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Discussion Paper Series

#2001-8

Conditions for Successful Technology Policy in Developing Countries – Learning Rents, State Structures, and Institutions

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December 2001

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UNU/INTECH Discussion Papers

ISSN 1564-8370

UNU/INTECH discussion papers intend to disseminate preliminary results of the research carried out at the institute to attract comments

† The authors thank Anthony Bartzokas for his very helpful comments on the first version of the paper and an anonymous referee for his/her comments on the second version of the paper. They also acknowledge useful comments received at a workshop in Sussex, UK from Martin Bell, Dieter Ernst, Rhys Jenkins, Margaret Sharp, Morris Teubal, and especially Larry Westphal.

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ABSTRACT

The paper develops an analysis of the economic, political, and institutional conditions for successful design and implementation of technology policy in developing countries. After a brief introduction (section 1), we discuss contending economic theories of technological change and technology policy (section 2). It is concluded that, despite many pro-market arguments, market imperfections inherent in the process of technological change make the creation of learning and innovation rents by the state potentially very beneficial, especially in developing countries. The next section (section 3) analyses the political and institutional factors that determine how effectively such rents can be created and managed. Then we discuss how the scope of technology policy in developing countries is affected by the recent changes in domestic and international policy contexts such as domestic deregulation and the emergence of a "liberal" world order represented by the WTO (section 4). The paper ends with a brief conclusion (section 5).

Key words: Industrial Policy, Technological Development, State Autonomy, Institutions

JEL classification: L5, O3, O4

1. INTRODUCTION

The last two decades have seen an explosion in the economics of technology. Pioneering works by Rosenberg (1982), Nelson & Winter (1982), and Freeman (1982) have opened up a whole new chapter in the study of technology, which emphasizes the evolutionary nature of technological progress and the role played by institutions and policy factors in stimulating the process (see Dosi et al. (eds.), 1988, Lundvall (ed.), 1992, and Nelson (ed.), 1993). These new theoretical developments, naturally, have influenced the literature on technology policy in developing countries, producing a new breed of theoretically sophisticated and empirically well-grounded literature (important early works include Fransman, 1984, Fransman & King (eds.), 1984, and Pack & Westphal, 1986; Lall & Teubal, 1998, provides a state-of-the-art synthesis).

It is within this intellectual context that the present paper explores the economic, political, and institutional conditions for effective design and implementation of technology policy (especially the kind based on state-created learning rents) in developing countries. The paper is organized in the following way. After providing a comprehensive discussion on contending economic theories of technological change and technology policy (section 2), we discuss the political and institutional conditions required for the successful design and implementation of technology policy (section 3). This is followed by an assessment of technology policy records in developing countries (section 4) and a forward-looking discussion on the impact that changes in domestic and international contexts are having on the conduct of technology policy in these countries (section 5). Our conclusions are presented in section 6.

2. THE ECONOMICS OF TECHNOLOGY POLICY IN DEVELOPING COUNTRIES: CONTENDING VIEWS

Broadly speaking, there exist two contending views on technology policy in developing countries. The first view, which can be termed the "pro-market view", argues that, if left alone, profit-maximizing firms driven by competitive pressure will choose and develop technologies that are not only the most profitable but also beneficial for society. The supporters of this view, therefore, argue for a market-based technology policy, with the possible exception of subsidization of R&D with a strong public good character.[1] The alternative view is what we term the "state-promotion" view, which identifies a host of market imperfections, especially prevalent in developing countries, that dampen the pace of technological innovation and learning. The advocates of this view argue that policy interventions are required in order to create incentives for productivity growth and innovation.

2.1 The pro-market view

There are two strands in this view. The first focuses on the impact of state-created rents on static efficiency of technology use (section 2.1.1), while the second strand goes beyond comparative statics and introduce some dynamic elements by incorporating a more process-oriented view of competition and economic selection (section 2.1.2).

2.1.1. "Competition is the enemy of sloth"[2]: the standard cases for competition

In the textbook Neoclassical model, it is argued that invigorating competition increases technical efficiency both at the sectoral and the firm levels on account of competition acting as an efficient selection and disciplining mechanism. The selection function of the market ensures that even if firms are not profit-maximizers they will be displaced by the entry and expansion of relatively low cost firms, thus resulting in sector- and firm-level cost minimization (see Alchian, 1950, and Geroski, 1991). Thus seen, it is not necessarily profit-maximizing calculus but competition that forces firms to make cost-minimizing adjustments.

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1 A market-based technology policy is not a contradiction in terms. It essentially implies a commitment by the state to a rights structure which allows the "free" functioning of product and factor markets. However, there is a deeper problem with this line of argument, which is that defining the "free market" is a highly ambiguous exercise (see Chang, 2000b and forthcoming; also see section 4.2).

In this view, state-created transfer rents (e.g., rents created through trade protection or subsidies) result in conventional deadweight losses. Furthermore, entry and exit barriers are said to distort the readjustment of output and factors of production between differentially efficient firms and result in long-run technical inefficiency within a sector. Moreover, it is contended, in so far as policy-created rents exist, firms will engage in rent dissipation activities which result in social costs over and above the traditional deadweight loss triangle. Given the relative insignificance of deadweight losses, it is the rise in technical and allocative inefficiencies on account of *rent dissipation* activities which provides strength to this argument at the empirical level.[3] In the remaining part of this section we examine two varieties of this argument, namely the x-efficiency argument and the rent-seeking argument.

2.1.1.1. Competition, managerial effort and technological efficiency

The first generation models of x-inefficiency (the term is due to Leibenstein, 1966) argued that state-created rents increase x-inefficiency by distorting the effort-leisure trade-off of firm managers (see Corden, 1974; Bergsman, 1974; White, 1976; Martin & Page, 1983).

These models regard managerial or labour *effort* as a discretionary variable, which suggests that firm-level cost-minimization becomes a function of the *effort* and *leisure* decisions of the manager (Leibenstein, 1982). It is well established that in the case of a lump-sum subsidy there will be an unambiguous rise in x-inefficiency (Corden, 1974, and White, 1976). However, Martin & Page (1983) show that, if subsidies are per unit of effort, there is no *a priori* reason why entrepreneurial effort should fall. They show that a per-effort subsidy, by increasing firm-level profits, results in entrepreneurial *leisure* becoming more expensive as a greater amount of profit has to be given up for each unit of leisure. Therefore, the substitution effect of an increase in profits on leisure is negative. On the other hand, the income effect is positive because with more profits more leisure can be afforded. They conclude that the sign and the magnitude of x-efficiency effects under these subsidies are indeterminate and depend on the actual response function of managers.

The second generation models derive x-inefficiency effects from agency problems, which exists because the effort of managers and other firm employees is either not observable or cannot be monitored costlessly by owners (Williamson, 1975; Jensen & Meckling, 1976; Fama, 1980; Hart, 1983; Shapiro & Stiglitz, 1984; Bowles, 1985; Scharfenstein, 1988).

Hart's (1983) model shows how *competition* between firms may sharpen managerial incentives when agency costs exist. The model assumes that firms face common cost shocks and that two

2 Caves (1980, p. 88).

3 Applied studies have shown that the deadweight loss in itself constitutes a very small cost to economies.

types of firms exist in the industry: Managerial (M) firms which are confronted with the agency cost problem and Entrepreneurial (E) firms, where the principal runs the firm.[4] Hart assumes that the M-firm manager's utility is a function of managerial compensation and is not too responsive to monetary incentives. It follows that the optimal incentive contract an owner can offer her manager is a single profit target, because, by assumption, wages greater than the reservation wage have no affect on managerial motivation. This contract ensures that managers work efficiently when productivity is low in order to meet the fixed profit target. However, since a manager is bound to be optimally rewarded, in high productivity states, she slackens.

The intuition of the model is that when the marginal cost of production, which is perfectly correlated across firms, is low, E-firms expand their output because E-firm managers who do not indulge in slack are more efficient in these states.[5] As the proportion of E-firms increases, industry output is higher with positive shocks (when costs are lowered) which results in lowering the market price and hence the potential of managerial slack or x-inefficiency in M-firms. To the extent that a higher number of E-firms represents an increase in competition, this model suggests that *competitive product markets lead to a reduction in x-inefficiency or a rise in technical efficiency by dissipating M-firm profits*.[6]

It has been shown by Scharfstein (1988), however, that the results obtained by the Hart model are not robust. He shows that increased competition can lead to *greater* slack, if managers are highly responsive to monetary incentives.

2.1.1.2. Rent-seeking and technological efficiency

The proponents of rent-seeking theory have argued that under state-promotion policies, instead of devoting their time and effort to managing production efficiently, managers will tend to fritter away their effort in lobbying state officials to establish and maintain policy-created rents (Krueger, 1974, Posner, 1975, and Buchanan et al. (eds.), 1980, are the classic works; also see Martin & Page, 1983). This would result in a deterioration in firm-level technical efficiency as inputs are diverted away from production.[7] It is argued that, if the amount of (managerial and other) labour time allocated to these activities is increasing over time, rent-seeking and corruption could affect the rate of growth, rather than just the level, of technical efficiency (see Olson, 1982).

4 In Hart's model the division between the two types of firms is explained by a fixed cost of becoming an entrepreneur.

5 In low productivity states, where M-firm managers increase effort, both firms are equally efficient.

6 The increase in the number of M-firms should also count as an increase in competition, but there is no mechanism in the model which induces this. Therefore, an increase in the number of E-firms is equivalent to an increase in the number of firms.

