knowledge or R&D stock. Thus, the larger this stock, the lower is the labour per unit of R&D output. The model captures two features of innovation. The first is that innovation is driven by the expectation of future profits. This is exemplified by the requirement that the cost of development of a product equals the discounted present value of future monopoly profits from its production and sales, given free entry into the product development industry (see equation (1)). The second is the unintentional and uninternalized consequence of past product development for cost of future product development. This can be viewed as a consequence of learning by doing in the product development industry along the lines of Arrow (1962). The benefits from lowered development costs accruing to future product developers does not enter the cost-benefit calculus (equation (1)) of present product developers. Thus, these benefits do not accrue to, and hence are not internalized, by them. This leads to their “under supplying” new product designs in a private market equilibrium relative to a social optimum. I come back to this later on.

Suppose the stock $K(t)$ of R&D reflects learning by doing according to $\dot{K} = n(t)$. Then by a proper choice of units we can set $K(t) = n(t)$.

Now the cost $c_n [w(t)]$ of each new brand is $[a_{Ln} / n(t)] w(t)$. If we choose a new brand as the numéraire, then free entry into R&D sector will ensure zero profits in that sector, so that

$$1 \equiv c_n [w(t)] = \frac{wa_{Ln}}{n} \quad (7)$$

omitting the time argument t from w and n . Under monopolistic competition in the symmetric equilibrium, the price $p(t)$ of a unit of each brand will equal its marginal cost $w(t)a_{Lx}$ times the mark-up or

$$p(t) = \left(\frac{\sigma}{\sigma - 1} \right) wa_{Lx} \quad (8)$$

where σ (the elasticity of substitution in consumption) is the elasticity of demand⁴. Denoting $\frac{\sigma - 1}{\sigma}$ as α , we can rewrite

$$\alpha p = wa_{Lx} \quad (9)$$

Equations (7) and (8) imply that wage rate $w(t)$ and price $p(t)$ grow at the same rate as $n(t)$.

The factor market clearance condition, given that $\dot{n}(t)$ units of new brands are being developed, and denoting by $x(t)$ the aggregate output of all brands together, yields

$$[a_{Ln} / n] \dot{n} + a_{Lx} x(t) = L(t) \quad (10)$$

For simplicity, let us assume that $L(t)$ is a constant L . Aggregate consumer expenditure $E(t)$, by definition, equals $p(t)x(t)$. Substituting for $x(t)$ and using (7) and (9) in (10) we get

$$\frac{\dot{n}}{n} = [L / a_{Ln}] - \alpha \eta \quad (11)$$

where $\eta = E / n =$ expenditure per brand.

Profits $\pi(t)$ per brand equals price $p(t)$ minus cost wa_{Lx} times output $\frac{x}{n}$ or

⁴ Given that all products developed at any time t have the same cost of development, and that each unit of product, once developed, costs the same to produce and that there are no other costs, it is clear that it is costless to differentiate (for the consumer) one product from another.

$$\pi(t) = (p - a_{Lx}w) \frac{x}{n} = (1 - \alpha) \frac{px}{n} = (1 - \alpha)\eta \text{ using (9)} \quad (12)$$

Since $c_n(t) \equiv 1$ from (7), it follows from (2) that $\pi(t) = \dot{R}(t)$. Using (6), it follows that

$$\dot{R}(t) = \frac{\dot{E}}{E} + \rho = \pi(t) = (1 - \alpha)\eta \quad (13)$$

Since $\eta \equiv E/n$ it follows from (13) that

$$\frac{\dot{\eta}}{\eta} + \frac{\dot{n}}{n} + \rho = (1 - \alpha)\eta \quad (14)$$

Substituting from $\frac{\dot{n}}{n}$ from (11) in (14) we get

$$\frac{\dot{\eta}}{\eta} = \eta - \rho - [L/a_{Ln}] \quad (15)$$

It can be shown that the only solution to the differential equation (15) that satisfies the transversality condition for intertemporal consumer welfare maximization is the stationary solution $\dot{\eta} = 0$. This in turn means, using (15) and (11) and setting $\dot{\eta} = 0$, that the growth rate g of the stock of brands is given by

$$g = \frac{\dot{n}}{n} = (1 - \alpha)[L/a_{Ln}] - \alpha\rho \quad (16)$$

It is clear from (16) that g is higher the lower is the labour needed per unit of R&D as indexed by a_{Ln} , and higher the mark-up over marginal costs (that is, lower the value of α) and lower the value of ρ , that is, greater the patience of consumers. It also shows that g is higher the larger the value of L , the size of the labour force. This is not realistic since it implies that large populous countries such as China and India would have faster growth of R&D. However, this

unrealistic feature of the model can be and has been remedied (Matsuyama (1992)) without weakening the other results.

The utility $u(t)$ at any point in time t of the representative consumer of this economy is given by (3). In the steady state path $n(t)$ grows at the rate g . Expenditure per worker is the wage rate w . Substituting in (3), $u(t) = \text{Log} \left[n(t)^{\frac{1}{\sigma-1}} \left(\frac{w}{p} \right) \right] = \text{Log} \left[n(t)^{(1-\alpha)/\alpha} \left(\frac{w}{p} \right) \right]$. Since w/p is constant over time (see (9)) and $n(t)$ grows at the rate g , the representative consumer's utility $u(t)$ rises over time (linearly) at the rate $(1-\alpha)g/\alpha$. Thus a consumer is better off living in a large economy that starts with the same number of brands of consumer goods as a smaller economy, because her initial utility is the same in both countries but rises faster (i.e., g is larger) in the larger countries.

Helpman (1990) extends this model of innovation in a closed economy to a world of two countries, North and South. North is developed and it is where innovation takes place. However, a Northern entrepreneur knows that he is not assured of indefinite monopoly, as he would have been were North to be a closed economy, because of the threat of imitation by the less developed South. Suppose at time t the total number of brands in existence and invented in the North be $n(t)$ of which n_s have already been imitated by the South and $n_N = n - n_s$ are yet to be imitated. Let $\mu = \frac{\dot{n}_s}{n_N}$ be the endogenous instantaneous rate of imitation, with every Northern brand yet to be imitated having the same chance of being imitated. Let $F(t, \tau)$ be the probability that a brand developed at time t will be imitated by the South before $\tau \geq t$. It is easy to show that

$$F(t, \tau) = \left[1 - e^{-\mu(\tau-t)} \right] \quad (17)$$

Northern entrepreneurs maximize the expected present value of their profits, given $F(t, \tau)$ and that they lose their market to Southern imitators once they are imitated. Free entry into R&D sector in the North leads to the following analogue of (1)

$$c_n [w_N(t)] = \int_t^\infty [1 - F(t, \tau)] \left[\int_t^\tau \exp[R(t) - R(u)] \pi(u) du \right] dF(t, \tau) d\tau \quad (18)$$

where $w_N(t)$ is the Northern wage rate.

