Economics of Public Involvement in Market Development

Private Versus Public Incentives for Market Development Investments: Is There a Role for Public Policy?

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We treat market development as an economy-wide process which, to be socially profitable, must lead to growth in economic welfare. This treatment places emphasis on market failures. From the perspective of supply, it entails failures that preclude the efficient allocation of resources to meet final demand. Resources include those allocated to the production of product, process, and social innovations that save resources for a given value of output. It suggests that the principles of dynamic comparative advantage are important to growth in welfare, that it is socially desirable to specialize in some markets, invest in the development of others and to disengage or retreat from those that are unlikely to yield a maximum expected return to resources.

This treatment also suggests that it can be socially profitable to invest in the development of market demand. For example, while consumers are viewed as sovereign over their preferences for attributes, attributes are bundled in products and services, and hence the nature and level of the attributes may be poorly known. Consumers may also be uninformed about the utility derived from a particular set of attributes. The most common example is when, in part, utility depends on health and health depends on consumption goods, leisure and non-choice variables. Since the mapping from choice variables and their associated attributes to health is typically poorly known, consumers are prone to make allocative errors. Interventions that lower these errors can be socially profitable.

As Stiglitz has amply shown years ago, when information is costly, goods are non-rival and non-excludable, competitive markets fail to perform the magic of the invisible hand. Then, imperfect competition, government intervention, and collective action may yield Pareto superior outcomes to those of the competitive market.[1] In this case, whether imperfect competition leads to a decline in welfare depends on how their excessive rents are allocated. If incentives encourage the allocation of rents to better inform consumers and to reinvest in the production of product and process innovations and other activities that improve welfare, then the traditional measures of welfare and consumer losses due to market power, such as those provided in Connor and Peterson and others may be seriously misleading.

To narrow the scope of our paper, we focus on the nature of economic growth and the process by which growth comes about. Attention is focused largely on contributions from the new growth theories, how markets and market structures can influence sources of growth externalizes, and implications for policies that stimulate growth—and hence competitiveness—of agriculture in general and the value-added sector in particular. To initiate and provide a background for this discussion, time series data on the U.S.

economy, the agricultural sector and the value-added sector (food, tobacco, textiles, paper and lumber) are used to contrast the relative shares and sources of economic growth. This analysis suggests the nature of growth linkages between agriculture and the value-added sector, and the extent to which the source of contributions to growth differ between sectors. Then, we review elementary growth theory in order to distinguish differences between sources of growth that affect levels from those that affect growth rates. This discussion is followed by an overview of the insights provided by the more recent contributions to the growth literature and their policy implications.

Sector Shares and Sources of Growth

The agricultural sector has declined from 9 percent to only 1 percent of the U.S. economy while the services sector has grown from 29 percent to 53 percent during the 1948 to 1992 period. The composition of agricultural output has not changed significantly as the share of crops and livestock in total value of farm goods remained almost equal throughout the period. However, the value added to agricultural output has grown substantially, exceeding the size of the agricultural sector by a magnitude of three. The largest component of the value-added sector is food and kindred products which accounts for almost 65 percent of total (Gopinath and Roe, 1995). Increasing agriculture's competitiveness in the world economy entails increasing the efficiency of these two sectors, recognizing that they must compete with the rest of the economy for economy-wide resources.

Factors contributing to economic growth vary substantially from one sector of the U.S. economy to another even though the various sectors are intricately linked and forced to compete for economy-wide resources. While the growth in real U.S. gross domestic product (GDP) has averaged 3.15 percent over the period 1948 to 1992, growth in agriculture's GDP has averaged 0.25 percent (Table 1). Growth in the levels of labor and capital have contributed, on average, about 75 percent to economy-wide growth, leaving approximately 20 percent to be attributed to increases in total factor productivity (TFP) and about 5 percent to favorable changes in the terms of trade. Overall, technical change bias has been labor using and capital saving (Gopinath and Roe 1994; Jorgenson et al.), whereas, in the agricultural sector, it has been materials using (Gopinath and Roe, 1995).

In contrast, the growth in agriculture's real GDP has only averaged a mere 0.25 % over the same period, while output growth has averaged 2.1 % (Appendix Tables A.1, A.2, A.3). The average net effect from the departure of labor and the increase in material and capital deepening, was almost sufficient to leave the sector at a zero level of growth. Despite the large negative sectoral terms of trade effects (-1.84 percent per year), the main driving force for growth in agriculture is the relatively high rate of total factor productivity (TFP) which, by itself, augmented the increase in agriculture's GDP by an average of 2.41 percent per year.[2] As is well known, the benefits from these gains have been largely appropriated by final consumers as the negative change in the terms of trade suggest.

Since Griliches, the relatively large TFP for agriculture has been the subject of a plethora of research, most of which has shown extraordinarily large social returns. For instance, Huffman and Evenson find that the social marginal internal rate of return

Table.1 Growth Comparison (1949-1991)

	Aggregate Economy	Agriculture	Value added
Growth Rate/Year	3.15	0.25	1.26
Labor	1.13		-0.03
Family Labor		-0.56	
Hired Labor		-0.43	
Capital & Property	1.20	0.03	0.26
Materials		0.64	1.03
Services/Energy			0.25
Terms of Trade	0.15	-1.84	-1.12
TFP	0.62	2.41	0.88

Source: Gopinath and Roe (1994) and Gopinath and Roe (1995).

as high as 41 percent for investments in public agricultural research in the case of the United States. In addition, strong evidence for research spill overs among states and complementarities between public and private investments in research and development has also been identified for U.S. agriculture (Deininger, 1994). This evidence suggests that public expenditure in more basic research induces further private sector investments to adapt and apply this new knowledge for commercial advantage.