7 Of course, rent-seeking can also have economy wide allocative inefficiency effects.

More recently, Bardhan (1997) and others have argued that rent-seeking and corruption activities may also slowdown the rate of technological change through their adverse affect on investment in innovation. Several reasons are given in support of this view. Firstly, higher bribes lower the return on investment in innovation relative to rent-seeking, thereby lowering the incentive to innovate (Murphy et al., 1993). Secondly, Boycko et al. (1995) argue that corruption/rent-seeking contracts cannot be enforced in court which leaves the control rights on the returns from investment in innovation often arbitrary and uncertain, opening space for the bribee to renege on his agreement with the briber and/or the agreement open to re-negotiation. Given that most investment in innovation or knowledge creation has a sunk cost character, the increased uncertainty associated with weakly defined rights is argued to create disincentives for innovation.

While these more recent argument raise some important "dynamic" issues that were neglected in the first-generation rent-seeking models, many of the problems and costs associated with state-created rents identified by rent-seeking theory may be reduced through appropriate institutional arrangements, as we shall show below (see section 3; also see Chang, 1994, ch. 2).

2.1.2. Models of industry dynamics

An important assumption underlying the models discussed above is that knowledge about the range of technologies is exogenously given, is public, and is costlessly available to all firms. From this, it follows that the objective of technology policy should be no more than creating environmental conditions which stimulate the efficient *utilization* of technology. However, there are "pro-market" models which focus on the micro details of industry evolution and recognize uncertainty in the acquisition, utilization and development of technology across firms. It is to these models that we turn in the remaining part of this section.

2.1.2.1. The Austrian view

Although Neoclassical economists have long neglected its view, the Austrian School has for nearly a century promoted a "pro-market" view of competition that is much more process-oriented and conscious of uncertainties involved in the use and the generation of technological knowledge (classic works include Mises, 1929, Hayek, 1949, and Kirzner, 1973).

The Austrians emphasize that human knowledge, including technological knowledge, can never be fully codified and therefore knowledge transfer is a key problem in economics. They argue that only the decentralized coordination process of the market allows such transfers to be made successfully. In Hayek's words, it is through the market that "the combination of fragments of knowledge existing in different minds bring about results which, if they were to be brought

about deliberately, would require a knowledge on the part of the directing mind which no single person can possess' (Hayek, 1949, p. 54). Kirzner (1973) argues that although the market does not embody all the information necessary for coordination, it is an essential mechanism which reveals this information through a competitive process.

In other words, the virtue of the market mechanism, according to this argument, is that it acts as the most economical mechanism through which dispersed agents exchange information without explicit coordination. If this is the case, the market mechanism may need to be preserved to promote economic change (Chang, 1994, p.73). In a similar vein, Nelson (1981) argues that even though waste is bound to be generated by organizing innovation through the competitive process (on account of duplication), this may be a price worth paying to avoid the dangers of relying on a single mind for innovation. "The case for private enterprise as an engine of progress must be posed in recognition of bounded rationality" (pp.108-9). [8]

2.1.2.2. Recent Neoclassical models of industry dynamics

More recently, a number of Neoclassical models have tried to incorporate the Austrian-type "process-oriented" view of the market in the study of industrial dynamics (Jovanovic, 1982; Ericson & Pakes 1987; Lambson, 1991; Hopenhayn, 1992; Olley & Pakes 1992).

These models all begin with the assumption that producers within the same industry differ in their productive efficiency and are subject to idiosyncratic shocks or uncertainty with regard to their costs.[9] The key result of these models is that increased market-based competition leads to an 'optimal' rate not only of technology utilization (as in the models reviewed in section 2.1.1) but also of technology creation and diffusion. Market competition is seen as an essential pre-requisite for an increase in the rate of technological change.

In a representative model, Hopenhayn (1992) assumes a market which is composed of a large number of price-taking firms producing a homogenous output. Firms are assumed to differ with regard to their efficiency because of *the diversity of technology choices among firms*. As a result, the output of each firm is a function of ϕ, a random productivity shock following a Markov process, which is independent across firms. The distribution of future productivity is described by the distribution function $F(\phi_{t+1}/\phi_t)$, which is strictly decreasing in ϕ_t. The assumption says that relative to a firm with a low ϕ_t, a firm with a higher productivity shock in

[8] On the definition of bounded rationality, see Simon (1983) and Nelson & Winter (1982).

[9] The actual source of the uncertainty differs across models. In Jovanovic (1982), the distribution of productive efficiency among firms is known to all, but prior to production no firm knows what its true costs are. Each firm regards itself as a random draw from a given population distribution and this "prior" distribution is updated as evidence comes in. Olley & Pakes (1992) and Ericson & Pakes (1987) assume uncertainty in the returns to firm investments

period t has a larger probability of having high productivity in year t+1. This implies that expected discounted profits are an increasing function of a firm's current shock ϕ_t.

Since the current period productivity ϕ_t, which the firm observes, determines the likely future trajectory of productivity through the distribution function $F(\phi_{t+1}/\phi_t)$, firms with a positive productivity shock expect high future profit streams and increase their output and market share, while firms with a low ϕ_t expect low future profit streams, produce low output and, therefore, lose their market share.

Hopenhayn demonstrates that firms exit the market if $\phi_t<X_t$, where X_t is the lowest productivity which will result in positive expected profits for the firms over future periods. Firms with $\phi_t \geq X_t$ remain in the market. This implies that the market forces the least productive firms to exit over time thereby increasing industry level productivity growth.

This model shows that industry-level productivity growth is improving due to *the selection effect of competition* which allows high productivity firms to enter, survive, and grow, and displace low productivity firms that decline and exit (Schumpeter, 1987, is an obvious inspiration here). Competition results in increasing dynamic efficiency by allowing resources to be allocated between firms on account of their relative productivity growth trajectories, while fear of extinction and lower profits forces firms not only to reduce x-inefficiency but also to undertake technical change (also see Nelson & Winter, 1982).

In this model, state intervention is predicted to lower the rate of technological change. For example, an increase in entry costs (Ce) due to government entry regulation reduces the mass of entrants and the rate of entry. This lowers productivity growth through a price and a selection effect.[10] If industry level input prices are fixed then an increase in Ce results in output price increases, leading to a higher level of firm output for each ϕ. Lower entry and higher output prices protect high-cost incumbents from selection effects and their higher earned profits allow them to increase output. Therefore, for any fixed mass of surviving firms, the market share of high-cost incumbents will be higher in the high entry cost case, dampening industry-level productivity growth relative to the situation where entry costs were zero. Furthermore, high output prices result in decreasing X_t, allowing the proportion of firms on relatively lower productivity trajectories to increase. This dampens the selection effect and has an adverse affect on industry-level productivity growth.

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in R&D. However, the results regarding the effects of competition do not tend to differ much among these models.

[10] Exit barriers have an analogous effect. For similar results also see Hopenhayn & Rogerson (1993).

Although the model says nothing about the effect of state created-rents on productivity levels, intuitively one would argue that state-created rents would reduce average productivity too. This is because they dampen the selectivity effect and, given the model's technological assumptions, cannot have a positive effect on the productivity shock that is the driving force of the model. In conclusion, the main result of these models is that policies which increase state-created rents "or inhibit entry and exit reduce average productivity through selectivity effects" (Tybout 1996, p.46), whereas competition and deregulation of entry unambiguously increase it.

2.1.3. Summing-up

The models presented in section 2.1 show that, *given exogenously specified data about prices, technology and/or its distribution among firms*, competition maximizes technical efficiency and the rate of technological change. Under these assumptions it is, indeed, true that policy-created *transfer rents* will create distortions which lower technical efficiency and its rate of change, although as we have argued competition may not have positive effects on managerial effort under certain conditions.

However, the models presented above do not admit any *incentive* problems in using the market as a mechanism to stimulate technological change. As we argue in the next section, relying on the market may create disincentives for innovation and learning because of number of important market imperfections.

2.2. The state-promotion view

In the pro-market view of technology policy that we reviewed in section 2.1, technological change is seen to be *exogenous* to the system. It falls, to quote Hahn & Mattews (1964), as manna from heaven. Therefore, this view of technological change is really not a view about technological *development and innovation* but about the efficient *utilization* of technologies given the state of technological knowledge.

In contrast, the state-promotion view starts from the observation that the effective use of technology requires not only adapting it to local conditions but also a significant amount of investment in organizational and institutional adaptation (see Fransman 1984, Dosi *et al.* 1988 and Khan 2000a). The supporters of this view argue that the process of technological adaptation or learning is subject to a number of important market imperfections and therefore activist technology policy is needed to set the *necessary* incentives for innovation and learning.

2.2.1. Market imperfections that affect technological progress

In this section, we review theoretical arguments that highlight market imperfections that are inherent in the process of technological progress and also discuss how these market failures manifest themselves in the particular context of developing countries.

2.2.1.1. Learning externalities

Atkinson & Stiglitz (1969) challenged the old view of technological change which was based on the notion that, given factor prices, technologies which allow current-cost-minimization are the most efficient. Their model starts with the assumption that improvements in production techniques are likely to be clustered around factor combinations already in use and will, therefore, have limited effect on technologies embracing other factor combinations. To use their parlance, technological progress is localized. Given that in the 20th century most inventions have taken place in developed countries, it follows, according to their view, that technological change will have a limited effect on developing countries which have traditionally employed labour-intensive technologies.[11]

An implication of this theory is that, if a particular type of technological change is associated with a higher rate of productivity growth, the distance between economies choosing such technologies and other economies will increase over time. That is to say, the history of technological trajectories matters. It follows that "[f]irms will thus switch from one technique to another not when they have equal factor costs at current factor prices, but at some date before that" (Stigilitz, 1986, p. 131), because rational firms account for different dynamic cost reduction trajectories of different techniques.