Substituting for $F(t, \tau)$ and differentiating we get the analogue of (2)

$$\frac{\pi}{c_n} + \frac{\dot{c}_n}{c_n} = \dot{R} + \mu \quad (19)$$

Comparing (2) with (19) it is seen that the threat of imitation adds a risk premium μ to the interest rate \dot{R} to which the sum of the instantaneous rate of profit (π / c_n) and capital gains (\dot{c}_n / c_n) has to equal.

We now turn to the Southern process of imitation following Helpman (1990, pp. 31-33) very closely. Suppose it takes resources to imitate a brand. Specifically, a Southern entrepreneur needs a_{LI} / n_S units of labor per brand for imitating a product that is yet to be imitated, given that n_S products have already been imitated. In other words, the stock of knowledge capital in the South is the number n_S of products already imitated. Having imitated a variety, she needs a_{LX} units of labor per unit of output in manufacturing (just like the North). Imitation takes place only if the present value of profits covers imitation costs. For an imitator, however, the profit calculation is more involved. If she did not face competition from the original Northern innovator, she would mark up price above marginal costs in the usual way. When the resulting price falls short of Northern marginal manufacturing costs, she can still charge this price without being threatened by the Northern producer. This happens when the

South's wage rate is lower than the proportion α of the North's wage rate and is termed the 'wide gap' case (the gap in relative wages is wide). Otherwise, the Southern imitator charges a price that equals the North's marginal manufacturing costs. Naturally, the imitator would lose money in either case if the wage rate were lower in the North, so that active imitation requires a lower wage rate in the South, and this is assumed hereafter. Free entry into imitation implies a no-arbitrage condition such as equation (2).

The labor-market clearing in the South (the analogue of equation (10)) implies:

$$a_{Ll}\dot{n}_s / n_s + a_{Lx}x_s = L_s \quad (20)$$

Now assume the wide-gap case, so that the South's pricing equations are similar to those of the North. Together with the market-clearing, no-arbitrage conditions, and the growth-of-spending equation (in which the subjective discount rate is the same in both countries), the pricing equations imply a steady-state growth equation that is analogous to equation (16)

$$g = (1 - \alpha)L_s / a_{Ll} - \alpha\rho \quad (21)$$

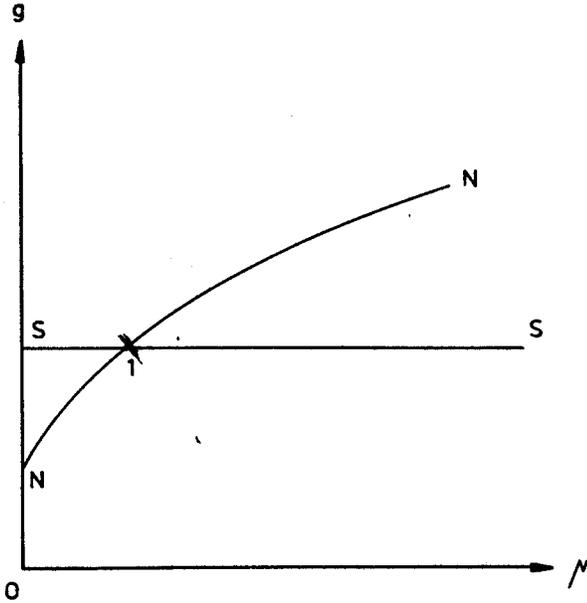
A similar procedure for the North, using equation (19), yields an equilibrium steady-state relationship between the rate of innovation and the rate of imitation:

$$(1 - \alpha)(L_s / a_{Ll} - g)(g + \mu) / \alpha g = g + \mu + \rho \quad (22)$$

The left-hand side of (22) represents the profit rate, while the right-hand side represents the cost of capital, i.e. interest rate *plus* the risk premium. The right-hand side increases, while the left-hand side declines, as g increases. Therefore, an increase in the rate of innovation g reduces profitability relative to the cost of capital. Alternatively, an increase in μ raises the right-hand side but raises the left-hand side even more. Therefore, an increase in the rate of imitation increases the profitability of innovation relative to the capital cost. This explains the

upward slope of curve NN in Figure 1 along which equation (22) holds. As equation (21) holds along SS, the equilibrium levels of innovation and imitation are given by the intersection point 1.

FIGURE 5
NORTH-SOUTH PRODUCT CYCLE



Several implications of this model are worthy of note. First, observe that if innovation in the South requires more resources than imitation, which is reasonable, then trade with the North speeds up long-run growth in the South. This can be seen from equation (21). Without trade, the growth equation is the same [see (16) for a closed economy], except that a_{LL} is replaced by a larger coefficient. Second, trade with the South speeds up long-run growth in the North. This is shown in Figure 1 by the fact that the vertical intercept of NN identifies the autarky growth rate, so that both countries grow faster by trading with each other. Third, it is clear from Figure 1 that a larger South raises both the rate of innovation and the rate of imitation. A larger North, by

contrast, does not affect the rate of innovation but reduces the rate of imitation. Lower rate of imitation is associated with longer average time periods during which Northern entrepreneurs command monopoly power. Fourth, it can be shown that the larger a country, the larger is its relative wage rate.

Turning to policy implications, in the single country model, as was noted earlier, growth of innovation (and hence growth of utility of the representative consumer) under laissez faire is not socially optimal for the reason that the private product developer does not take into account that by his developing a product today, he generates a positive externality for a product developer in the future, because each product developed today adds to knowledge capital that reduces future product development costs. For this reason, some degree of growth promotion through subsidies for innovation is desirable. But how much?

A social planner of this economy would maximize discounted present value of aggregate welfare subject to the constraint of aggregate labour availability (see (10)) $a_{Ln}g + a_{Lx}x = L$ through her choice of g and x . Aggregate consumption per brand is $\frac{x}{n}$ and aggregate utility U is easily seen to be:

$$U = \frac{1}{\sigma - 1} \text{Log}n + \text{Log}x = \left(\frac{1 - \alpha}{\alpha} \right) \text{Log}n + \text{Log}x \quad (23)$$

Now $n = n_o e^{gt}$ and $x = \frac{(L - a_{Ln}g)}{a_{Lx}}$. Thus discounted sum of utility

$$W = \int_0^{\infty} e^{-\rho t} U(t) dt = \frac{1}{\rho} \left[\text{Log} \left(\frac{L - a_{Ln}g}{a_{Lx}} \right) + \text{Log}n_o \right] + \frac{g(1 - \alpha)}{\alpha \rho^2} \quad (24)$$

Maximizing W or equivalently ρW , leads to maximizing $\text{Log}(L - a_{Ln}g) + \frac{g(1-\alpha)}{\alpha\rho}$ with respect to g . Thus the socially optimal g^* is

$$g^* = \frac{L}{a_{Ln}} - \left(\frac{\alpha}{1-\alpha} \right) \rho \quad (25)$$

Comparing g^* with the laissez-faire market optimum g given by (16), it is seen that

$$g^* = \frac{g}{1-\alpha} > g \quad (26)$$

Hence, subsidies that bring market optimum growth closer to the social optimum g^* are worthwhile, but further increases in subsidy would reduce social welfare.