The source of TFP growth in agriculture is surely not restricted to the sector alone. Much of the investment in research leading to new discoveries and advancements in human skills is an economy-wide process, the gains from some of which surely lead to efficiency gains in agriculture. Agriculture also benefits from investments in public goods such as roads, infrastructure and institutions (social infrastructure as noted by Stern) that improve the efficiency of markets to transfer resources intra- and inter-temporally. Efficiency gains related to management and organization, such as more efficient information assembly, processing and changes in the design of incentive systems that lead to a more efficient coordination of resource allocation activities, must also contribute to efficiency gains in the sector. Still, our knowledge of the relative levels of these various contributions and how markets fail to optimally supply them is poorly understood, and even more so for the case of the value-added sector.

The sources of growth in the value-added sector's real GDP are summarized in the right-hand column of Table 1. A more disaggregated breakdown is provided in the

Appendix Tables A.1 through A.6. Its growth in real GDP averaged about 1.26 percent per year over the 1950 to 1991 period, with output growth in the neighborhood of 2.4 percent. It too suffered from adverse terms of trade effects (-1.12 percent), primarily for food and textiles (see Appendix Table A.5). Increase in capital and services contributed positively to growth. However, the two major sources of growth in real value added came from the increase in materials (1.03 percent) and TFP (0.93 percent). The composition of the total cost of production of value-added sector (Gopinath and Roe, 1995) shows a large share for the materials category which includes the primary outputs from agriculture. Hence, the sources of productivity growth in agriculture, which gave rise to the aforementioned 2.1 percent annual growth in its output, in turn contributed significantly to the growth in the value-added sector.

This reflects one source of complementarity between the two sectors. To determine this contribution more precisely requires estimates of input-output coefficients for each of the value-added subsectors. Another source of complementarity, albeit not shown in Table 1, is the extent to which the attributes produced or added to agriculture's primary output by the value-added sector slowed down or diminished what would otherwise have been more adverse changes in agriculture's terms of trade. Finally, the contribution of TFP to the growth in the value added also translates into efficiency gains that permit this sector to compete more favorably for agriculture's primary output, further slowing or diminishing the terms of trade decline to the sector.

Now, what is the nature of the economic problem? Would a benevolent, all-knowing social planner allocate resources to the production of TFP that would yield growth contributions of the magnitude we observe in the data, or are there "market failures" in which the invisible hand functions more like a clumsy foot? Of course, government intervention, or collective action by sector representatives or others whose welfare is affected by the failure, may act so as to internalize the externalities. Can mechanisms be designed to correct for these failures? Is it possible that the design of mechanisms to correct for them may lead to an environment that creates other failures? For instance, is it likely that concentrated industries with imperfectly competitive markets or collusion of some type by industry representatives may result in internalizing the growth externalities, but also extract excessive rents from consumers? Or, is the nature of growth externalities so economy-wide that they can only be internalized by public sector intervention. Of course, a variety of interventions by both public and private organizations and the design of various mechanisms are likely required so the overall problem is to determine the nature of those public interventions and mechanism designs that are likely to be most socially profitable.

Elementary Growth Theory: A Point of Departure

Insights provided by the early contributions to growth theory, e.g., Solow, continue to play an important role in the so-called new growth theory, and thus serve as a useful point of departure to our discussion of the sources of economic growth as they may apply to the value-added sector. In particular, we need to distinguish between growth level and rate effects, to identify the mechanisms contributing to TFP growth, and consider the implications to public sector intervention and mechanism design.

The simplest version of the Solow model is to posit an aggregate production function of capital K and labor L. In Cobb-Douglas form

$$(1.0)\ Y_t = K_t^{\beta}\ (A(t)L_t)^{\alpha} \quad 0 < \alpha,\beta < 1,$$

where A(t) is an exogenously given rate of efficiency gain so that the product $A(t)L_t$ may be thought of as "efficiency labor." With a fixed savings rate s, aggregate net investment, $\dot{K}_t = dK_t/dt$, is simply the difference between gross investment and depreciation δK_t,

$$\dot{K}_t = s\ K_t^{\beta}(A(t)L_t)^{\alpha} - \delta\ K_t$$

Dividing both sides through by the amount of efficiency labor; differentiating the capital-efficiency labor ratio with respect to time, $\dot{k}_t \equiv d(K_t/A(t)L_t)/dt$; and rearranging terms yields the growth rate of capital per capita of effective labor

$$(2.0)\ \dot{k}_t/k_t = s\ k_t^{\beta-1}(A(t)\ L_t)^{\alpha+\beta-1} - \delta\ \dot{A}(t)/A(t) - \dot{L}_t/L_t$$

What does this model have to do with our story?

First, suppose the industry is competitive and exhibits constant returns to scale in the choice variables K_t and L_t of producers. Second, assume there is no exogenous technological change so that A(t) is constant. Then, net capital accumulation is just equal to the rate of depreciation and growth in labor, and the long-run equilibrium growth rate is zero as depicted by point a, Figure 1. Short-run growth effects (both positive and negative) are depicted by levels of capital per effective worker that depart from k* or k'. Third, if the level of net investment were to increase (i.e., a change in s)[3], then the marginal product curve in Figure 1 shifts upward, as does output per-capita (Figure 2), but the long-run growth rate remains at zero (point b). That is, changes in the level of investment affect the *level* of real output, not the *rate* of output growth. The relationship to our story is that the contribution from factors is equivalent to our level effects while the efficiency term A(t) is our TFP discussed in Sector Shares and Sources of Growth. If, for example, $A(t) = e^{gt}$, then the steady state rate of growth in TFP would be the coefficient αg.