Furthermore, if the chosen technique offers learning-by-doing type of cost reductions, the firm ought not to follow the myopic rule of static profit maximization (Dasgupta & Stiglitz, 1988a). Learning-by-doing implies that a firm's marginal costs are not only a function of technology and factor prices but are also a decreasing function of its production (Arrow, 1962a). In this case, a firm's production decision implies an inter-temporal externality, which suggests that increasing production today will result in lowering its marginal costs tomorrow. Dasgupta & Stiglitz (1988a) argue that, therefore, a rational firm will not make decisions according to private returns offered by the myopic rule, but will take into account the inter-temporal consequences of its production decision, even if this means making losses in the short run. This is because production in the current period may need to be increased to the point where marginal revenue lies below marginal costs for the dynamic gains from learning-by-doing to be achieved.

[11] Similar argument was made by the so-called "appropriate technology" literature in the 1970s. See Stewart (1974) for a review of this literature.

The question to ask in this context is whether market competition enables firms to develop long-term time horizons, even if there might be losses involved in the short run. There are a number of reasons why the market might reinforce the myopia of producers.

Firstly, the process of discovering and learning new technologies requires a lot of effort and investment in the methods of search, production, and the use of technology. Since there is no blueprint of how best to do things, the process is fraught with uncertainty and involves considerable risk (Nelson & Winter, 1982). Especially in developing economies, where credit markets and insurance markets are particularly imperfect (see section 2.2.2.1), high-risk projects involving the modernization of technology might not be attractive, as "capital markets do not like the combination of risk and illiquidity which infant industry investment represents" (Khan, 2000a, p. 31).

Secondly, knowledge creation and technological change have attributes of pure public goods, i.e. it is both non-rival and non-exclusive in character (Arrow, 1962b, Stiglitz, 1996, and Fransman, 1998). The public good nature of technological learning implies that under competition there might well be under-investment in learning because the private benefits that entrepreneurs could appropriate fall below the social benefits from such investment.[12]

It is usually argued that this market failure can be overcome through the use of the patent system (see Davies, 1991, and Stiglitz, 1996). However, in developing countries the property rights defining a system of patents are either non-existent or weakly defined, thus strengthening the *disincentives* for investing in learning. Furthermore, it is difficult to see how innovation-related to learning existing technologies, which will be the bulk of innovation in developing countries, can be effectively patented.

2.2.1.2. Coordination failure

Another important point not addressed by the pro-market view is that technological change may require *planned* coordination to be successful (Chang & Rowthorn, 1995). Abramovitz (1986) points out the problem for market-based coordination of technological change in the presence of complementary investments.[13] He argues that, if "the capital stock of a country consists of an intricate web of interlocking elements, [then] it is difficult to replace one part of the complex with more modern and efficient elements *without a costly rebuilding of other components"* (pp.

[12] Although in theory it is possible for firms to internalize the externality associated with the appropriability problem by organizing side-payments for new entrants to stay out, this may not be feasible due to high transaction costs (Chang, 1994, ch. 3).

[13] Although complementarity belongs to the general class of externalities, it nonetheless differs from standard positive and negative externalities. Standard positive and negative externalities refer to the *level* of satisfaction or costs experienced by external actors as a result of an agent's actions. In contrast to this, complementarity refers to an increased *relative* preference that agents experience from choosing similar or complementary actions (Ray 1998).

401-2). Although he concedes that "[t]his may be handled efficiently if all the costs and benefits are internal to the firm", he points out that when the capital stock is "*interdependent in use but divided in ownership*...the adaptation of old capital structures to new technologies may be a difficult and halting process" (p. 402, emphasis added).[14]

Therefore, when technological upgrading involves complementarities and sunk costs, it may well be the case that decentralized market-based coordination results in reinforcing the status-quo technology. This occurs because these conditions may result in a divergence between individual costs and social gains, as the gain of an individual is contingent upon complementary investments being made by others. In a decentralized system where *ex ante coordination* is limited (Richardson 1960) and where transactions costs prohibit the drawing up of contracts (Chang 1994), it will be individually rational to stick to the status-quo technological structure, rather than upgrading their technologies, in order to guard against the losses that may be incurred in the event of misaligned expectations regarding the actions of others.[15]

2.2.1.3. Increasing returns

In industries where increasing returns are pervasive, being a follower (which developing country firms typically are) may make it extremely costly to enter these markets even in the long-run (Ray, 1998).[16] The reason is that, in the presence of increasing returns, established producers who control large portions of the market operate much lower down their average cost curves, making it extremely difficult for the follower firms to be cost-competitive. The follower firms in turn find it difficult to enter the market because they operate at a higher point on their average cost curves due to their low level of output.[17]

In order to attain competitive cost levels, the follower has to increase output. However, in order to do this, it has to bear losses in the transitional period given the relative cost advantage of its competitors. Given capital market imperfections, it is quite probable that the follower firm is unable to gain access to credit, thereby getting excluded from the market. This is especially true as high fixed investment requirements are involved in increasing returns sectors.[18] If these

[14] The classic case is the continued use of the QWERTY keyboard (David 1985).
[15] The effect of technological change on growth in the presence of externalities, spillover effects, and complementarities has been an important area of concern in the New Growth Theories (see Romer, 1986; Lucas, 1988; Romer 1990). These theories stress the existence of multiple equilibria in the presence of these types of externalities. However, models in this tradition have been criticized for having a rather simplistic view of technological progress, which do not adequately reflect the macroeconomic, institutional, organizational, and political factors present in the process. For some critical reviews, see Verspagen (1992), You (1994), and Nelson (1997).
[16] Here we are considering increasing returns that are internal to the firm and do not manifest themselves in the form of externalities.
[17] For simplicity, we are assuming that all firms operate on the same cost curve.
[18] See, for example, the long pursue model in Tirole (1988, pp. 337-9).

industries also offer more dynamic technology trajectories, then being excluded from these markets will also involve high long-run costs for developing countries. In this case, relying on the market may not be the most socially beneficial policy.

2.2.2. The case for activist technology policy in developing countries

Those imperfections in the market mechanism that we identified above provide the grounds for an activist technology policy in developing countries. Such policy aims to promote technological learning by socializing the risk involved in the process and internalizing the inter-temporal externalities associated with it.[19] In this section we examine the case for activist technology policy in greater detail.

2.2.2.1. Creating rents for learning and search

In the cases of both localized technological change and learning-by-doing, all that is required of the state seems to be to compensate firms for the losses involved in adopting new technology by creating a subsidy which allows firms to take a dynamic perspective on technological choice and production. This not only allows the diffusion of advanced technology but also allows the dynamic gains associated with learning-by-doing to come about.

However, as Fransman (1984) points out, there are a number of potential dangers in the incautious use of the concept of learning-by-doing. The key issue is that the gains associated with learning-by-doing are not automatic. They require effort and investment in creating new ways of 'doing' and the process involves considerable uncertainty (also see Pack & Westphal, 1986). Fransman argues that the key metaphor here is *search*, which has been defined as "all those organizational activities which are associated with the evaluation of current routines and which may lead to their modification to more drastic change or to their replacement" (Nelson & Winter, 1982, p. 400). The difference in the two metaphors is that learning-by-doing posits a passive role for the firm in the process of knowledge creation, while search highlights the firm-level costs and uncertainty associated with knowledge creation. The question is whether learning rents are sufficient incentives for firms to undertake search activities when market imperfections associated with technological innovation exist.

If the process of investing in firm-level search and innovation activities is fraught with uncertainty and risk and if there are sunk costs associated with this investment, then firms will under-invest in search. This suggests that, to create incentives for firm-level investment in search, rents need to be created at the firm level, rather than at the sectoral level (e.g., industry-

[19] Articles that formalize this line of argument include Krugman (1984), Dasgupta & Stiglitz (1988a), Helleiner (ed.) (1989), Aoki et al. (1997), and Khan (2000a).

wide trade protection). Sectoral level learning rents might create inadequate incentives for learning, if the consequent increase in entry and the resulting increase in payments to factors in inelastic supply[20] end up dissipating these rents too rapidly at the firm level.

One way to create rents at the firm level is to regulate entry in the short- to medium-term while providing sectoral learning rents. This will allow the rents to be captured by incumbent firms, thereby setting incentives for firm-level investment in search and innovation. It is needless to say that these rents should not be dissipated too rapidly (Khan, 2000a).

Another way to create firm-level rent is to use "directed credit", namely, credit directed by the government to particular firms (or types of firms). This tool has been used in Japan and some other successful East Asian countries (Amsden, 1989; Chang, 1993; World Bank, 1993; Hellman et al., 1997). Directed credit makes sense as a tool for creating learning rents, if the knowledge created by learning is tacit and cannot be appropriated by the lender, which results in the private return from learning being less than the social return. Developing ideas pioneered by Stiglitz & Weiss (1981), Hellman et al. (1997) argue that in such cases, where credit market imperfections are constraining the experimentation with projects which offer significant dynamic efficiency and associated social returns, there is a case for a state policy of directed credit to such projects.