Helpman points out that foreign trade policy could be used to accelerate long run economic growth, for example, if it succeeds in shifting resources toward innovation. However, the particular policy used would matter since some policies are more prone to unleashing distortionary rent seeking. Thus:

“even in cases where the free-trade growth rate falls short of the optimal level and trade policy accelerates growth, trade policy may nevertheless be harmful. Monopolistic competition per se introduces a distortion that can be aggravated by a growth-enhancing trade policy. In addition, in the presence of rent seeking, growth is slower under quotas than under tariffs because quotas divert resources to rent seeking, thereby reducing employment in R&D. This effect is particularly strong when rent seeking uses entrepreneurial skills that are useful in product development. These examples highlight the role of policy in a dynamic context.” (Helpman, 1990, p. 35)

Lucas (2002, Chapter 3) describes a model in which learning occurs in individual product lines. New goods or product lines, which are better in a well-defined sense than other goods in existence, are introduced, and labour reallocated between new and old goods, all the time. The rate at which the new goods are introduced is endogenous. It is assumed, as in the Helpman model, that the learning accumulated in producing a good reduces the cost of producing each

good that is introduced later. Thus the spill-over effect is loaded in the direction of improving productivity of better goods introduced later. The spillover decays in the sense that the initial productivity of a good is a weighted average of learning on lower quality goods, with the weights declining exponentially with the difference in qualities. The equilibrium rate of introduction of new goods is inversely proportional to the rate of decay of spill-over experience, an increasing function of the spill-over parameter, and the learning rate, and increases as employment is more heavily concentrated on more advanced or better goods.

Lucas finds his learning-spillover models attractive for at least two reasons, the main one being that it offers the potential of accounting for the great differences in productivity growth rates that are observed among low and middle income economies, although he admits that little is known empirically about crucial spillover parameters of the model. The second reason is that the model is consistent with a strong connection between rapid productivity growth and trade or openness. For example, in two small economies facing the same world prices and with similar factor endowments, suppose one somehow shifts its workforce onto the production of goods not formerly produced there, and continues to do so, while the other continues to produce its traditional goods. The learning-spillover theory implies the economy that shifts its labour force would grow more rapidly. For the story of such a shift to be plausible, the shifting economy has to open up a larger difference between the mix of goods it produced and the mix it consumes (recall that both economies are assumed to have similar incomes and tastes and to face the same world prices). Thus a large volume of trade is essential to a learning-based growth episode. This reasoning applies also to show why import-substitution policies ultimately fail, although they might initially succeed in stimulating growth. As Lucas rightly argues, an economy which exports agricultural products and imports manufactures, could create prohibitive trade barriers

which succeed in closing the economy, and in shifting workers to producing formerly imported manufactures, and indeed rapid learning will occur initially. But this is just “a one-time stimulus to productivity, and thereafter the mix of goods produced in this closed system can change only slowly, as the consumption mix changes” (Lucas, 2002, p. 94). Thus there is no room for opening a large gap between what is produced and what is consumed in a relatively closed economy. This observation of Lucas is broadly consistent with the experiences of China and India after their opening to foreign trade and investment compared to the pre-reform period when their economies were insulated from world markets. The rate of TFP growth in China during the pre-reform period of 1953-78 was 1.1% per year, whereas in the period 1979-94, it jumped to 3.9% per year (Hu and Khan, 1997). Various, and differing, estimates of TFP growth are available for India. But they all confirm that once India began to liberalize and open the economy, hesitantly and to a limited extent in the 1980s and purposefully and across the board in the 1990s, TFP growth accelerated (Srinivasan, 2003, Table 7.6).

There are alternative ways of modeling entrepreneurship. I will conclude this section with a particularly insightful model of Acemoglu et al (2003). The authors distinguish financing from management, with managerial selection being important from the perspective of innovation, and draw out the implications of alternative development strategies for innovation. They consider an economy where firms owned by capitalists are run by managers hired by capitalists. Managers are of two types (high and low skill) and perform two tasks: engage in innovation, a task in which skills are important for success, and adoption of technologies from the world frontier, a task in which skills are not as important. Each firm also invests, choosing between levels large and small. Investment costs are financed either through retained earnings or borrowing from competitive intermediaries. There is a moral hazard problem in that a manager could divert a

fraction of the firm's returns for his own use without ever being prosecuted. Capitalists make contracts with managers and financial intermediaries, the contract specifying the loan amount from intermediaries, payments to managers and intermediaries and the level of investment.

In its dynamic equilibrium path, an economy starts with an investment-based strategy (high investment) and long-term relationships between firms and managers and as it approaches the world technology frontier. There is a switch to an innovation-based strategy with lower investment, shorter relationships, younger firms and more managerial selection. However, depending on parameter values, there is the possibility that an economy could fall into one of two traps: a stagnation trap, where the economy starts too far below, and progressively falls further and further behind, the world technology frontier, and a non-convergence trap, where the economy grows at the same rate as the world frontier without ever converging to it. This occurs when the economy fails to switch out of the investment-based strategy. The authors show that the switch out of the investment-based strategy may occur too soon because firms do not internalize the greater consumer surplus from higher investment or too late because the presence of retained earnings enables managers not having to compete for investment funds and thus shield themselves from competition. This prolongs the investment-based strategy.

Several policy implications are drawn by the authors. First, when the switch is too soon policies restricting competition or subsidizing investment would slow the switch. However, situations where retained earnings shield insiders too much and economies never switch from the investment-based strategy (and hence do not converge to the world frontier), such policies might lead to non-convergence traps. The authors recognize that while a welfare maximizing policy sequence consists of a set of policies that at early stages of development would encourage investment and protect insiders, thus being anti-competitive, and at later stages would be pro-

competition, such a sequence creates serious problems of political economy. For example, as has happened in economies that have been protected from domestic and import competition through public policy interventions as in India, beneficiaries of such policies would resist reforms. Thus a well-meaning attempt to encourage domestic investment at early stages of development through inward-oriented and anti-competition policies could end up preventing the economy from adopting policies that would speed up growth at later stages.

2. Entrepreneurship and Finance

2.1 Role of Venture Capital

In the models of Section 2, innovators were directly rewarded by monopoly profits or managerial compensation. Financing of innovation was not an issue and there was no role for financial intermediaries in the innovation process. There is no doubt that in reality innovation also comes about from the implementation of ideas generated by entrepreneurs who lack finance by those who can provide it. The problem of finance is particularly acute for start-up firms using as yet proven and tested technologies. By definition, having just started operations or are about to do so, they cannot bank on their established reputation in the market for obtaining finance at affordable costs. Also, entrepreneurs, who are good at developing a potentially highly profitable product or process, need not necessarily have adequate managerial and salesmanship skills. Thus, for successful commercialization of an entrepreneur's idea, she may need more than finance from financiers. Among alternative means of financing, such as issuing of equity or debt in capital markets, borrowing from banks and other financial intermediaries, venture and so on, not all are likely to be accessible on similar terms to an entrepreneur. They also will differ significantly in providing the non-financial services by them. Informational asymmetries, reputation effects, moral hazard, and adverse selection that arise in financial markets are likely to

be particularly severe for entrepreneurial finance. In the following discussion, I will focus on the role of venture capital in particular, and also the impact of the “financial revolution” more generally on entrepreneurship.