In our discussion below, emphasis is placed on sources that affect the *rate* as opposed to factors affecting the *level* of growth. To understand the rate of growth effects, we will need to *endogenize* A(t). It is also important to understand how the economic system generates A(t); what part of the system generates the equivalent of A(t) from normal market forces and hence is not likely to be among the socially optimal government interventions; and what part is generated from spill-overs or externalities.

How does this framework serve as a point of departure to insights that the more modern literature might suggest? First, growth must be associated with factors that can be accumulated. Second, if returns to scale are constant (CRS), then in competitive equilibrium the value of output is exhausted by payments to factors of production; nothing is left over for investment in research and development! Industries in which returns to scale are constant and in which there is no provision of public goods should, in principle, experience zero levels of TFP growth. If returns to scale were decreasing and A(t) constant, then growth in the steady state is negative.[4] Moreover, decreasing returns imply rents which, in equilibrium, must be zero. If the technology exhibits increasing returns to scale, then a set of prices to support an industry equilibrium cannot be found.

Since we, in fact, observe growth, the above model suggests we need to reexamine

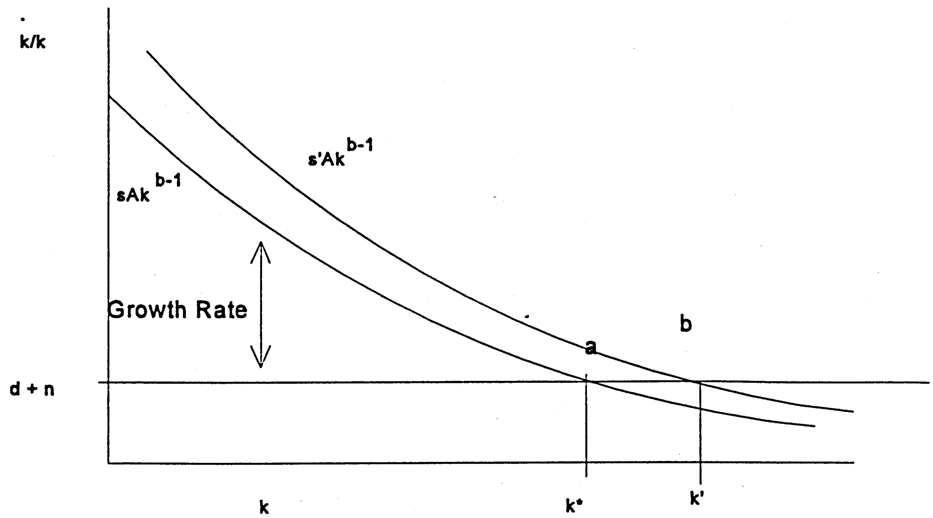

Figure 1. LEVEL EFFECTS

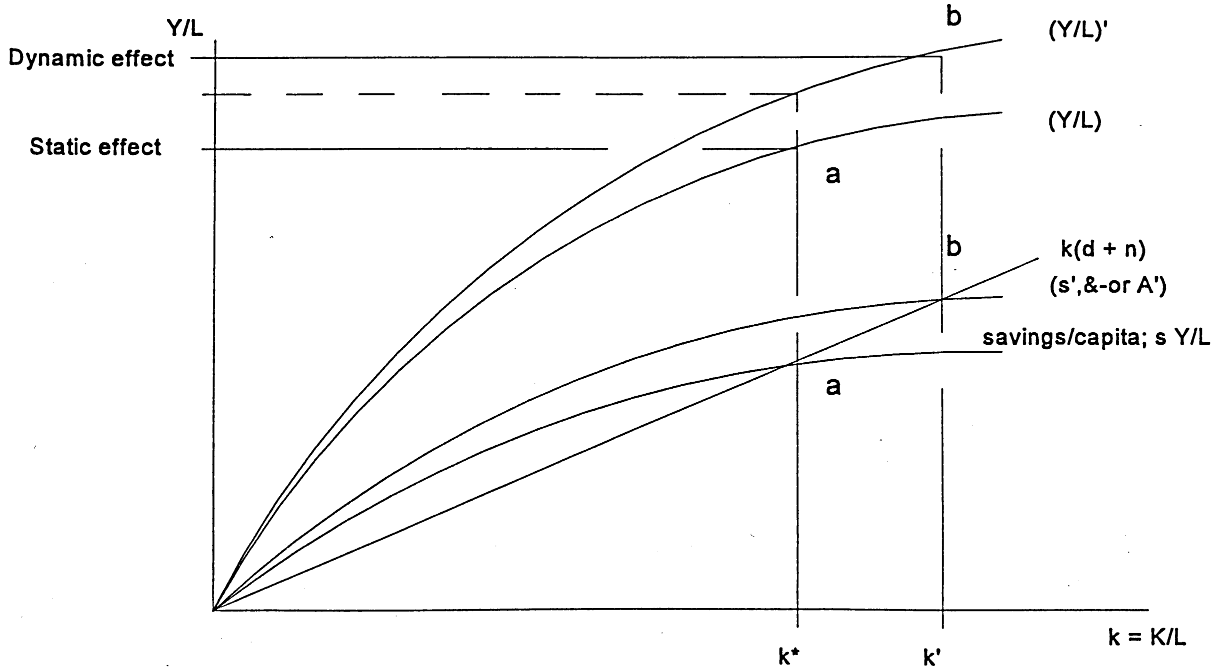

Figure 2. RATE EFFECTS

the CRS assumption, to reconsider market structures and to search for growth externalities. There are two ways in which we might re-think the scale problem. The first is to recognize increasing returns to scale at the industry level but constant returns to scale at the firm level. In this case, as we see below, a component of TFP can be viewed as an externality. This approach has been used by Romer (1989). The mechanism design problem is how to internalize the externality and do so in a way that precludes other externalities common to collective action.