2.2.2.2. Coordination problems

When there is a possibility of an economy settling into a low-level equilibrium in the presence of complementarities, an activist technology policy may be beneficial. This is because the state may lower the transaction and bargaining costs involved in investment coordination by providing a "focal point" or a "common vision" around which private sector decisions can be coordinated (see Chang, 1994, ch. 2, and Chang & Rowthorn, 1995). Indicative planning, followed in both Japan and France, is a good example of such an exercise (see Cohen, 1977, and Hall, 1986, for France; see Johnson, 1982, and Dore, 1986, for Japan).

What is important to note here is that the state's commitment to its "indicative plan" may be made more credible by backing it up with some financial commitments, which can serve as a "signalling" device (Porter 1990, ch. 12). However, in order to function well, these subsidies have to be *conditional* upon learning (Amsden, 1989; Wade, 1990; Chang, 1993; Evans, 1995; Aoki et al., 1997). Aoki et al. (1997) have formally shown why conditional subsidies are superior to standard subsidies when coordination problems abound. They argue that subsidies whose renewal is conditional upon learning increase the incremental value of cooperation, as the agents' rewards are renewed only upon satisfactory performance. In contrast, a standard subsidy has no effect on the incremental value of cooperation and is consistent with both

[20] We are assuming an upward sloping long-run supply curve.

cooperative and non-cooperative equilibria. Therefore the chance that coordination problems are overcome is much greater with *conditional subsidies.*

2.2.2.3. Increasing returns

As we have pointed out (section 2.2.1.3), increasing returns in the presence of imperfections in the capital market might well put a follower firm in a disadvantaged position, as they cannot enter the market and move down the long-term cost curve until they become equally cost-efficient as the incumbent firms.

One action that the government can take to enable follower firms to overcome this problem is to provide extra demand for its output by import protection, export subsidization, or priority in government procurement (e.g., see Krugman, 1984, Markusen et al., 1995).

Alternatively, the state can act as a surrogate capital market and provide directed credits (possibly subsidized) to follower firms who would have been rationed out by private sector lenders (see section 2.2.2.2).

2.3. The management of learning rents

What will ensure that firms benefiting from a directed credit policy and/or the policy-created rents will actually invest in creating dynamic efficiency, as opposed to dissipating these rents in x-inefficiency and rent-seeking, especially given that the process of rent-creation distorts the selection and disciplining effects of competition? This is the key question which bedevils the pro-interventionist arguments, not least because many real-life experiments with learning rents have failed (see section 4).

As we mentioned above (section 2.2.2.2), many commentators have argued that an effective way to ensure the benefits from these rents is for the state to reward rents conditional upon specified performance criterion, such as technological upgradation and exports, which are pre-specified and credible (Amsden, 1989; Chang, 1994; Amsden & Singh, 1994; Hellman et al., 1997; Aoki et al., 1997; Khan, 2000a).

This form of rent-creation, termed “contingent rents”, provides an endogenous enforcement mechanism in which the principal (the state) elicits performance from agents (firms) by making their relative reward in the contest for rents contingent upon specified performance criteria. Non-renewal of the (often implicit) contract, which needs to be credibly committed to, provides the necessary threat or discipline. This is because in the event of low relative performance, the agent either loses the entire reward or a large portion of it to a competitor. This form of rent-

creation is an effective way to ensure that social benefits associated with the rent policy are forthcoming.[21]

However, it is one thing to say that we can *theoretically* design a mechanism to create learning rents with endogenous enforcement mechanism but it is another to say that it can be done *in practice*.

This is especially the case if redistributive lobbies are well organized and well entrenched, thereby constraining the state from credibly committing itself to contingent rent-type policies.[22] In this case, the state may foster infants which never grow up or fail to shut down declining industries in time (or ever). Similarly with powerful lobby groups, the economic criteria for rent allocation may be supplemented or even replaced by non-economic criteria (Stiglitz 1990). Lastly, when the government intervenes through directed credit programmes, it may be forced to provide *de facto* insurance against bank losses, giving rise to moral hazard problems on the part of both the firm and the bank, as neither agent now bears the full cost of potential losses (for a criticism of this view, however, see Chang, 2000a).

Thus seen, the crucial condition for successful use of learning rents is that the state is able and committed to monitor relative firm performance at low costs and to impose penalties in the event of non-performance – characteristics that are summed up in the notion of "state autonomy" – originally a Marxist concept, but later widely used in the so-called "developmental state" literature (see Johnson, 1982; Evans, 1995; Woo-Cumings (ed.), 1999). In the next section, therefore, we consider the institutional and political conditions which guarantee such disciplinary ability of the state, drawing from the experiences of a number of East Asian and European countries which have used learning and innovation rents successfully.

[21] The theory of yardstick competition suggests that such contests are an effective way to create incentives for agents whose performance, although observable, is a garbled message of their effort due to environmental uncertainty (see Nalebuff & Stiglitz 1983). Equilibrium in such model is one where agents exert maximum effort because, with relative performance monitoring, an agent cannot attribute poor performance to adverse circumstances.

[22] For empirical evidence on the failure of the state in creating such policies, see section 4. Also see Bardhan (1984) and Khan (1989).

3. POLITICAL AND INSTITUTIONAL CONDITIONS FOR THE SUCCESS OF ACTIVIST TECHNOLOGY POLICY

3.1. State autonomy

As we pointed out earlier, successful use of learning rents requires an "autonomous" state that can discipline the recipients of such rents when necessary. During the earlier days of the debate on activist industrial and technology policies, it was often thought that state autonomy can only be possessed by non-democratic states such as those found in East Asia. Relatedly, drawing on the experiences of East Asia and France, some have also suggested that a high disciplinary capacity of the state requires a highly centralised power structure.

However, such conclusions are not warranted. First of all, regarding the relationship between the state autonomy and democracy, it should be noted that many democratic states have successfully disciplined the recipients of learning rents – Japan, France, Norway, Finland, and Austria are good examples.[23] At the same time, many non-democratic states have failed to discipline non-performers, even if they manifestly had the intention of doing so.[24] Secondly, in terms of power distribution (regardless of the existence of formal democracy), not all autonomous states with disciplinary power had centralised power structure. While state power in Japan, France, Korea, and Taiwan may have been highly concentrated in an elite bureaucracy, those in Finland, Norway, and Austria have been less concentrated, as they were based on a tripartite bargaining between the state, business, and labour. In other words, a high degree of state autonomy may reside in many different institutional forms (democracy or authoritarianism, bureaucratic centralism or tripartite power sharing, etc.).

Another point that has emerged from the earlier discussions on state autonomy is that not all forms of state autonomy are equally desirable. This is because too high a degree of state autonomy may imply an excessive distancing of the key decision-makers from the business sector, which increases the risk of poor policy design and implementation (due to the lack of detailed information at the design stage and of "interactive learning" during the implementation

[23] See Magaziner & Hout (1980), Johnson (1982), and Dore (1986) for the Japanese experience. See Cohen (1977), Kuisel (1981), and Hall (1986) for the French experience. See Fagerberg et al. (1990) for the Norwegian experience. For the Finnish and the Austrian experiences, see Vartiainen (1995).

[24] Some of these states may have had some success in imposing a degree of credible conditionality to the recipients of particular learning rents. However, these gains have been overwhelmed by the costs arising from these states' inability to prevent "wasteful" political

stage). This is a particularly important problem in the case of technology policy, because of the high degree of uncertainty involved in the very process of learning.

Focusing on this problem, Evans (1995) has suggested that state autonomy, if it is going to be beneficial, needs to be "embedded" in a dense policy network linking the state and the business sector, which will ensure constant information flows between the two. Of course, this does not mean that greater embeddedness is necessarily better. This is because greater embeddedness, while reducing information costs, may increase rent-seeking costs and enforcement costs (on the other hand, greater autonomy may lower rent-seeking costs and enforcement costs but raises information cost). Therefore there is a tradeoff between state autonomy and embeddedness which needs to be resolved very cautiously[25].

3.2. The bureaucracy

Important as it may be, state autonomy, even of the embedded kind, will not be enough in guaranteeing the success of technology policy, if the state bureaucracy does not possess the ability to make informed decisions regarding the highly complex and uncertain matters involved in technology policy. Based on such reasoning, many have argued that the sophisticated industrial and technology policies used in certain countries in East Asia and Europe cannot be used by most developing countries, as they do not possess high quality bureaucracies. They also argue that the lack of strong bureaucratic traditions in these countries make the construction of high quality bureaucracies next to impossible. Two points need to be made vis-à-vis this line of argument.

First of all, we must be careful in defining the "quality" of bureaucracy. The popular perception is that a high quality economic bureaucracy needs to be staffed with people with advanced training in economics or management, but the East Asian experiences suggest that this may not be the case. Most of the elite economic bureaucrats in Japan have been lawyers by training (Johnson, 1982). Especially in the early days Korea also has had high proportion of lawyers in the economic bureaucracy (Chang, 1993). And in Taiwan many elite economic bureaucrats have been engineers by training (Wade, 1990). These lawyers and engineers did have some training in economics, but the economics training that they had was often of "wrong" kind (e.g., Japanese economics faculties have been until recently dominated by Marxists) and was not of

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mobilization which were intended at undermining the existing property (and other) rights structure and the political bargaining process itself (see Khan, 2000b).

[25] However, in some East Asian countries, most notably Korea, with the growing power of the business sector, the delicate balance between autonomy and embeddedness seems to have been broken in favour of the latter (see Chang, 1998, Chang et al., 1998, Chang, 2000a, and Chang & Evans, 2000).

such high quality by international standards until recently. In contrast, the economic bureaucracy in India has not been very successful in guiding the economy despite the high quality economics training that its staff had.26 Therefore, we can only concur with Johnson (1982) that the bureaucratic competence that is needed for successful industrial and technology policies is that of a generalist, rather than that of the economist in the conventional sense.