Venture capitalists are important intermediaries since they typically finance small and young firms with few tangible assets other than their product or process about which they know more than potential investors and which often operate in rapidly changing markets. Venture capital organizations, unlike other financial intermediaries, have developed many mechanisms for overcoming the problems in financing such potential high return but high risk firms (Gompers and Lerner, 2001, p. 145). Before turning to these mechanisms, let me first briefly describe a theoretical model developed by Amador and Landier (2002) in a preliminary study.

Amador and Landier, like Acemoglu et al (2003) put firm managers along with financing constraints at the center of innovation-implementation process. In their model, managers are the ones who generate ideas of projects. They can implement their ideas either inside their firms or be financed outside with VC. Firms, because they own assets complementary to the project, could face a lower cost of implementation. On the other hand, a VC organization could offer a contract to the manager that is contingent on the project’s outcome. The owner of the firm (i.e., capitalist, as in Acemoglu et al), will let the manager implement it within the firm if the cost of compensating the manager to do so does not exceed the cost of the competition it would face if the manager implements the idea outside. The manager would opt for outside implementation if the expected payoff for him from doing so would exceed what the capitalist would be willing to offer to implement it inside the firm. The VC market influences these decisions by affecting both the projects that can be implemented outside and the payoff (to managers) to acquire new ideas. In the presence of asymmetric information, moral hazard and differences in beliefs about

the probable success of projects, they show that the most innovative projects are implemented in new ventures and more focused firms innovate more. Also, if the marginal innovation is implemented under the outside threat, a better VC market increases the innovation rate. If it would have been implemented even without the threat, a better VC market, by reducing the firm's payoffs would reduce the innovation rate.

Lerner (1998) provides a succinct description of the problems faced by start-up firms, particularly those in high technology industries, and the role of venture capital (VC) and outside investors in addressing them. Typically, such firms are characterized by significant uncertainties and information asymmetries that could result in opportunistic behavior by entrepreneurs. Serious incentive problems arise from conflicts between firm managers and investors and these could affect the supply of debt and equity capital to firms. For example, with equity financing the manager has an incentive to engage in disproportionately (to her) beneficial but wasteful expenditures while bearing only part of their costs. Debt financing might induce the undertake excessively risky activities. Because outside investors are aware of these incentives, they would demand a higher rate of return than the cost of funds internally generated by the firm. Even if the manager is driven to maximize shareholder value, if she is better informed about investment opportunities and acts in the interest of current shareholders, she would issue new shares only when the company's stock is overvalued. The information asymmetries and their consequences in debt markets are well-known since the work of Stiglitz and Weiss (1981).

VC organizations address these information problems and alleviate capital constraints by first intensively scrutinizing the firms before providing capital, and then by monitoring them afterwards. First, the initial scrutiny is intense with only a very small proportion of firms seeking finance being funded. The funding is often syndicated, with more than one syndication partner

having to approve funding before it is disbursed. Second, approved funding is disbursed in stages, so that managers have to go back often to their financiers, thus enabling them to ensure that funds are not wasted. Finally, venture capitalists intensively monitor managers through their insistence on representation on the board of directors, preferred stock and restrictive covenants on finance. For all these reasons, VC is the dominant form of financing for privately held technology-intensive firms.

Developing a successful product requires heavy up-front investments in development and branding, which are facilitated if there are VCs. The quality of VC, and not merely the quantity, is important. Interestingly, although the Indian software industry in Bangalore has been very successful, the absence of a vibrant VC market has been a significant constraint in addition to others on its growth. As two pioneers of industry put it:

“Though Bangalore has attracted several high-quality, technology-focused venture capitalists, it has a long way to go before matching the hands-on approach, commitment, relationships, and risk appetites of some of the leading VC funds in the [Silicon] Valley . . . Efficient commercialization of cutting-edge output from research labs, entrepreneurship forums at universities, highly efficient alumni networks, close links between leaders in academia and business, risk appetites of venture capitalists, synergies between science/engineering schools and business schools, collaborative research among universities, keiretsus bringing together business and venture capitalists, angels with willingness to nurture talent, the abundance of forums where youngsters may put forth their ideas and interact with industry leaders, opportunities for collective learning—all these are differentiators that put the Valley several notches above other high-tech habitats. In sum, Silicon Valley operates in a vibrant market economy that reveres innovation” (Murthy and Raju, 2002, pp. 200-01).

Indian software firms look for VC funding from sources outside India⁵. Interestingly, The Indus Entrepreneurs (TiE), an organization of Silicon Valley IT professionals from the Indian

⁵ An Indian IT consultancy and software firm, Patni Computer Systems emerged as the biggest beneficiary of VC funding in the Asia Pacific region. According to the Thomson Corporation of Hong Kong, a total of \$1.9 billion VC investments was disbursed to Asia Pacific companies in 2002, with 232 VC firms participating in 381 rounds of financing that supported 362 companies. However, the total amount disbursed sharply declined from over \$5.0 billion disbursed a year earlier (www.thomsonfinancial.com, News Release, January 20, 2003).

subcontinent, has greatly contributed to this outcome. TiE has a network of chapters in the subcontinent and elsewhere and plays a mentoring role for aspiring entrepreneurs. Its publication (TiE, 2003) on its mentoring experiences is a practical guide to entrepreneurship.

3.2 Venture Capital – Empirical Findings

Gans et al (2002) note that between 1991 and 1999 there was a rapid increase in VC investments and venture-backed firms accounted for more than 8% of all domestic innovation in the US. They examine whether the returns to innovation are earned through product market competition (the Schumpeterian gale of creative destruction) or through cooperation with established firms through several mechanisms such as alliances and acquisition. These mechanisms differ in their impact on future incentives to innovate but share the common feature of foreclosing product market competition. The strength of the Intellectual Property Regime (IPR) influences the absolute and relative returns to competition and cooperation. There is an ‘expropriation’ threat in either choice: under competition incumbents could attempt to reverse engineer and sell an imitation of the innovation. Under cooperation, negotiating the sale of innovation runs the risk of disclosure, thus eroding the bargaining position of the innovator and reducing the incumbent’s willingness to pay for the innovation. More generally, costs of search and bargaining as well as uncertainty about the value of the innovation could affect the choice between competition and cooperation.