Another approach is to relax the assumption of perfect competition. Then, the value of output is not exhausted by payments to factors of production, leaving some rents to be reinvested in activities that may not be directly productive but that may contribute to the expansion of the frontiers of knowledge such as research and development, as suggested by Romer (1990). Granted, a mechanism design problem may exist here as well. What prevents firms from using the rents to lobby for protection from competition, from buying out firms in other industries, or from simply increasing dividends?

Imperfect competition may enter in another way as well. If a firm is imperfectly competitive in the product market and a market exists for ideas (patents), then the imperfectly competitive firms will bid up the price of patents, increasing their production. The cumulative factor in this case is knowledge, but the production of knowledge consumes resources. As we will see, property rights and foreign trade can affect this source of growth.

We now turn to each of these possible sources of growth in the next section.

Endogenous Growth, Some Implications

The simple "generic" externality concept can be shown by developing the equivalent of (1.0) from the firm level. For an N firm industry, let

(1.1) $y_i = k_i^\alpha (A\ l_i)^{1-\alpha},\ i = 1,;,N$

denote the individual firm's production function of capital k and labor l, where A denotes the level of knowledge. Then, let A be a function of the total capital employed in the industry, say $A = (N\ k)^\gamma$. Since firms are identical, the equivalent of (1.0) becomes

(1.2) $Y = K^\alpha L^{1-\alpha} K^\gamma = (Nk)^\alpha (Nl)^{1-\alpha} (Nk)^\gamma$

where (1.1) is constant returns to scale at the firm level and (1.2) is increasing returns to scale at the industry level. Individual firms choose k and l, taking the externality, A, as given. Since all firms in the industry are identical, Romer (1986, 1989) normalizes the optimal level of l to unity, and essentially sets $\gamma = 1$. Then, (1.0) becomes

(1.3) $Y_t = (Nk)^\alpha N^{1-\alpha} (Nk)^{1-\alpha} = K\ N^{1-\alpha}$

A benevolent planner takes into account that the externality yields a growth rate of $(N^{1-\alpha} - \rho)/\sigma$ where ρ is the rate of time discount, $1/\sigma$ is the elasticity of consumption, and $N^{1-\alpha}$ is the marginal social product of capital. Since private firms ignore A, they perceive $\alpha N^{1-\alpha}$ as the marginal product of capital, in which case competitive markets yield a small level of growth, $(\alpha N^{1-\alpha} - \rho)/\sigma$. Now, policy and institutions matter since $\alpha < 1$ causes the market to produce lower than socially optimal growth rate.

This simple and abstract illustration suggests that since firms choose resource levels taking A as a parameter, they too are unlikely to be fully knowledgeable of the externality.[5] Even if they are aware, "non-market" or collective action is required to internalize the externality. Industry newsletters, producer associations and other organizational linkages currently exist that help provide knowledge of spill-overs among firms in an industry. But, outside the computer industry, collective action to undertake or sponsor joint research and development (R&D) activities seems rare. Further, the knowledge component may be far broader than the industry per se, and instead relates to the more basic sciences, i.e., a public good that is more economy-wide. Then, a free riding problem can exist in cases in which it is perceived not to be in the interest of a groups representing a fairly small sector of the economy to expend political or other resources to resolve a market failure whose gains from resolution are largely shared by the rest of the economy.

Another form of an externality along the above lines is learning by doing. Lucas' review and extension of this literature finds that returns to learning by doing on individual product lines tend to be high initially, but later decreasing marginal returns occur. Consequently, cumulative effects do not lead to increasing returns to scale (IRS) at the industry level in the long run. Further, it then appears high learning rates as a source of efficiency gains are *not* associated with a particular product or industry per se. To avoid the decline in productivity from learning by doing on a single product line, what becomes important is the mix (scope) of goods produced and the continual change of this mix to sustain high rates of efficiency gains from learning. Effectively, the problem becomes one of how an industry (or economy for that matter) allocates its work force to the production of goods of different vintages that in turn gives rise to new products and, hence, more rapid rates of learning. To the extent that learning has spill-over effects on other product lines, scale economies come about. Further, the size of the market and openness of the economy now become important because of their impact on learning and the opportunity to spread learning costs over more units of product. Hence, growth in TFP will depend upon three parameters: the decay rate of spill-over experience, the level of spill-over, and the learning rate within a particular product line.

Stokey, and Young extend this line of reasoning and show analytically that a sustained movement from less sophisticated to more sophisticated products is important to growth. Higher rates of growth are obtained to the extent that the work force can be concentrated on the production of goods near a sector's quality frontier, thus accumulating human capital rapidly enough through high learning rates associated with new activities and through the spill-over of this experience to the production of still newer goods. Interestingly, the result is much like a treadmill. Comparative advantage is not determined by primary resource endowments, as the older views suggest. Instead, ideas, design and process engineering of the new product is soon imitated and adapted in an industry in another country. If innovation is not continued, the industry in the former country faces increased competition from abroad. So, to sustain a comparative advantage, innovation must continue; but because it leads to adaptation in an industry in another country at some point, innovation in the former country becomes an engine of growth for the latter country as well.