Secondly, while acknowledging its importance, we need to be more careful in understanding the role of bureaucratic "tradition". To begin with, long bureaucratic traditions do not automatically guarantee a high quality bureaucracy, as we can indeed see in the very examples of those East Asian and European countries that have successfully used learning rents. For example, the Kuomintang bureaucracy that engineered the Taiwanese "miracle" had been notorious for corruption and incompetence until the 1950s, despite 2.5 millennia of highly-developed Confucian bureaucratic tradition (Cheng et al., 1998). The French bureaucracy was regarded as overly conservative and ineffective for nearly a century before the Second World War, despite its long tradition of centralized bureaucratic rule (Kuisel, 1981). Similar, if somewhat less dramatic, cases can be found in Korea and Austria. What is even more interesting, however, is that although these examples show how easy it is to squander even millennia-old bureaucratic traditions, they also show that a good bureaucracy can be constructed relatively quickly if political conditions are right.27 For example, the quality of its bureaucracy was such that Korea was sending its bureaucrats to Pakistan and the Philippines for extra training until as late as the late 1960s, but a continuous effort at civil service reform made its bureaucracy highly reputable by the late 1970s. The transformation of the French bureaucracy after the Second World War or that of the Taiwanese bureaucracy after the 1949 defeat by the Communists also provide important examples of quick bureaucratic transformation.

3.3. Institutions that provide control over resource flows

Many people think that technology policy is simply about handing out R&D subsidies or tariff protection. We may have contributed to this impression by presenting the creation and the administration of learning rents as the central element in technology policy in developing

[26] At least until the 1970s, the quality of economic expertise in Indian economic bureaucracies far outstripped that found its Korean counterpart. This becomes evident if we compare the early Korean five-year plan documents of the 1960s (which employ little more than simple macroeconomic accounting and projection) with the early Indian five-year plan documents of the 1950s and the 1960s (which were based on sophisticated economic models such as the Mahalanobis model).

[27] Khan (2000b) argues that, in societies with initially high levels of political mobilizations, the political costs of changing the status quo structure might be very high. In these cases political costs would inhibit such moves.

countries. However, there is more to technology policy than the creation and the management of learning rents.

As we argued earlier (section 2.2.2.2), one important function of industrial and technology policies is the provision of an "entrepreneurial vision", which provides the "focal points" around which private sector investment decisions can be (both formally and informally) coordinated. 28 While the forging of a common understanding through the continuation of policy dialogue through various "intermediate" institutions that link the government with the business sector is critical (see section 3.4)29, channels of control over financial and real resources by the state also play an important role. Two of these stand out – state-owned enterprises and the control over the financial sector.

3.3.1. State-owned enterprises

Many of the countries with successful technology policy have used state-owned enterprises (henceforth SOEs) extensively. The popular conception is that the larger the SOE sector is, the less efficient and dynamic the economy will be, but the evidence, both in general and those from East Asian and European examples cast doubt on such argument.30 For example, France, Austria, and Norway, all with excellent economic records, have had large SOE sectors, especially during the early postwar years.31 Taiwan has one of the largest SOE sectors in the non-oil-producing world (Amsden, 1985) – even more so if we include the "party enterprises", namely, those enterprises owned by the Kuomintang party which are often classified as "private" enterprises (Fields, 1998).

It is not simply that the SOE sectors are big in these countries. They also have been most dynamic, and have led the process of industrial modernization. In the European countries that we mentioned above, SOEs provided the vehicle through which new industries with large and

[28] Once again, it has to be emphasized that, in countries where redistributive lobbies are entrenched, the creation of consultative networks might actually constrain the autonomy of the state and thus its ability to provide a "vision".

[29] The best example is provided by the development of "information technology" industries in East Asia. On Japan, see Okimoto (1989) and Fransman (1990). See Evans (1995) for Korea and Taiwan.

[30] The earlier orthodox position on the role of SOEs in developing countries is well summarized in World Bank (1983). Subsequent criticisms (reviewed in Cook & Kirkpatrick (eds.), 1988, and Chang & Singh, 1993) forced the World Bank and its associates to revise its position (World Bank, 1995), but even this revised position have a lot of problems (Chang & Singh, 1997).

[31] As of the mid-1970s, the share of public enterprise sector in GDP was 14.5% in Austria and 11.9% in France, when the industrial country average as 9.6%. During the same period, Austria (19.2%) had the highest share of the public enterprise sector in gross fixed capital formation in the industrialized world, and Norway (17.7%) was behind only Australia (18.7%) and the UK (18.6%). See Chang & Singh (1993) for further details.

risky investments could be developed. The Taiwanese government also started off some risky, high-technology SOEs and spun off private sector firms from it - some of the leading semi-conductor firms in the country were created in this way. Korea's SOEs have also played a crucial role in certain leading industries such as steel and telecommunications.

Of course, a large SOE sector is not necessary for an effective technology policy. For example, while the Japanese SOE sector as a whole is not exceptionally small, the Japanese SOEs have played a minimal role in manufacturing. However, it seems reasonable to conclude that SOEs can provide, and have provided, an important channel through which industrial and technology policies can be effectively implemented by making it easier for the state to create learning rents in industries where the private sector firms are not willing to enter.

3.3.2. Control over the Financial Sector

Control over the financial sector has been a more important institutional basis than the control over SOEs for effective technology policy in developing countries, although the exact mechanism through which such control was instituted and maintained has been different across countries.

In many countries during much of the postwar period, this took the form of state ownership of banks and other financial institutions, which were critical in the successful use of directed credit policy (see section 2.2.2.1 on the logic of directed credit policy). The bulk of the banking sector is still state-owned in France and Taiwan. The Korean state completely owned the banking sector until the mid-1980s, and still controls a number of key banks. In Norway, at one point the state banks controlled over 50% of the bank loans (Fagerberg et al., 1990). The Japanese state may have owned only a relatively limited part of the financial sector, but its ownership of some development banks and the famous post office savings scheme allowed it to control a substantial amount of financial flows in the economy.

Direct ownership, however, is only one of the ways in which the state can maintain its control over the financial sector. The East Asian and the European countries that we are talking about all possessed what is known as the bank-led financial system32, where banks are highly exposed to highly-geared corporations (with the exception of Taiwan, where the corporate

[32] One myth that need debunking is that the bank-based financial system is somehow a "deviation" from the "norm" of the Anglo-American-style capital-market-based financial system. The reality is, if anything, the reverse (see Zysman, 1983, Cox (ed.), 1986, and Dertouzos et al., 1989).

gearing ratio is low).33 This gave their states enormous leverage over the banks, and enabled them to use their influence on bank credit decisions both as a way of subsidizing learning activities and as a means to discipline non-performers.34

3.4. Intermediate institutions

As our earlier discussion of "embedded autonomy" indicated, "intermediate" institutions that link the state apparatus with the business sector play a critical role in ensuring that state autonomy is exercised in a productive way.

For this purpose, Japan used the now-famous deliberation councils, which had representations from both public and private sectors, as well as "third parties" such as the academia, the press, and occasionally other social actors such as consumer groups (World Bank, 1993, ch. 4). Korea used similar, if more state-dominated, institutions, including its own unique monthly export promotion meetings during the 1960s and the 1970s, presided by the president and attended by top bureaucrats and top business leaders (Jones & Sakong, 1980). Taiwan had to use more informal networks, because its political conditions (such as the ethnic division between the political elite from the mainland and the "Taiwanese" business elite) made its state discourage the emergence of large-scale private sector firms, which were the main counterparts to the governments in the deliberation councils in Japan and Korea (Fields, 1995). In France, the continued exchange of the top managerial personnel between the public sector and the private sector seems to have ensured a good working relationship between the two, although this has attracted criticisms of "revolving door" at the top echelon of the French elite (Hall, 1986).

Once broad policy principles are decided at the national level through deliberation councils and similar mechanisms, these principles need to be translated into concrete action plans and enforced. And in this, industry associations can play an important role. First of all, they may be better able to devise policy implementation plans in a manner that is seen as "fair" (but not necessarily "equal" in the strict sense) among its members (for an interesting example from the Japanese shipbuilding industry in the late 1970s, see Dore, 1986, p. 145). Secondly, possessing

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[33] According to Demigruc-Kunt & Maksimovic (1996, p. 354), the average debt-equity ratio during the 1980s (1980-91) for the countries in our sample ranged from 361% (France) to 538% (Norway), except for Austria (270%). Even the much-lower Austrian figure was substantially higher than those of the Anglo-American countries (ranging from 125% for Australia to 179% for the USA).

[34] More recently, state control over the financial sector has been regarded as the main cause of the recent financial crisis in some East Asian countries. If anything, the evidence points to the other way – that is, the weakening of state control over the financial sector allowed the rapid and unsustainable build-up of short-term loans that eventually brought these economies down (see Radelet & Sachs, 1998; Furman & Stiglitz, 1998; Chang, 2000a).

detailed knowledge about the industry, they can better devise ways to monitor the compliance by its members to the agreed "collective action" schemes (see Magaziner & Hout, 1980, and Dore, 1986).

Thus seen, these "intermediate" institutions, by facilitating the information flows between the bureaucracy and the corporate sector, on the one hand, and by strengthening policy enforcement mechanisms, on the other hand, can provide the channels through which state autonomy could be "embedded" in the wider social context. As we argued earlier, embeddedness is especially important in the conduct of technology policy due to the higher uncertainties involved. Without such embedding, it would be difficult to create learning rents in the right areas and to the adequate extent, on the one hand, and to modify the policies quickly enough in response to unexpected contingencies arising out of the fundamentally uncertain nature of the learning process.