The empirical analysis of the authors is based on a comparison of 55 VC-backed firms, 63 firms backed by funding by the Small Business Innovation Program (SBIR) of the US government: the principal dependent variable is a combination of two distinct measures of cooperation strategy through two dummy variables, one indicating whether the firm earned licensing fees from innovation and the other indicating whether was acquired since the project

was funded. Explanatory variables included measures of IPR strength, measures of investment costs in acquiring assets necessary for effective competition, firm level and project level control variables. Briefly stated, the empirical results provide support for a model in which start-up innovators earn their returns on innovation through cooperation when there is strong IPR protection and costs of acquiring and controlling complimentary assets for effective competition are high. If IPR regime is weak, start-up innovators are more likely to pursue competition. The results suggest a more subtle role for IPR. While earlier literature emphasized the role of IPR in raising the absolute returns to competition and cooperation, the authors find that a stronger IPR raises the relative returns to cooperation.

Kortum and Lerner (2002) examine the influence of VC on patented inventions in the US across twenty industries over roughly three decades (1965-1992) using annual data on US patents issued to US inventors by industry and date of application as the dependent variable and measures of VC funding and industrial R&D expenditures as the main explanatory variables. They find that increases in VC activity in an industry are associated with significantly higher patenting rates. Their uni-variate comparisons of 122 VC-backed and 408 non-VC-backed firms suggest that VC-backed firms are more likely to patent, have previous patents cited and engage in frequent and protracted litigation of both patents and trade secrets. Their results are robust to different measures of VC activity, sub-samples of industries, and representation of the relationship between patenting, R&D and VC. Averaging across their preferred regressions, they find that a dollar of VC resulted in three times as much patenting as a dollar of R&D expenditure.

Gompers and Lerner (2001) point out that to understand the VC industry, one must understand the VC cycle. The cycle starts with the raising of VC funds, which is followed by investing in, monitoring of, and adding value to firms. The final step is the exit of VC from

successful deals and the return of capital to investors in the fund. The authors summarize the findings of the empirical literature on each segment of the cycle, namely, fundraising, investing and exiting. Hellman and Puri (2002) put together data on 170 young high-technology firms in Silicon Valley using a combination of surveys, interviews, commercial databases and publicly available information and examine the impact of VC on the development of new firms. They substantiate empirically Lerner's (1998) description of several ways in which venture capitalists interact with the firms they finance. They find:

“Obtaining venture capital is related to a variety of organizational milestones, such as the formulation of human resource policies, the adoption of stock option plans, or the hiring of a VP of sales and marketing. Firms with venture capital are also more likely and faster to replace the founder with an outsider in the position of CEO. Interestingly, however, founders often remain with the company, even after the CEO transition. The effect of venture capital is also particularly pronounced in the early stages of a company's development.”

Lerner (1999) notes that the US federal government played an active role in financing new firms, particularly in high technology industries since the Soviet Union launched Sputnik in 1957, a role that other governments in Europe and Asia, as well as those of states in the US, have tried to emulate. For instance, the Small Business Investment Company (SBIC) program provided \$3 billion to young firms between 1958 and 1962. In 1995, the Small Business Innovation Research (SBIR) program provided almost \$900 million to young technology-intensive firms. Many US states and some foreign countries have adopted similar policies in recent years. According to Lerner these policy interventions are based on two basic assumptions, namely, that the private sector provides insufficient capital to new firms and that the government can pick winners, that is, it can identify firms where investments will ultimately yield high social and/or private returns. There have been very few attempts to test either assumption. Lerner's empirical analysis of the long-run success of firms participating in the US SBIR program is

based on the employment and sales growth of 1,135 firms, approximately half of which received one of more awards of approximately half a million dollars in the first three cycles of SBIR. The other half was matching firms constructed to resemble the SBIR awardees. He finds that a decade later:

“the SBIR awardees have enjoyed substantially greater employment and sales growth than the matching firms. This superior performance, however, was not universal. The differentials in both employment and sales growth were confined to firms in zip codes that were simultaneously the site of substantial venture capital activity. The SBIR awards appear to have had much less impact on the performance of firms in other regions. The awards contributed both to the growth of firms that were or were not backed by venture capital, and that were or were not in industries heavily financed by venture capital. Some evidence suggests that the positive impact was strongest for firms in areas with many venture investments but in industries not frequently financed by venture capitalists.”
(Lerner, 1996, p. 6)

While these results are consistent with the hypothesis of capital constraints, it is also possible that they are also consistent with two other hypotheses: the selection process successfully picked winners, i.e., firms with superior long-run prospects and alternatively, the award of SBIR funding served as a favorable signal to other investors and potential customers of the firm. Lerner tests these alternative hypotheses and finds that they are not supported in the data. Another hypothesis that did not find support was that SBIR awardees grew because they established relationships with federal officials or politicians which led to their receiving government contracts. Lerner’s finding that the role of SBIR program seems to complement VC organizations and other private institutions that fund new firms, in the sense that the impact of SBIR awards in regions without private sector funding is important—it questions the wisdom of programs that provide public financing of and guarantees for VC funds that invest in economically disadvantaged areas.

In a very illuminating empirical study using household data from Thailand, Paulson and Townsend (2001) find substantial evidence that financial constraints play an important role in determining which households start (or expand their) businesses in rural and semi-urban areas. They identify running a business with entrepreneurial activity. They find that wealthier households and potential entrepreneurs who have more talent are also more likely to start businesses. The evidence that households who eventually start businesses accumulate wealth more quickly than the households who do not also suggests the severity of financial constraints. Finally, they conclude that financial constraints impose a greater constraint on entrepreneurial activity in the less developed Northeast compared to the wealthier central region of Thailand.

3.3 Financial Revolution and the Exploitation Growth Opportunities

Ranjarajan and Zingales (2003) provide a superb analysis of the role of the well-developed and deep financial markets in reducing risk and shifting it to those who are able and willing to bear it, thereby enabling the economy to exploit inherently risky, but highly productive, growth opportunities. They illustrate their analysis with a number of examples from history as well as contemporary events to show both the immense potential of the markets to reduce and allocate risks efficiently and to improve the efficiency of poorly managed firms through markets for capital control. They discuss the possibility of spectacular failures and collapses in financial markets that can be ruinous to individuals and even to economies, as the recent financial crises in East Asia, Russia and Latin American have shown. However, in their view, notwithstanding the spectacular failures, the overall performance of financial markets has been outstanding.

In a short but wide-ranging paper, the two authors (Rajan and Zingales, 2001) examine the implications of the “financial revolution” in the US and other advanced countries on the

organization of firms. The main elements of the financial revolution in their view are the ability of markets to (i) price a variety of financial instruments, such as derivatives, (ii) assess, reduce, and spread risks, and (iii) collect more and timely information on market participants by insisting, as a condition for participation, on improvements in accounting procedures, disclosure requirements and, above all, greater transparency in decision making. The revolution was in part a response to financial deregulation that reduced or did away with barriers that restricted the domains of different financial intermediaries. The resulting increase in competition among financial intermediaries and the emergence of new types of financial firms improved the functioning of markets with respect to pricing and allocation of risk.