Romer (1990) argues that to better understand the nature of growth externalities, i.e., how and in what ways markets fail to yield a socially optimal level of growth, a distinction must be made between the role of human capital and ideas and between goods that are rival or non-rival and their degree of excludability. Ideas (A) relate to both product and process innovations. Human capital (H), a rival good, is used to produce ideas which tend to be non-rival as their use by one does not preclude their use by another. Whether they are excludable depends on whether they are, for example, patentable, e.g., computer code for software application tends to be relatively more excludable than discoveries from basic research. Ideas, in turn, are an input into the production of human capital. Both human capital and ideas are goods whose production consumes resources. In this case, final good production has the form:

(1.4) $Y = F(K,H,A)$

If $F()$ is CRS in K and H, then no revenues are left for investments in A. If, however, firms produce differentiated goods and earn rents then some resources remain for investments in A. In order for a market for A to exist, property rights must be assigned or some way devised to make A excludable. Thus, product and process innovations (A), property rights, the size of the market, and departures from price taking become important components to increasing growth.

To glean the nature of these linkages, it is useful to describe in a bit more detail the Romer (1989, 1990) construct, and the contributions along the same lines made by Grossman and Helpman (1991a, 1991b) for the case of a small open economy. To do so, we draw upon the paper by Elbasha and Roe that draws heavily on these models to account for the effects of endogenous growth on the environment.

The conceptual framework is of a small open economy that produces two final goods, i = 1,2, using two factors of production (K, L), and a set of differentiated intermediate inputs, indexed D, and a CRS technology. Only the commodities are traded. Consumers are infinitely lived. Following Romer, and Grossman and Helpman, the intermediate goods sector is imperfectly competitive by virtue of producing differentiated intermediate goods which is defined by the Dixit-Stiglitz specification

(3.0) $D_i = [\int_0^M X_i(j)^\delta \, dj]^{1/\delta}, 0 < \delta < 1, i = 1,2$

where M(t) denotes the number or set of differentiated products available at time t and X(j) is the amount of differentiated input j. Each brand j of differentiated inputs ($j \in [0,M(t)]$) is produced by a single firm. Each X(j) is produced using a CRS technology and labor and capital. The set [0,M(t)] of differentiated inputs can be viewed as ideas, or process-product patents which are themselves produced by a third sector, the R&D sector. It is in the R&D sector that the set M leads to a growth externality. The level of R&D, as measured by M, is taken to be proportional to the accumulation of knowledge. Knowledge is mixed with labor and capital so that accumulation takes place. The production function for this sector appears as:

$$(4.0)\ \dot{M} = A_m K_m^{\theta} L_m^{1-\theta} M$$

where producers of $\dot{M}$ treat M as a parameter. M is excludable, say blueprints to a new design which is treated as though it is patent protected, but M is also non-rival since others can study the design, and using resources, produce a new idea. Further, the M in (4.0) has the cumulative-externality effect of A in (1.1). To this externality effect on growth is added the effect of imperfect competition. Since the intermediate inputs X(j) are differentiated, the producers of these inputs sell in imperfectly competitive markets.

A number of propositions follow from this structure. For instance, the more rate of growth is positive and proportionally related to the level of a country's (or sector's) endowment of K and L, the more productive is R&D (as determined by the magnitude of A_m, the smaller the rate of time preference (ρ), and, most importantly for our discussion here, the smaller the elasticity of substitution (δ). In other words, the more imperfectly competitive are the suppliers of intermediate goods in their product market, the higher the prices they are willing to pay in the market for ideas, M. The higher the prices for ideas, the more ideas that are supplied, the faster M accumulates and the more efficiently $\dot{M}$ can be supplied. It is in this way that the departure from price-taking gives rise to rents, some of which are allocated to the purchase of product and process innovations which further contributes to growth. Still, growth tends to be sub-optimal. Since M is an externality, and taken as a parameter by the R&D sector, the optimal level of growth as determined by a central planner is higher than the market determined level of growth.

When this framework is expanded to allow for foreign trade in final goods y and z only, the above framework suggests that changes in the terms of trade may increase or decrease growth. If the R&D sector is capital intensive, than a change in the terms of trade in favor of the export good y enhances (retards) growth if good y is less (more) capital intensive than the import good z. The intuition behind this result follows from the Stopler-Samuelson theorem which suggests that the price of the factor used intensively in the production of a traded good will rise (fall) with an increase (decrease) in the price of the good while the price of the other factor will fall (rise). If the R&D sector experiences a fall in the price of the factor it uses intensively due to changes in the terms of trade, its costs fall and the supply of innovations rise.

The more general consensus however is that growth should rise with increased trade, although the reasoning tends to be more intuitive. Trade in ideas, and ideas embodied in physical and human capital, a possibility which we precluded in the above framework, should contribute to growth (Romer, 1992). First, the scale of the market is expanded through foreign trade, thus increasing returns to the non-rival goods. On the other hand, opening up the R&D sector to foreign competition may dampen domestic R&D profitability, depending, in part, on how M in (4.0) is augmented by trade in ideas, and depending on the comparative advantage of the domestic R&D sector relative to the R&D sectors among a country's major trading partners.

An open economy also poses a threat to the rents earned by the producers of the intermediate goods X(j) as foreign firms seek to compete for them. Baldwin suggests that this form of competition is a source of growth. He argues that even though innovation is profitable, the monopolist may prefer to earn profits Π^N if pre-innovation profits Π^N exceed post-innovation profits Π^I less the cost of innovation F, i.e. if $\Pi^N > \Pi^I - F$. In an open economy with free trade, if the domestic firm does not innovate, the foreign firm may, causing $\Pi^N < \Pi^I - F$, and thus inducing the domestic firm to innovate. Further, since foreign technology often comes bundled with direct investment, foreign direct investment may stimulate productivity growth of domestic firms, as appears to have been the case with the U.S. auto industry.