4. HAS ACTIVIST TECHNOLOGY POLICY AIDED GROWTH?

In the above, we have provided strong theoretical reasons why an active technology policy may be essential for developing country states to pursue. We have also argued that the success of active technology policy not only depends on the design of policy but also on underlying institutional and political conditions. It is, therefore, important to ask whether the type of activist technology policy we have underlined has, in fact, been pursued by developing country states with relative success.

Given their vigorous use of activist technology policy, the East Asian countries have been widely discussed as key test cases for the contribution of activist technology policy. In many studies, growth accounting has been used to deduce the contribution made by technology policy to rapid growth in East Asia (for a critical review of the literature, see Felipe, 1999). These studies have used the Solow growth accounting approach to ascertain whether the growth in East Asia was largely accounted for by capital accumulation, the accumulation of other factors, or technological change (e.g., see Young, 1995; Collins and Bosworth, 1996; Klenow and Rodriguez-Clare, 1997). These studies believe that only if the high relative growth of East Asian economies can be explained by technological change (measured by total factor productivity growth), can activist technology policy be seen as contributing to growth.[35]

Table 1 is based on Collins and Bosworth (1996) and presents the contribution of factor accumulation and TFP growth in explaining the growth rates of different regions during the period 1960-94. It shows that East Asia was, indeed, the fastest growing region during this period. South Asia scored second in terms of regional growth comparisons.

[35] For a detailed critical discussion on the total factor productivity measure see Felipe (1999). The idea is to decompose the rate of growth into a capital accumulation effect, a labour accumulation effect and a residual effect. Under the neoclassical assumptions of constant-returns to scale and Hicks-neutral technological change it is shown that the "residual" measures disembodied technological change. Jorgenson and Griliches (1967) argue that effects caused by poorly measured inputs and an improper disaggregation of input composition, to allow for changing quality, is also captured in the residual. In this case the residual seizes to be a pure measure for technological change. An important thrust of the recent empirical literature on East Asia is to measure the technological change effect after controlling for these measurement problems.

Table 1. Sources of Growth, 1960-94 (% p.a.)

Region & Period	Growth of GDP	Growth of output per worker	Growth of physical capital per worker	Growth of education per worker	Growth of Total Factor Productivity
East Asia	6.5	4.2	2.5	0.6	1.1
South Asia	4.7	2.3	1.1	0.3	0.8
Latin America	3.4	1.5	0.9	0.4	0.2
Africa	2.8	0.3	0.8	0.2	-0.6

Source: Collins and Bosworth (1996), except for the GDP growth figures that come from Senhadji (1999) as reported in Guha-Khasnobis and Bari (2000).

Note: 1. East Asia consists of Indonesia, Malaysia, Philippines, Singapore, Thailand, South Korea and Taiwan.

2. South Asia consists of India, Pakistan, Nepal and Bangladesh.

Table 1 suggests that the high relative growth rate of East Asia is explained by a much faster rate of growth of capital accumulation compared to other regions. While TFP growth in East Asia was much faster than in Latin America and Africa, it was only modestly greater than that of South Asia. These figures clearly suggest that it was faster accumulation of capital stock rather than technological change that sets East Asian apart (representative studies include Young, 1995; Kim and Lau, 1994; Krugman, 1994). Is this evidence sufficient to reject the hypothesis that activist technology policy was an important contributor to East Asian growth? We think not.

Firstly, the evidence given in Table 1 is at the aggregate economy level, whereas, the arguments given for activist technology policy relate to the manufacturing sector. After all, the types of market failures we identified in section 2.2, which provide the theoretical justification for an activist technology policy, are most likely to be present in the manufacturing sector. Table 2 provides evidence for TFP growth in the manufacturing sector for the East Asian countries known for activist technology policy (South Korea, Taiwan, and Singapore) in comparison with manufacturing sectors in other economies.

Table 2. TFP Growth Rates in Key South Asian and East Asian Countries (% p.a.)

Country	Period	TFP Growth in Manufacturing
South Korea a)	1966-90	3.0
South Korea a)	1966-70	4.8
South Korea a)	1970-75	5.3
South Korea a)	1975-80	-0.7
South Korea a)	1980-85	5.1
South Korea a)	1985-90	0.8
Taiwan a)	1966-90	1.7
Taiwan a)	1966-70	3.1
Taiwan a)	1970-80	0.1
Taiwan a)	1980-90	2.8
Singapore a)	1970-90	-1.0
Singapore a)	1970-80	-0.9
Singapore a)	1980-90	-1.1
Pakistan b)	1960-70	5.06
Pakistan b)	1978-88	-0.9
India c)	1960-80	0.3
India d)	1981-93	-2.2
Turkey b)	1963-76	1.5
Brazil a)	1960-80	1.0
Chile a)	1960-80	0.7
Mexico a)	1940-70	1.3

Source: a) Young (1995), b) Sayeed (1995), c) Ahluwalia and d) Rao (1996).

Table 2 shows that the Korean and the Taiwanese manufacturing TFP growth performances have been exceptional. Among the countries in table 2, apart from Pakistan during the 1960s, Taiwan and South Korea outperform all other countries. Of course, given the errors associated with the measurement of inputs and outputs, it is not surprising that most TFP figures tend to be disputed. However, Table 2 shows that, even using Young's (1995) own figures, it cannot be stated the technological change, and hence, activist technology policy did not make any contribution to manufacturing growth in the East Asian economies that used such policy most aggressively.

However, Table 2 also suggests that some other economies that pursued an activist technology policy have not really been able to sustain high levels of TFP growth. Young (1994, 1995) has repeatedly pointed out the poor TFP performance of Singapore's manufacturing sector. We can add to this the poor performance of India and Pakistan over the seventies and eighties, when they were using activist technology policy. While figures for manufacturing are not available for the other East Asian economies, overall economy-wide figures suggest that these economies (except for Thailand) have performed as poorly as the South Asian region, as far as the rates of growth of TFP are concerned. The evidence is presented in Table 3. How can these cases be explained?

Table 3. Rates of Growth of TFP in Different Countries (% p.a.)

Country	Period	TFP Growth
Indonesia	1960-94	0.8
Malaysia	1960-94	0.4
Philippines	1960-94	-0.4
Singapore	1960-94	1.5
Thailand	1960-94	1.8
S. Korea	1960-94	1.5
Taiwan	1960-94	2.0
South Asia	1960-94	0.8

Source: Collins and Bosworth (1996)

Let us start by explaining the poor performance of policy activism in South Asia. This is easier to explain, as there appears to be some consensus in the literature on the causes of poor policy performance, even though there is a dispute on why South Asian states are constrained in terms of choosing better policies. The standard explanation for poor performance is South Asia is the presence of poorly designed industrial policies. It is accepted that South Asian states have been unable to create contingent-rent type incentives and have not been able to create endogenous enforcement of the rules of the contest (Ahluwalia, 1985; Khan, 2000). In short, the conditions required to create efficient rent-type incentives have been missing in South Asian technology policy. The net result is that South Asian states have historically protected infants that have failed to grow. What is in dispute is the reason why these states have been unable to choose a more efficiently designed technology policy.

Conventional explanations (Ahluwalia, 1985; Little et al. 1970; Bhagwati and Desai 1970) suggest that it was the excessive reliance on import-substituting policies, as opposed to export-orientation that has led to poor performance in South Asian industrial policy. This explanation has been contradicted by the Pakistani experience, which shows that import-substitution paid high dividends in the 1960s, resulting in buoyant output and TFP growth rates, whereas similar policies failed in the 1980s (Sayeed 1995). A more convincing political economy explanation has stressed the role played by redistributive coalitions, which have constrained the ability of South Asian states to discipline the recipients of policy-created rents (Bardhan, 1993; Khan, 1989 and 2000; Cheema 1999). In short, the political conditions required to create a well-functioning technology policy were missing in South Asia.

With regard to the East Asian countries other than Korea and Taiwan, it is not clear whether these economies can be classified as poor performers. After all, the rates of growth of output and accumulation were much higher in these countries compared to South Asia (World Bank, 1993; Collins and Bosworth, 1996). Furthermore, these countries pursued some activist technology policies, although certainly not as systematically and not as effectively as Korea and

Taiwan did (Jomo & Rock, 1998)[36]. The question is whether the high growth rates achieved by these economies were because of an activist technology policy or in spite of it.

Firstly, there is a great degree of empirical disagreement regarding the TFP performance of the East Asian economies outside Korea and Taiwan. The rates of growth of TFP growth vary depending on the study and the length of the period considered. As table 4 suggests, even the TFP growth rates of Singapore are under dispute. The Klenow and Roriguez-Clare (1997) estimates show a very dynamic performance as compared to Young's results. What notable is that there is a lot more disagreement on TFP estimates regarding the East Asian countries (except for Taiwan and Korea), compared to other regions. Therefore, on the basis of these estimates alone it cannot be contended that technology policy did not make any contribution to the fast rates of output growth achieved in the East Asian countries other than Korea and Taiwan.