Turning to the organization of firms, they note that because contracts are incomplete, the owner of a firm derives power from her ownership of unique alienable assets that are critical to production. Such power could arise from attributes of the owner such as her unique talent which is critical to the success of the firm or more generally other critical resources such as a set of clients and associates who are rely on working with the unique talent of the owner and who would have been less productive without her. This means that, unlike ownership of unique alienable assets which can be sold, control over other critical resources has to be built up through other means such as internal organization, work rules, and above all, incentives. The allocation of power within the firm or organization acquires its importance from its impact on incentives and the determination of the range of feasible action each member of the organization has. Moreover, allocation of power at a point in time determines the constellation of power in the future, and thus the future efficiency of the organization.

For the purposes of this paper, their application of the implications of the financial revolution on the framework of power allocation within firms to the exploitation of new project

ideas, which they characterize as growth opportunities. In the pre-financial revolution days, the balance of power within a firm affected project choice and implementation. Complementarities between a firm's financial capacity, consisting of existing assets which not only generate cash flow but could also serve as collateral, and its human capital meant interests of the firm's owners and insiders (particularly its managers) were aligned. Owners benefited from the property rights on growth opportunities exploited by the insiders through financing new investments from the firm's financial capital. Primarily because insiders lacked financing in the pre-revolution days, they were happy to remain with the firm and exploit the investment opportunities with its financial capital, thereby enhancing their own earnings potential and career prospects.

The financial revolution changed this situation in several ways. Greater transparency and voice for shareholders means that insiders had to convince outside shareholders that proposed investments were profitable. A variety of mechanisms (see Rajan and Zingales for details) emerged and were put in place that punished insiders financially if their case was found wanting. At the same time, if a project can be shown convincingly to be profitable to a firm's own bureaucracy and its outside shareholders, outside financiers could also be convinced of the same. Thus, with outside financing more easily available after the revolution, the need for insiders to rely on a firm's own financial capital for investment was diminished. Thus, much stronger complementarities from a technological perspective than earlier between a firm's financial capital and growth opportunities were needed if new opportunities for profitable investment were to be undertaken within the firm. Clearly this meant that the scope for profitable investment opportunities being implemented, within an existing firm or with outside financing, was widened by the financial revolution.

Needless to say, the financial markets in most developing countries are thin and underdeveloped and prone to manipulation. A revolution of the type described by Rajan and Zingales is likely only in the distant future. As the two authors explain in their book, robust financial systems started to emerge only in the nineteenth century in contemporary developed countries. The reason for this, and it is relevant for developing countries, is that financial development does not take place unless those who control or influence the levers of power want it to happen by creating the institutional framework for it. The framework includes not merely respect for the property of each citizen in the sense of allowing and enforcing each citizen's right to own private property, but also more broadly respecting the rule of law, in particular facilitating and enforcing of private contracts, and preventing arbitrary coercion and arbitrary taxation. Without these, saving and investing savings in productive assets, will not take place. Their recapitulation of the relevant periods of English history shows that the greatest obstacle to the development of free markets in general and financial markets in particular was the rapacity of governments. How the rapacity was tamed as constitutional limits to arbitrary exercise of power by the crown, the ascendance of Parliament and accountability of governments to the governed evolved is a fascinating story, ably told by the two authors. The lessons for the developing countries from this history are obvious enough if they wish to allow their financial sector to develop and sustain more rapid growth.

3. The Role of Government and Non-Profit Organizations in the Innovation Process

Besides private actors (innovators, entrepreneurs, firms, etc.), public non-profit motivated actors such as universities and research institutes (many of which, though autonomous, are funded largely by governments) and government agencies play an important role directly by spending on and doing research. Governments play an equally important role through public

policies (fiscal policies, trade policies, regulatory policies, and so on) which influence the incentives of private actors. In this section, I will first discuss publicly funded research and development (R&D) systems, then present some empirical evidence on the impact of openness to foreign trade on productivity growth and finally, briefly discuss the lessons about public policies from the success of the information technology (software) industry in India.

3.1 Public Funding of R&D

Data from World Bank (2002, Table 5.11) show that expenditures for R&D as a proportion of gross national income during 1989-2000 averaged as high as 3.67% in Israel, and in the range of 2% to 3% in industrialized countries. Among developing countries, the average proportions were as high as 2.70% in Korea and 1.93% in Egypt and in the range of 0.5% to 1% in many others such as Argentina, Brazil, Chile, and India. These expenditures are by no means negligible.

India spent 0.9% of GDP in total on R&D in 2000, up from 0.35% in 1970. The share of the private sector in the total doubled from 15% in 1970 to 30% in 1990 (Forbes, 2003, p. 36). Publicly funded and run research institutes such as the Council for Scientific and Industrial Research (CSIR), Indian Agricultural Research Institute (IARI), and several national laboratories have existed for decades. Also, defense expenditures in India (and some of the larger developing countries) include significant research components. The contribution of IARI in breeding and diffusing high-yielding varieties of cereals suited to Indian agro-climatic conditions and the resulting “Green Revolution” are well documented. However, the contribution of CSIR and the national laboratories to industrial development is, at best, modest.

The CSIR, set up by the colonial government in 1943, now employs over 10,000 scientists in 40 research laboratories. Forbes (2003, p. 32) states that it advertises itself as the

world's largest publicly-funded industrial R&D agency. He notes that several parliamentary committees reviewed CSIR's functioning and concluded that its contribution to Indian industry was negligible. In response to this adverse finding, as early as 1953, an independent organization, National Research and Development Organization, was set up for transferring technologies from the laboratories of the CSIR to industry. Its performance was apparently no better, with successive studies continuing to show negligible contribution to industry. Forbes includes excerpts from several of these studies in his paper to substantiate this.

Although hard-headed cost-effectiveness analysis across countries of R&D systems using a common methodology and using complete and reliable data does not exist, there are several studies that have looked at national R&D systems in several countries. Nelson (ed. 1993) reports on a comparative analysis of seven large and three smaller high income and five lower income countries⁶. An important objective of the project (other than a description and comparison of national innovation systems) derived from the concern of the authors that earlier studies had concluded, on the basis of little evidence or analysis, that particular features were behind country performance differences, a conclusion that was neither grounded on a strong conceptual understanding of what is or is not likely to be a causal factor nor the requirement that asserted causal connections be consistent with a wide range of country observations. The authors hoped to remedy these effects. Let me paraphrase some of the findings from individual country studies, as summarized by Nelson.

First, national policies targeted at helping high-tech industries through support of industrial R&D is very uneven. Second, affluent countries with large domestic markets are able to sustain a diverse range of productive activities, and in turn, this diversity enables them to

⁶ The countries were: US, Japan, Germany, Great Britain, France, Italy, Denmark, Sweden, Canada, Australia, Korea, Taiwan, Brazil, Argentina, and Israel.

support a significant R&D system. Clearly, poor countries, especially small, open and poor economies, cannot build a cost-effective domestic R&D systems. Third, resource endowments and the resulting pattern of its comparative advantage shape R&D systems at a basic level. For example, countries with abundant natural resources, including arable and fertile land, are unlikely to have a comparative advantage in manufacturing industry. As such, they are unlikely to develop an R&D system to support manufacturing industry. Per contra, countries that have to export manufactured goods to pay for their import of natural resources and farm products are much more likely to do so. This said, the comparative advantage based on resource endowments is only part of the picture: conscious decisions to develop and sustain economic growth in certain areas (i.e. “creating” comparative advantage) also matter. Fourth, self-reliance in national defence-related products and technologies may dictate significant spending on related R&D, which often spills over into the civilian sector over time.