Conclusion

Treating market development as a process which, to be socially profitable, must lead to growth in economic welfare, provides a broad scope for public investment in market development. Essentially, the scope of potentially socially profitable interventions includes the domain of market failures, some of which may occur in foreign markets. While not mentioned previously, the scope of interventions should also entail the dismantling of those domestic and foreign policy interventions that distort world markets through tariff and non-tariff barriers to free trade. Cooperation should also occur among trading partners in the establishment of sanitary and phyto-sanitary standards and other uniform grades and standards, weights and measures that allow markets to function efficiently in the allocation of resources to meet final demands.

Our major focus is on the sources and nature of efficiency gains from product and process innovations. This focus was chosen because recent research suggests that little is known about the process of economic growth, and that which is known suggests that market failures may play a major role in explaining the differential rates of economic growth in TFP among sectors of an economy and nations more generally. TFP gains are particularly important for maintaining international competitiveness and for competing in both domestic and foreign markets. Data from the agriculture and value-added sector of the U.S. economy show that TFP growth contributes strongly to both the growth in real GDP of agriculture and the value-added sector. Agriculture's TFP also contributes to the growth in the GDP of the value-added sector through level effects, while the efficiency gains in the value-added sector must also circumvent the more negative terms of trade experience by agriculture in recent years. Hence, the maintenance of both a competitive primary sector and a value-added sector would appear to be self reinforcing. It would tend to preclude the export to other countries of the value-added technologies and, instead, encourage the export of value added.

Unfortunately, little is known regarding the process and source of these efficiency gains, although some are likely to emanate from sector specific sources, such as R&D to develop high yielding and disease resistant varieties of grains, while other sources are likely to be more economy-wide and even international in scope. The analytical and recent empirical contributions to the literature suggest that growth rates must be associated with factors that can be accumulated. Accumulation is affected by the returns to scale of technology and whether agents take into account the source of the accumulative factors (such as learning by doing, spill-overs of knowledge from the scale of economic activities, etc.) when they are making resource allocation decisions. If so, a market failure occurs, the correction of which can yield a higher rate of economic growth. It is fairly clear that "ideas" or blueprints for innovative production and process activities tend to be non-rival in the sense that their use by one does not preclude their use by another. These "ideas" accumulate into human knowledge which, in turn, becomes an input in the production of human capital which further contributes to the production of "ideas." This production process is sensitive to provision of property rights to new ideas, otherwise they are likely to be under produced. Imperfectly competitive market structures can partially internalize these externalities, depending on whether incentives exist to allocate excessive rents to the production of efficiency gains. The problem is to devise social mechanisms that induce these industries to allocate their rents in this manner, either through selected policy instruments or by encouraging collusion so as to internalize the source of the growth externality. The danger, of course, is that collusive behavior may also induce other unproductive forms of rent seeking.

Romer suggests policies that seek to identify and support those sectors or firms that are likely to be on the quality frontier of a production or process innovation must also be sufficiently strong and free from the influence of rent seeking so policymakers are willing to cull those sectors and firms which do not attain this frontier. This likely requires a level of competence and ruthlessness uncommon to most democratic governments. Undistorted, General Agreement on Tariffs and Trade legal foreign trade in human capital and "ideas" is likely to foster productivity growth. If non-rival goods are, in fact, a major source of productivity growth, then markets are likely to under produce them. The most successful sectors and economies are likely to be differentiated by the quality of public institutions that are successful in resolving sources of market failures in their provision.

APPENDIX I

Table A.1. Contributions to Farm GDP Growth 1949-1991 (Percentage)

YEAR	FARM GDP GROWTH	FARM AGG PRICE	HR.LABOR PRICE	FARM AGG INPUT	TOT.FACTOR PRODUCTIVITY
1949-91	0.25	-1.84	-0.43	0.11	2.41
1949-53	-2.82	-4.14	-0.08	0.90	0.49
1953-57	-4.93	-6.20	-0.37	0.80	0.84
1957-60	0.12	-3.14	-0.59	0.08	3.77
1960-69	0.96	-1.42	-0.61	-0.32	3.31
1969-73	8.97	5.15	-0.42	-0.21	4.45
1973-79	4.12	0.80	-0.70	1.81	2.22
1979-91	-0.15	-2.01	-0.32	-0.71	2.57

Table A.2. Real Price Contributions to Farm GDP Growth 1949-1991 (Percentage)

YEAR	MEAT PRICE	DAIRY PRICE	GRAIN PRICE	CROPS PRICE	AGGR PRICE
1949-91	-0.26	-0.64	-0.46	-0.48	-1.84
1949-53	-1.74	-1.70	-0.64	-0.06	-4.14
1953-57	-1.78	-1.72	-0.76	-1.95	-6.20
1957-60	0.70	-1.11	-0.94	-1.79	-3.14
1960-69	-0.02	-0.29	-0.29	-0.81	-1.42
1969-73	2.10	0.20	1.67	1.18	5.15
1973-79	0.59	0.49	-0.44	0.16	0.80
1979-91	-0.34	-0.38	-0.63	-0.66	-2.01

Table A.3. Input Contributions to Farm GDP Growth 1949-1991 (Percentage)

YEAR	HR LABOR PRICE	FM LABOR QTY	MATERIALS QTY	PROPERTY QTY	CAPITAL QTY	AGGR* INPUT
1949-91	-0.43	-0.56	0.64	-0.05	0.08	0.11
1949-53	-0.08	-0.95	1.04	0.07	0.75	0.90
1953-57	-0.37	-1.04	1.60	0.04	0.19	0.80
1957-60	-0.59	-1.51	1.59	0.03	-0.02	0.08
1960-69	-0.61	-0.75	0.44	-0.06	0.05	-0.32
1969-73	-0.42	-0.39	0.03	0.05	0.09	-0.21
1973-79	-0.70	-0.35	1.68	0.23	0.25	1.81
1979-91	-0.32	-0.11	-0.13	-0.25	-0.22	-0.71