Table 4. Different Estimates of TFP Growth Rates in South-East Asia

Country	Author	Period	TFP Growth Rate (% p.a.)
Indonesia	Young (1994)	1970-85	1.2
	Klenow and Rodriguez-Clare (1997)	1960-85	1.9
Malaysia	Young (1994)	1970-85	1.0
	Klenow and Rodriguez-Clare (1997)	1960-85	2.0
Philippines	Collins and Bosworth (1997)	1960-94	-0.4
	Klenow and Rodriguez-Clare (1997)	1960-85	-0.7
Singapore	Young (1994)	1970-85	0.1
	Klenow and Rodriguez-Clare (1997)	1960-85	3.3
Thailand	Young (1994)	1970-85	1.9
	Klenow and Rodriguez-Clare (1997)	1960-85	2.7

Furthermore, if we move away from Neoclassical assumptions, which view technological progress as exogenous, disembodied and Hicks-neutral, it is by no means clear that technological diffusion can be disembodied from the process of capital accumulation. In fact, the *embodiment hypothesis* contends that new technological knowledge is present in capital goods, and thus more recent additions to the capital stock must be weighted more heavily than earlier additions. If this view is correct, then it is not easy to separate the effect of the movements along a production from the movements of the production function (representing technological change). In this case, a movement along the production function will result in a movement of the production function, as most technological progress is embodied in new inputs

[36]Although, recent work suggests that Southeast Asian states were not as autonomous as the Korean and Taiwanese states, and were exposed to a degree of redistributive bargaining by political coalitions (Jomo and Khan 2000).

(Kaldor, 1957; Pasinetti, 1959). As Felipe (1999, p. 22) puts it, "[i]t is not clear that purchasing machinery represents exclusively capital accumulation; that how well one uses it represents technical progress; and that both can be easily split".

Therefore, the observation that high rates of accumulation are strongly correlated with high rates of output growth in East Asia need not imply that technological change was absent from the growth process. Indeed, the proponents of the *embodiment hypothesis* (e.g., Arrow, 1962, or Kaldor, 1957) would argue to the contrary. The evidence that TFP growth was not rapid need not imply that an active technology policy made no contribution to the growth process, unless the embodiment hypothesis is explicitly tested and rejected. However, none of the studies cited above have done this. Again we find that the evidence suggesting that an active technology policy made no contribution is highly disputable.

Finally, Nelson and Pack (1999) have forcefully argued that, if one is to neatly separate the contribution of capital accumulation from that of technological change, one has to test for the factor bias of technological change and correctly specify the functional form of the production function. They show that the empirical observation that rates of labour productivity growth in East Asia were correlated with high rates of accumulation is consistent with both a constant-returns-to-scale function with a high elasticity of substitution and neutral technical change, on the one hand, and a diminishing-returns-to-scale function with a low elasticity of substitution and labour-saving technological change, on the other hand. In the former case with a steeper production function, relatively less overall growth would be attributed to a shift in the production function. In the latter case, as they put it, "experienced productivity growth is almost totally the result of the establishment of a new production function … in that very little growth in labour productivity would have occurred had the economy remained on its old production function" (Nelson and Pack 1999, p. 426). In this case, less of output growth can be attributed to growing accumulation, and more is attributed to technological change. They present simulation exercises to show that this interpretation better fits the East Asian data, with the region experiencing labour-saving technological progress through the employment and innovation of completely new techniques of production. This message is consistent with the findings of most case studies of the technological process in East Asia (Hobday, 1995; Kim, 1997; Goto and Odagiri, 1997).

On balance, it seems that activist technology policy played a vital role in stimulating technological change in East Asia, especially in Korea and Taiwan. What needs to be explained is the process through which the South Asian attempts to foster similar types of policies gave poor results. These confirm our own discussion in section 3 and the recent literature that emphasises the role played by political and institutional conditions as determinants of the effectiveness of activist technology policy (e.g., see Jomo & Khan, 2000).

5. THE FUTURE OF ACTIVIST TECHNOLOGY POLICY: CHANGING DOMESTIC AND INTERNATIONAL CONTEXTS

Many commentators argue that the activist technology policy of the kinds successfully practised by some East Asian and European countries until recently are becoming increasingly difficult to implement, because the domestic and international contexts of technology policy have changed. They point out that, domestically, the past failures of activist technology policies have prompted many developing countries to adopt wide-ranging deregulation and liberalization. Given the current consensus, especially among donors, a government that does not want to lose credibility cannot go back to the old regime very easily. Internationally, it is argued, the move towards more liberal cross-border trade and investment regimes is making more and more tools for rent creation "illegal" and open to international sanctions. In this section, we try to correctly characterize these changes and assess their implications carefully so that we can make a balanced judgement on the future of activist technology policy.

5.1. The domestic context: Liberalization and deregulation

Liberalization and deregulation are the new buzzwords in technology policy circles in many developing countries. Many people argue that, in order to unleash innovative entrepreneurship and engender dynamic efficiency, there is a need for a radical deregulation and liberalization. While there are still many who argue for deregulation and liberalization on the basis of a rather naïve belief in the optimality of the market mechanism, others acknowledge market imperfections but deploy more sophisticated arguments. There are two important arguments that deserve our attention.

The first argument is that, while there may be some market imperfections relating to technological progress, markets work fairly well in most cases. And more importantly, even where market imperfections exist, voluntarily negotiated institutional changes will redress the underlying conditions that create these market imperfections (e.g., inefficient property rights) (Hayami & Ruttan, 1985, is a classic statement of this position).

The second argument puts emphasis on the fact that, like markets, states too work imperfectly. They argue that because of rent-seeking, corruption and information constraints, relying on the state may in fact result in technological stagnation (Krueger, 1974, Baumol, 1990, and Murphy et al., 1993).

The first position – namely the belief that, while imperfect markets exist they can be, and will be, improved through voluntary contracting – needs to be critically evaluated in light of recent developments in institutional economics (Coase, 1937 and 1960, are the seminal works; also see Dahlman, 1979). According to this argument, given the pervasiveness of measurement problems, opportunism, and bargaining costs, institutional change may well not come about through voluntary bargaining, thus reinforcing the status quo.[37] In fact the justification for activist technology policy by others[38] and by the present paper (see section 2.2) is precisely based on the recognition of the limits to individual contracting as a means to overcome market imperfections.

The second position needs to be taken more seriously, especially given the widespread failures of activist technology policy in developing countries in the past, which is exactly why many of these countries are turning to deregulation and liberalization. However, this view still has a number of shortcomings.

First of all, as we argued in section 2.2, deregulation and liberalization will not in themselves stimulate developing countries along dynamic technology trajectories. It may be reasonably expected that an increase in competition may result in improvements in sector-level *technical efficiency*, as slack is reduced, especially in economies which have been overprotected and in which the state has been unable to enforce contingent-rent-type incentives for political and institutional reasons.[39] However, to conclude from this argument that competition will stimulate *technological change* is to make a leap of faith. Recent empirical evidence on the effects of deregulation/liberalization on productivity growth shows ambiguous results, suggesting that deregulation in itself cannot explain changes in the incentives for technological change across sectors and countries. [40]

Secondly, this view also fails to acknowledge that in many industries significant barriers to entry have to be negotiated by followers, if they are to move onto dynamic technological trajectories. In this case, a move towards deregulation/liberalization will slow down the rate of technological change in developing countries, as it removes the *incentives* which compensate

[37] On these issues, see Cooter (1982), Milgrom & Roberts (1990), Dow (1993), Chang (1994), Cheema (1999), and Khan (2000b).
[38] Cooter (1982), Amsden (1989), Chang (1994), and Chang & Rowthorn (1995).
[39] Evidence on this issue in the Bangladeshi context is provided by Khan (1989) and Bhaskar and Khan (1995).
[40] For recent evidence on Colombia, Chile, and Morocco, see Tybout & Roberts (1996). For recent evidence on sectors in India, see Ahulwalia (1991), Balakrishnan & Pushpangadan (1994, 1998) and Rao (1996a, 1996b). For evidence on the spinning sector in Pakistan, see Cheema (1999). For evidence on Taiwan, see Aw et al. (1997). Of these, the Colombia, Chile and Taiwan studies show that deregulation and liberalization improved sector-level productivity growth trajectories, while the India, Pakistan and Morocco studies suggest a negative or zero effect on sector-level productivity trajectories.

followers for the costs of late entry. In addition, the recent moves towards the enforcement of intellectual property rights and patents as part of a new set of global rules may well reinforce these entry barriers (see section 5.2. for further discussion; also see Chang, 2000c). In industries where R&D involves sunk costs, the incumbents who have a head start in research can *credibly* commit to strategic entry deterrence by investing a small amount into a research programme and by announcing their intention of competing with any other firm(s) thinking of doing research in the area (Dasgupta and Stiglitz 1988b). A follower firm who recognizes the head start of the incumbent(s) *will desist from entering the research race*, since it will be unable to recover the R&D investment in the event of losing the race. Moreover, Stiglitz (1996) has shown that, with these entry barriers, the overall rate of R&D will slow down, as the incumbent's *threat* of speeding up R&D is a sufficient entry deterrent, thus removing the pressure on the incumbent(s) to speed up R&D.

Thirdly, the supporters of this view rarely acknowledge the political costs of deregulation and liberalization. However, any shift in state policy in favour of deregulation/liberalization will itself involve rent-seeking as changes in the *existing* rights over policy-created 'rents' will affect the income flow for relevant agents (Cheema 1999, p. 5).[41] Therefore, such rent-seeking costs need to be taken into account when considering the net social benefits of these moves. Moreover, even if the deregulation/liberlization recipe is the correct one, its efficient institutionalization is contingent upon the outcome of "political contests" that are society-specific. For example, empirical evidence suggests that where deregulation and liberalization of sectors have been accompanied by financial bail-outs of non-performing firms, the incidence of internationally uncompetitive firms increases after the change in policy (Cheema, 1999, and Pursell, 1990).