The most interesting findings relate to the features common to effective innovation systems across countries. These are mostly other features of the economy than of its R&D system per se. In countries successful in innovation in specific industries, firms in such industries were competent across the board in product design and production, effective overall management, responsiveness to market demands as well as in forging links into upstream and downstream markets. Such countries have education and training systems that turn out individuals with knowledge and skills required by their competent firms. University research is also a major contributor to successful innovation: those countries with strong research communities in their universities engaged in research in the sciences associated with particular industries (e.g., chemicals, pharmaceuticals, agricultural science, etc.) tend to be innovative in those industries. Public research institutes complement rather than substitute for university

research. Last, but perhaps the most important, are public policies (fiscal, monetary and trade) that promote competition, particularly with foreign firms in domestic and export markets.

3.2 Foreign Trade and Domestic Productivity Growth

In the Helpman model of Section 2, free trade of the innovating North with an imitating South accelerated the rate of innovation. Foreign trade policy intervention was also seen as having the potential to accelerate innovation and growth over the free trade steady state equilibrium as long as such intervention does not trigger distortionary rent seeking. In the Lucas model, foreign trade results in the emergence of a gap between what is produced and consumed at home. This gap results in a continuous shift of labour into the production of goods not previously produced. In turn, the shift means that learning benefits are sustained as the economy moves its labour from producing goods in which learning peters out, to new goods in which they are significant. Thus, sustained growth emerges as an outcome. The Indian software industry's success is in large part due to its export orientation.

The positive effect on innovation of openness to foreign trade is direct as well as indirect mechanisms. One of the latter is through foreign direct investment (FDI) and the associated technology transfer by multinational corporations (MNCs). Sidney Winter, in his comments, has described this mechanism and its significance. Gur Ofer in his comments draws attention to other channels. He points out that almost all critical inputs needed for growth, such as capital, managerial skills, knowledge, innovations and even institutions not only can be imported, but also in greater amounts, faster and cheaper than just a couple of decades ago. Among the importables (through FDI), he includes key financial service institutions such as banks, insurance companies, accounting and consulting firms. This leads him to suggest that developing countries should concentrate on the non-tradeable segment of institutional development. These non-

tradeables are the same ones stressed by Rajan and Zingales (2003): institutions of governance, law enforcement, protection of property and contracts and a level ground for doing business by all. There is a large literature, theoretical and empirical, on the roles of foreign trade, FDI and MNCs in accelerating growth in developing countries. It will take me too far from the concerns of this paper to discuss this literature and its findings⁷. Instead, I will limit myself to two empirical studies that substantiate the importance of openness in promoting domestic productivity growth, which is an indirect measure of the effects of innovation.

Eaton and Kortum (1997) examine productivity growth since the Second World War in five leading research economies: France, West Germany, Japan, the UK, and the US. They estimate a multi-country model of technological innovation and diffusion to address several controversies:

“One is whether countries that start out poor grow faster than initially rich countries, so that income levels are ‘converging.’ A second is whether sources of growth are primarily domestic or foreign in origin. A third, and perhaps most fundamental, is what causes growth rates in output per worker to differ among countries: differences in capital per worker or differences in available technology.” (Eaton and Kortum, 1995, p. 1)

They conclude:

“As for the issue of foreign vs. domestic sources . . . growth is primarily the result of research performed abroad. We find that even the United States obtains over 40 per cent of its growth from foreign innovations. These findings seem to be consistent with historical accounts.” (Eaton and Kortum, 1995, p. 30)

The study of Eaton and Kortum was confined to just five leading R&D countries. Coe and Helpman (1995) and Coe, Helpman, and Hoffmaister (1997) test the impact of openness on the transmission of technical knowledge across countries and hence on TFP growth. Both estimate variants of the following basic regression:

⁷ Some relevant and recent papers are Borenzstein et al (1998), Lipsey (2002), Moran (2002) on effects of FDI, Brown et al (2003) and UNCTAD (2002) on MNCs, and Prasad et al (2003) on effects of financial globalization.

$$\text{Log}F_i = \alpha_{oi} + \alpha_1 \text{Log}S_i^d + \alpha_2 \text{Log}S_i^f + u_i, \quad (27)$$

where F_i = level of total factor productivity in country i

s_i^d = domestic knowledge stock of country i ⁸

s_i^f = foreign knowledge stock relevant for country i defined as the sum of import-share weighted domestic knowledge stock of countries from which i imports

u_i = random disturbance.

The sample of Coe and Helpman (1995) include 21 OECD countries and Israel for the years 1971-90. Their results suggest a statistically significant and similar quantitative impact of domestic and foreign knowledge stocks on TFP growth.

Coe, Helpman, and Hoffmaister (1997) analyze data from 77 developing countries for the period 1971-90. Since few developing countries undertake R&D, the variable S^d of equation (27) is not relevant. In addition to $\text{Log}S^f$, they include the secondary school enrollment rate E , the share of imports from industrial countries M , dummies for time periods 1971-75, 1975-80, 1980-85, and 1985-90, and the interaction (i.e., product) of S^f with each of M and E . For various reasons of primarily econometric nature, they settle on the specification:

$$\begin{aligned} \Delta \text{Log}F = & -\frac{9.853}{(3.043)} \Delta M + \frac{0.837}{(0.252)} \Delta(M \text{Log}S^f) \\ & + \frac{0.247}{(0.096)} \Delta \text{Log}E, \text{ Adjusted } R^2 = 0.208. \end{aligned}$$

Using this equation, they estimate R&D spillovers from the industrial countries to the developing countries. These estimates suggest that such spillovers from North to South are substantial and in 1990 “may have boosted output in the developing countries by about 22 billion US dollars” (Coe, Helpman, and Hoffmaister, 1997, p. 148, emphasis added). To put this figure in perspective, total official development aid from multilateral and bilateral sources in 1990

amounted to about 50 billion US dollars. Like all cross-country regressions, the two studies are subject to criticism on data, econometric and analytical grounds [see Srinivasan and Bhagwati (2001) for a critique]. What is more, Keller (1998) shows that replacing actual import share weighted foreign knowledge stocks by random share weighted ones reduces the impact of domestic stock and increases that of foreign stock in explaining TFP! Since the rationale for using actual import weights is that through trading more with a country having a large knowledge stock, a country can augment its productivity by importing a variety of intermediate and capital goods embodying that knowledge, Keller's results based on random, rather than actual, import weights could be interpreted either as raising doubts about trade as a mechanism through which knowledge spillovers occur or alternatively that the growth of knowledge stocks of different industrial countries was very high correlated so that alternative weighing schemes yield highly correlated values for S^f .