Table A.4. Contributions to Value-Added Sector GDP Growth 1950-1991 (Percentage)

YEAR	GDP GROWTH	AGG. PRICE EFFECT	AGG. INPUT CONTR.	TOTAL FACTOR PRODY.
1950-91	1.26	-1.12	1.50	0.88
1950-53	2.42	-0.83	0.63	2.62
1953-57	-0.68	-3.00	1.31	1.01
1957-60	0.71	-1.37	0.78	1.30
1960-69	1.79	-1.33	1.66	1.45
1969-73	2.59	0.78	0.74	1.07
1973-79	2.88	0.97	2.25	-0.34
1979-91	-0.06	-1.45	1.09	0.31

Table A.5. Real Price Contributions to Value-Added Sector GDP Growth 1950-1991 (Percentage)

YEAR	FOOD PRICE EFFECT	TOBACCO PRICE EFFECT	TEXTILE PRICE EFFECT	PAPER PRICE EFFECT	LUMBER PRICE EFFECT
1950-91	-0.80	0.06	-0.28	-0.07	-0.02
1950-53	-0.79	0.07	-0.25	0.17	-0.03
1953-57	-2.38	0.02	-0.55	-0.02	-0.08
1957-60	-0.86	-0.02	-0.31	-0.20	0.01
1960-69	-0.70	-0.03	-0.29	-0.27	-0.04
1969-73	1.36	-0.04	-0.30	-0.24	0.00
1973-79	0.81	0.03	-0.20	0.30	0.04
1979-91	-1.34	0.21	-0.22	-0.09	-0.01

Table A.6. Input Contributions to Value-Added Sector GDP Growth 1950-1991 (Percentage)

YEAR	CAPITAL	LABOR	ENERGY	MATERIAL	SERVICES	AGGR* INPUT
1950-91	0.26	-0.03	0.04	1.03	0.21	1.50
1950-53	0.03	0.15	0.00	0.27	0.18	0.63
1953-57	0.01	-0.09	0.09	1.13	0.16	1.31
1957-60	0.19	-0.22	0.04	0.59	0.17	0.78
1960-69	0.23	0.02	0.08	1.18	0.15	1.66
1969-73	0.21	-0.18	0.01	0.81	-0.11	0.74
1973-79	0.33	-0.05	0.01	1.80	0.16	2.25
1979-91	0.36	-0.02	0.01	0.37	0.37	1.09

APPENDIX II

A.II. GDP Function Approach

Denote at time t the aggregate economy's technologically feasible combinations of outputs and inputs as the set τ^t where, $(\mathbf{y}, \mathbf{v}) \in \tau^t$ implies that the net output (netput) vector $\mathbf{y}$ is produced by the non-negative vector of primary inputs $\mathbf{v}$. Define the economy's period t Gross Domestic Product (See Woodland) function by:

$$g^t(\mathbf{p},\mathbf{v}) \equiv \max_y\{\mathbf{p}^T\mathbf{y}: (\mathbf{y},\mathbf{v}) \in \tau^t\}$$

where, $\mathbf{p} > 0$ is a given vector of output prices. Thus, $g^t(\mathbf{p},\mathbf{v})$ is the maximum value of domestic outputs given $\mathbf{v}$ and aggregate technology set τ^t. Under certain assumptions on τ^t, g^t completely characterizes the technology set τ^t (i.e., there is duality between τ^t and g^t). Also, $g^t(\mathbf{p},\mathbf{v})$ is a convex and linearly homogeneous function of $\mathbf{p}$ and a concave, non-decreasing and linearly homogeneous function of $\mathbf{v}$.

A.II.1. Productivity Index

Let $\mathbf{p} > 0$ and $\mathbf{v} > 0$ be a reference price and input vector, respectively. Diewert and Morrison define the period t *theoretical productivity index* depending on $(\mathbf{p},\mathbf{v})$ by:

$$R^t(\mathbf{p},\mathbf{v}) \equiv g^t(\mathbf{p},\mathbf{v})/g^{t-1}(\mathbf{p},\mathbf{v})$$

$R^t(\mathbf{p},\mathbf{v})$ is the percentage increase in output (valued at reference prices) that can be produced by the period t technology set, given that, in both cases, the private production economy is using the same reference input vector $\mathbf{v}$. The following two are ideal indices for (2):

$$R_L^t \equiv [g^t(p^{t-1},v^{t-1}) \,/\, g^{t-1}(p^{t-1},v^{t-1})]$$

$$R_P^t \equiv [g^t(p^t,v^t) \,/\, g^{t-1}(p^t,v^t)].$$

R_L^t is a Laspeyres type index which uses period t-1 output prices and primary input quantities as references, while R_P^t is a Paasche type productivity index which uses period t prices and quantities as references. Given competitive profit maximizing behavior and a translog form for the Gross Domestic Product function (See Diewert and Morrison; Gopinath and Roe (1994). Diewert and Morrison prove that it is possible to evaluate a geometric mean of the two:

$$(R_L^t.R_P^t)^{(1/2)} = (a/(b.c))$$

where,

$$a = p^t.y^t/\, p^{t-1}y^{t-1},$$

$$\ln b = \Sigma_i\ (1/2)[(p_i^t y_i^t/p^t y^t) + (p_i^{t-1} y_i^{t-1}/p^{t-1} y^{t-1})][\ln(p_i^t/p_i^{t-1})]$$

$$\ln c = \Sigma_j\ (1/2)[(w_j^t v_j^t/w^t v^t) + (w_j^{t-1} v_j^{t-1}/w^{t-1} v^{t-1})][\ln(v_j^t/v_j^{t-1})]$$

Note that the geometric mean of the two indices, can be evaluated using aggregate price and quantity data where, a is growth in real value of output, b is a translog output price index, so (a/b) is an implicit output quantity index while c is a primary input quantity index. The following section deals with each of the components of 'b' and 'c' in greater detail.