In response to these criticisms, it may be argued that, even if deregulation and liberalization is not an ideal solution, these policies, once they have been implemented, should not be reversed lest such reversal damages the government's policy credibility. However, policy credibility cannot be an end in itself, and therefore if the benefits from more sensible policies outweigh the costs from losing policy credibility, a change in policy direction should be recommended (for a critical assessment of the issue of policy credibility, see Grabel, 2000).

[41] Chang & Rowthorn (1995) argue that "when the mobility of certain assets is limited for reasons such as limited malleability of physical or human capital, the owners may suffer substantial cuts in their income if they accept the 'imperatives of the market' and move to the 'next best' option" and therefore that "the owners of these assets may not accept the imperatives of the market and may take 'political' action to redress the situation ... thereby provoking counteraction from others in society" (p. 41).

5.2. Changing international environment

In the 1990s, there have been an increasing push by the leading industrialized countries, through various multilateral and bilateral initiatives, towards the establishment of "liberal" international regimes that constrain the freedom of individual countries in their use of trade, industrial, and technology policies. The most important of these regimes is obviously the launch of the World Trade Organisation (WTO). However, there have also been other moves such as the attempt to introduce Multilateral Investment Agreement (MIA), which aims to restrict industrial and technology policies that discriminate against foreign companies, and bilateral negotiations that are aimed to strengthen the protection of intellectual property rights especially by developing countries.

These attempts have not always been successful. The attempt to push further with the WTO talks in Seattle in late 1999 failed due to strong resistance from developing countries as well as from various pressure groups from developed countries. The talks regarding the MIA initiated by the OECD have also been aborted in 1998 by the resistance of many developing countries and some advanced countries. Indeed, quite surprisingly, by late 1999, even the OECD acknowledged the need to introduce the "code of conduct" for the transnational corporations (TNCs), something that had not been heard of since the 1970s. Bilateral talks to strengthen intellectual property rights in developing countries have been only partially successful.

Despite these recent setbacks, considerable changes have happened in the international environment for technology policy recently. Therefore, it is important for developing countries to correctly assess the implications of these changes. For this purpose, it is probably most useful to look at the implications of the WTO regime, as other initiatives are not as comprehensive as the latter and are yet to be established (MIA being the best example).

The launch of the WTO has prompted many people to argue that, whatever their merits may have been in the past, activist trade, industrial, and technology policies using learning rents are "out" now. Is this true? (for further details, see Akyuz et al. 1998, Chang 1999, and Amsden, 2000)

To begin with, there is a genuine uncertainty as to how this regime is going to evolve. There are on-going disputes on what is "free and fair trade" among the members of the WTO, as best seen in the debates on whether "lax" labour and environmental standards in developing countries constitute "unfair competition". And as far as these disputes reflect the genuine differences in values and goals, rather than simple foot-dragging, this dispute is not going to go away easily (on the difficulty of defining the free market, see Chang, 1997, 2000b, and 2000c). Moreover, it is not clear how exactly these disputes will actually be resolved, given the formally "democratic" decision-making structure of the WTO – unlike those of the WB and the IMF,

where the principle of "one dollar one vote" rule reins or that of the UN, where some countries have formal veto power – and the increasing willingness of the developing countries to exploit this in their interests (for further details, see Evans, 2000).

Second, while it is true that under the WTO, rules on the use of tariffs, subsidies, etc. have become tighter, it is not as if everything was allowed under the old regime. Even under the old GATT regime, there were a lot of restrictions on what countries can do, and countries like Korea often exploited grey areas in implementing its policies. Therefore, it is important not to over-estimate the relative impact of the WTO.

Third, we have to note that, even on paper, the WTO agreement by no means obliges countries to abolish all tariffs and protections, and many developing countries have decided on tariff ceilings that are still considerable (Amsden, 2000).[42] Moreover, this tariff cut is supposed to be done over a period of 5-10 years, so there is still a breathing space – although this has more or less run out for many countries in many areas, where the agreed changes are supposed to be made by early 2000. Obvious exceptions in this regard are the least developed countries who have until 2006 to reduce tariffs and the product patent protection that has the deadline of 2005. In reality, however, some countries have reduced their tariffs much more than and much quicker than what they need to, partly in their desire to be on the "good books" but also because of the pressures exercised on them by the Bretton Woods institutions.

Fourth, infant industry protection is still allowed (up to 8 years), although it must be pointed out that infant industry protection was *not* the clause invoked by countries like Korea when using protection under the old GATT regime – they usually used the balance of payments (BOP) clause that we discuss below.

Fifth, there are still provisions for "emergency" tariff increase ("import surcharge"). This can be done on two grounds. The first is a sudden surge in sectoral imports, which a number of countries have already used (e.g., Argentinian tariff on Brazillian cars). The second is the overall BOP problem, for which almost all developing countries qualify and which a number of countries have also used. Since countries have discretion on how much emergency tariffs can be imposed on which commodities, as far as these are on the whole commensurate with the scale of the BOP problem, there is still a lot of room for deliberately creating rents in areas where learning opportunity may be maximized.

Sixth, not all subsidies are "illegal" for everyone. For example, the poorest countries (roughly below $1,000 income per capita) are allowed to use export subsidies, which other countries

[42] Some countries reduced such ceilings substantially – for example, India cut its trade-weighted average tariff from 71% to 32%. However, many countries, including India, have fixed them at

cannot. Subsidies for agriculture, regional development, basic R&D, environment-related technology upgrading are still allowed. Especially from the point of view of the present paper, it is very important to note that many standard tools of technology policy – for example, establishment of science parks, R&D subsidies, joint public-private R&D efforts – are still available. Moreover, the subsidy restrictions only cover "trade-related" policies, which means that there are many "domestic" policies that can be used for the creation of learning rent and other technology policy purposes – examples will include subsidies on equipment investments, support for start-up enterprises, subsidies for investment in particular skills, etc..

Sixth, although the future shape of the TRIPS (trade-related intellectual property rights) regime is still not entirely certain, given the way in which the developed countries, especially the US, are pushing it, it is likely to have some important adverse effects on technology absorption by developing countries (see Chang, 2000c, for further details). However, it must be said that the technologies that many developing countries need to absorb are often the ones that are too old to have patents, an overly pessimistic conclusion should not be drawn.

Lastly, as for the TRIMS (trade-related investment measures), it should be noted that it is not as stringent as it is sometimes thought to be. Amsden (2000) points out that developing countries can maintain or even strengthen local contents requirement, which is an important tool for technology upgrading. She also argues that they are still allowed to use export promotion measures, such as “trade balancing stipulations” (where TNCs are required to exports final products whose value equal the imports of parts and components) or export requirement for TNCs in export processing zones. She points out that many countries (e.g., Brazil, Argentina, Chile, India, Indonesia, Mexico, Malaysia, Thailand) have in fact been using these provisions in a number of industries (e.g., automobile, pharmaceutical, various consumer goods industries).

Thus seen, the changing international environment has certainly imposed considerable extra constraints on the conduct of trade, industrial, and technology policies by developing countries, but these constraints are by no means overwhelming. And many countries have actively sought, and succeeded, to use activist policies without breaching the WTO requirements. And with the increasing demands by the developing countries to forge an international trading and investment order that is less one-sided, backed up for one thing by the “democratic” structure of the WTO, the scope for activist policies may even increase in the future.

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relatively high levels – for example, Brazil cut its trade-weighted average tariff from 41% to 27%, Chile from 35% to 25%, Turkey from 25% to 22% (see Amsden, 2000, table 1).

6. SUMMARY AND CONCLUSION

In this paper, we have argued that various naïve "pro-market" views on technology policy in developing countries are not warranted. Instead we argue that the process of technological development in these countries is fraught with market imperfections – such as learning externalities, coordination failure, and increasing returns to scale – that call for an activist technology policy. We have also pointed out that the presence of transaction costs imply that such market imperfections cannot be addressed through voluntary contracting among economic agents, thus lending further advantage to state mediation and arbitration.

We are acutely aware that a socially beneficial execution of activist technology policy needs certain economic, political, and institutional conditions. The policy should be designed in a sophisticated way that fully reflects the exact nature and the extent of market imperfections in the areas concerned and that builds in effective monitoring and enforcement mechanisms. This, in turn, requires a state which has the willingness and the ability (informational, financial, and institutional) to discipline the non-performers. We argued that such a state is not easy to construct, as the experiences of many developing countries suggest, but that neither is it impossible to, as the experiences of some successful European and East Asian countries show. We have also argued that the changing domestic and international policy contexts, while not making activist technology policy impossible, make a more careful policy design necessary.

It is our contention that we need go beyond the naïve pro-market view or the naïve pro-state view on technology policy in developing countries. While it is important to acknowledge the market imperfections and transaction costs that create the need for activist technology policy, it is equally important to understand the various economic, political, and institutional factors that influence the effectiveness of technology policy. Without an approach that acknowledges the imperfections of both markets and states, we will not be able to come up with a balanced and realistic view on such a complex and difficult issue as technology policy.

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† The authors thank Anthony Bartzokas for his very helpful comments on the first version of the paper and an anonymous referee for his/her comments on the second version of the paper. They also acknowledge useful comments received at a workshop in Sussex, UK from Martin Bell, Dieter Ernst, Rhys Jenkins, Margaret Sharp, Morris Teubal, and especially Larry Westphal.

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