4.3 The Indian Software Industry and the Sources of its Success

I will conclude this section with some remarks on the successful Indian software industry. This industry is widely viewed to be high-tech and knowledge intensive. IT and software services output grew by an annual average rate of 50% during the second half of the 1990s and accounted for 2.9% of GDP in 2000-01. Software exports increased from \$0.3 billion in 1993-94 to \$7.2 billion in 2001-02 (Reserve Bank of India, 2003, pp. II-12, VII-18). Indeed, it is no exaggeration to say that the success of the industry, particularly recognition abroad (especially in the Silicon Valley) of the professionalism and competence of software engineers, has brought a certain visibility and media attention that India rarely received in the past. Within India, the success of IT has transformed the mindset of the young to one of confidence in their ability to compete with the world's best from one of resignation and despair. According to Murthy and

Raju (2002), the revenues of IT industry grew in excess of 50% a year after 1991, reaching \$7 billion in 2000. They cite a report by the consultants McKinsey which projected in 1999 that the revenues would grow to \$87 billion by 2008, of which \$50 billion would be from exports. The growth since their paper was written in 2000 has exceeded their expectations. What is more, even during the slowdown in growth in the US and Europe after 2000, Indian IT exports continued to grow. For the purposes of this paper, what is of interest is the extent to which India's educational and R&D systems, public policies and ease of access to finance contributed to parrot the success of IT industry and possibly constrain its future growth. From this perspective, the paper of Saxenian (2002) and comments on it by Murthy and Raju and also Desai are illuminating.

Saxenian points out that prior to 1984, India's then dominant import-substitution-led (ISI) development strategy "stifled entrepreneurs and isolated India from the global economy. As a result, exports to promote software exports during the period never took off" (Saxenian 2002, p. 171). Export performance requirements (such as a guarantee to export a certain amount of software) in return for a license to import state-of-the-art computers after paying high customs duties and obtaining foreign exchange allocations prevented the takeoff. Only after the rejection of ISI and the idea of self-reliance in software, allowing import of any form of software under liberal rules, attempts to attract foreign investment and to provide venture capital by the Rajiv Gandhi government, the industry had a chance to develop. Yet, Saxenian quotes Sen to the effect that "until 1991-92, there was virtually no policy support at all for the software sector. Even the term 'benign neglect' would be too positive a phrase to use in this connection" (Sen, 1994, p. 55). Of course, the systemic reforms of 1991 following a balance of payments crisis abandoned ISI and opened the economy to foreign trade and investment. The creation of

Software Technology Parks (STPs) in the early 1990s, which are in effect an export processing zone for software, provided infrastructure and administrative support, two concessions guaranteed access to high-speed satellite links and reliable electricity.

The contribution of the Indian educational system, particularly the elite Indian Institute of Technology and other engineering colleges, to the growth of the IT industry in India and to the supply of IT professionals to the Silicon Valley cannot be underestimated. Of course, emigration of highly trained (with substantial subsidies from the government) has been viewed as brain-drain and Cassandra's like the UNDP have been estimated that the net loss (costs of training minus emigrant's remittances to India) at \$2 billion or more. This is not the occasion to critique UNDP. Suffices it to say that the real question is not brain-drain per se but one of whether subsidizing higher education is socially justified. It can be argued that subsidizing primary and secondary education rather than higher education would be socially worthwhile. Be that as it may, as Saxenian documents, the Indian educational system generated trained programmers and systems analysts whose wages (in 1994) were less than 10% of the wages of similar personnel in the US. Indeed, Murthy and Raju (2002) identify having a pool of well-educated, high quality, English-speaking professionals as the greatest advantage of India's IT industry. Among its several disadvantages, I have already drawn attention in Section 3 to the absence of a vibrant VC market in Bangalore.

Desai (2002) argues that "the domestic software industry—as distinct from body-shopping [i.e., sending technicians abroad to service foreign enterprises in situ]—could not have become internationally competitive if India's computers had continued to cost 50 to 100% more than its competitors" (Desai, 2002, p. 204). The abolition of quantitative restrictions on computers and peripherals in 1992 and the suspension of restrictions on foreign direct investment (FDI) in the

software industry, not only contributed significantly to the success of India's IT but are also testaments, according to Desai, to the damage that lack of openness exemplified by high tariffs and restrictions on FDI have done in the past and continue to do (though to a lesser extent now) on other sectors of the Indian economy.

4. Conclusions

I will be very brief in my conclusions. The theory as well as empirical evidence reviewed here point to the vital role openness to foreign trade, investment and technology plays in spurring entrepreneurship, innovation and growth. Access to finance for entrepreneurs, particularly in the form of venture capital, is important. But it is not just the quantity of capital but the quality aspects unique to VC, such as initial scrutiny of applications for finance and later continued monitoring, that are important as well in encouraging entrepreneurship. The financial revolution that Rajan and Zingales (2001) describe is yet to happen in many developing countries, and indeed their financial sector is rudimentary. As such, traditional balance of power probably continue to prevail. Also, the creation of a vibrant VC market is problematic. However, as Desai (2002) suggests, citing the examples of Japan and Europe, their importance in financing start-ups might be exaggerated.

It is clear that there is room for developing countries to open their economies to a greater extent to trade and FDI, that is participate in globalization more. But whether they will or be deterred from doing so by gloom and doom about globalization being propagated by assertions unsupported by rigorous analysis by luminaries such as Stiglitz (2002) is an open question. The empirical literature on VC financing reviewed in Section 3 emphasized the importance of strong IPR. However, this finding has to be put in perspective: they show that given that ideas of entrepreneurs are protected by patents, the stronger the IPR, the lower would be the chance of

expropriation of their ideas. But this by itself does not mean that patents and their strong protection necessarily increase the rate of innovation, and that even if they did, they are the most cost-effective means of encouraging innovation. The study by Lerner (2002) on the nearly 150 years of patent protection in 60 countries including the United States, the paper of Boldrin and Levine (2002), and of Sakakibara and Branstetter (2001) on Japanese Patent Law Reforms throw doubt on the first hypothesis. Cohen et al (2000) surveyed 1,478 R&D laboratories in the US manufacturing sector in 1994 and found that of many mechanisms available to firms for protecting their profits from inventions, patents tend to be the least emphasized by firms. Their findings confirm an earlier survey by Mansfield (1986) who found that absence of patent protection would not have affected innovative efforts of a majority of firms in most industries with the exception of pharmaceuticals, and Levin et al (1987) who report that for firms in most industries, including the most R&D intensive industries (with the exception of pharmaceuticals), patents were not important for reaping profits from their innovations. On the second hypothesis also the evidence is not conclusive. Indeed, whether profit-driven research has the inherent tendency to focus on those areas in which market rewards with patent protection would be highest and neglect other areas (e.g., curative and preventive medicines for diseases widely prevalent in poor countries) has been debated. Unfortunately, without any serious analysis of its global social value, IPR regimes have been strengthened through the agreement in Trade Related Aspects of Intellectual Property Services and enshrined in the WTO.

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