A.II.2. Price and Input Effects on Aggregate Output

This sub-section provides economic interpretations for the components of output price index (b) and real input quantity index (c). Define output price effects $P_{L,i}^t$ and $P_{P,i}^t$ for each good i analogous to the productivity index defined earlier: for i = 1,..N

$$P_{L,i}^t = g^{t-1}(p_i^t,p_j^{t-1},..,p_N^{t-1},v^{t-1}) \,/\, g^{t-1}(p^{t-1},v^{t-1})\ ;$$
$$P_{P,i}^t = g^t(p^t,v^t) \,/\, g^t(p_i^{t-1},p_j^t,..,p_N^t,v^t)$$

These indices provide answers to the following comparative statics type question: "What is the proportional change in private product that can be attributed to the change in i^{th} output price between period t-1 and t, p_i^{t-1} to p_i^t, holding constant primary inputs, the technology set and other output prices?" It follows that,

$(P_{L,i}^t.P_{P,i}^t)^{(1/2)} = b_i$ where,

$$\ln b_i = (1/2)[(p_i^t y_i^t/p^t y^t) + (p_i^{t-1} y_i^{t-1}/p^{t-1} y^{t-1})][\ln(p_i^t/p_i^{t-1})]$$

Similarly, for each input j, define input quantity effects $Q_{L,j}^t$ and $Q_{P,j}^t$ as: for j = 1,..M

$$Q_{L,j}^t \equiv g^{t-1}(p^{t-1},v_j^t,v_i^{t-1},..,v_M^{t-1}) / g^{t-1}(p^{t-1},v^{t-1})$$

$$Q_{P,j}^t \equiv g^t(p^t,v^t) / g^t(p^t,v_j^{t-1},v_i^t,..,v_M^t)$$

The above two indices answers the following question: "What is the proportional change in private product that can be attributed to the change in j^{th} primary input between period t-1 and t, v_j^{t-1} to v_j^t, holding constant output prices, technology and other primary inputs?" It follows that,

$(Q_{L,j}^t.Q_{P,j}^t)^{(1/2)} = c_j$ where,

$$\ln c_j = (1/2)[(w_j^t v_j^t/w^t v^t) + (w_j^{t-1} v_j^{t-1}/w^{t-1} v^{t-1})][\ln(v_j^t/v_j^{t-1})]$$

APPENDIX III

Data

Time series data on the prices and value of output in each of the three sectors (Farm, Industry and Services); quantities of primary inputs (employment and capital input); and shares of labor and capital in GDP are obtained from the National Income and Product Accounts of the Bureau of Economic Analysis, U.S. Department of Commerce for the period 1948 to 1992. The data on value of output is based on establishment survey using revised SIC classification (1987). Farm goods consists of primary (raw) products arising out of farms. The major products under industry are mining, manufacturing (durable and non-durable, including food processing) and construction while that of services include finance, insurance, real estate, health,legal and educational services, Government and others. Labor is given by the number of full-time equivalent employees in all three sectors. The capital input (in constant billion dollars with base 1987) series is derived as gross stock (perpetual inventory) less depreciation (hyperbolic decay), by the Bureau of Labor Statistics, U.S. Department of Commerce.

U.S. farm sector is disaggregated into four outputs, namely, Meat Animals, Dairy (includes poultry, eggs and others), Grain (food and feed grains) and Crops (oil seeds, cotton, tobacco, vegetables, fruits and nuts). There are five inputs: Hired Labor, Family Labor, Real Property (farmland and service structures), Capital (durable equipment farm inventories such as beef cows, dairy cows, stocks of bulls, sheep and hogs and others), Materials (agricultural chemicals, fuels, natural gas and electricity, feed, seed and livestock purchases, and others). Price and quantity for each output and input were derived as Tornqvist-Theil indices (Ball et al.)

The valued-added sector consists of five outputs, namely, Food and Kindred Products, Tobacco Manufactures, Textiles, Paper and Allied Products and Wood and Lumber Products. On the input side time series data for the years 1949 through 1991 were available for Labor, Capital, Energy, Materials (includes primary agricultural products) and Purchased Services. The shares of the value of inputs and outputs in GDP are shown in Figure 1 and 2 (Source Bureau of Labor Statistics, U.S. Department of Commerce).

NOTES

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1. See Falconi and Roe for a situation in which imperfect competition can yield Pareto-superior outcomes in markets in which consumers are uncertain of the health impacts of food substances. When consumers update their expectations in a Bayesian manner, advertising is shown to increase welfare.

2. The TFP estimates may be biased upward even though the Department of Commerce attempts to adjust the data for input quality. The data for agriculture is taken from the U.S. Department of Agriculture, but it too may suffer the same problem.

3. With some adaptation, this framework can be extended to an open economy with an asset market to allow for other factors that affect the level of investment.

4. To see this, take logarithms and derivatives of both sides of (2) to obtain:

$$0 = (\beta-1)(\dot{k}_t/k_t) + (\alpha + \beta - 1)(\dot{L}_t/L_t).$$

5. This is another problem with market failures. Market agents are unlikely to be aware of the failure and therefore unable to diagnose the problem. "Political entrepreneurs" or innovators that see opportunities for gain are often required to resolve these sources of inefficiencies.

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