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Industrial Policies, the Creation of a Learning Society, and Economic Development

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Industrial policies – meaning policies by which governments attempt to shape the sectoral allocation of the economy – are back in fashion, and rightly so. The major insight of welfare economics of the past fifty years is that markets by themselves in general do not result in (constrained) Pareto-efficient outcomes (Greenwald and Stiglitz, 1986).

Industrial policies seek to shape the sectoral structure of the economy. This is partly because the sectoral structure that emerges from market forces, on their own, may not be that which maximizes social welfare. By now, there is a rich catalogue of market failures, circumstances in which the markets may, say, produce too little of some commodity or another, and in which industrial policies, appropriately designed, may improve matters. There can be, for instance, important coordination failures – which government action can help resolve.

But there are two further reasons for the recent interest in industrial policy: First, it has finally become recognized that market forces don’t exist in a vacuum. Developmental economics routinely emphasizes as central to growth the study of institutions. All the rules and regulations, the legal frameworks and how they are enforced, affect the structure of the economy. So unwittingly, government is always engaged in industrial policy. For example, when the US Congress passed provisions of the bankruptcy code that gave derivatives first priority in the event of bankruptcy, but which said that student debt could almost never be discharged, even in bankruptcy, it was providing encouragement to the financial sector. Secondly, it has also been realized that when the government makes expenditure decisions – about infrastructure, education, technology, or any other category of spending – it affects the structure of the economy.

This paper is concerned with one particular distortion: that in the production and dissemination of knowledge. Markets, on their own, are not efficient in the production and dissemination of knowledge (learning). Sectors in which learning and research are important are typically characterized by a wide variety of market failures.
Both econometric and historical studies highlight the importance of learning and innovation. Maddison’s (2001) research, for instance, documents that from the origins of civilization to the early 1800s, there was essentially no increase in incomes per capita. The economy was close to static. The subsequent two centuries have been highly dynamic, leading to unprecedented improvements in standards of living.

Since the work of Solow (1957), we have understood that most increases in per capita income – some 70 percent – cannot be explained by capital deepening; for the advanced developed countries most of the “Solow residual” arises from advances in technology. At least for the past quarter century, we have understood that a substantial part of the growth in developing countries arises from closing the gap in knowledge between themselves and those at the frontier. Within any country, there is enormous scope for productivity improvement simply by closing the gap between best practices and average practices (Greenwald and Stiglitz, 2014b).

Knowledge is different from conventional goods; it is, in a sense, a public good (Stiglitz, 1987a, 1999) – the marginal cost of another person or firm enjoying the benefit of knowledge (beyond the cost of transmission) is zero; usage is non-rivalrous. Markets are not efficient in the production and distribution of public goods. It is inevitable that there be, or that there ought to be, a role for government.

Moreover, as Arrow (1962a) pointed out fifty years ago, the production of knowledge is often a joint product with the production of goods, which means that the production of goods themselves will not in general be (intertemporally) efficient.

If it is the case that most increases in standard of living are related to the acquisition of knowledge, to “learning,” it follows that understanding how economies best learn – how economies can best be organized to increase the production and dissemination of productivity-enhancing knowledge – should be a central part of the study of development and growth. It is, however, a subject that has been essentially neglected. That would, by itself, be bad enough. But Washington Consensus policies based on neoclassical models that ignore the endogeneity of learning often have consequences that are adverse to learning, and thus to long-term development.

Creating a learning society

Not only is the pace of learning (innovation) the most important determinant of increases in standards of living; the pace itself is almost surely partially, if not largely, endogenous. The speed of progress has differed markedly both over time and across countries, and while we may not be able to explain all of this variation, it is clear that government policies have played a role. Learning is affected by the economic and social environment and the structure of the economy, as well as public and private investments in research and education. The fact that there are high correlations across industries, firms, and functions (environmental factors) suggests that there may be beneficial clusters or that there may be spillovers. But the fact that there are benefits for others – and firms – at the national, and worst, the global, level, suggests that it is important to move smoothly either toward or away from these externalities.

All of this highlights the need to create economic and learning spillovers to standards of living. The goal is to enhance efficiency or those that enhance learning either in the United States or in other countries.

And this is even more relevant in per capita incomes. If the “Solow residual” is attributable to differences in productivity in economies and societies, then the gap in knowledge is likely to entail learning how to use it.

Market failure and learning

While the fact that high productivity depends on the production and dissemination of the knowledge base is not new, the nature of the knowledge base has changed.

The first set is relatively simple. Standard production and dissemination technologies do not solve, and externalities, and thus the market will not, in general, provide what is required. Even when an individual discovers what he or she believes is required, the knowledge base will not be included in GDP. But even more important are the contributions: Think of the knowledge that underlies the discovery of the laser.

But externalities are not just inherent in the market – there are now ways of doing business where one firm must have some knowledge or information that another firm or another country does not. The second set is far more complex. Some aspects of the knowledge base are created by high levels of innovation, and the rewards are typically very large. This is often the case, though in some cases greater than the amounts that the market would have awarded (between innovations that are designated as public goods, the market would have awarded them very much less. The failure to
Market failure and learning

While the fact that knowledge is a (global) public good means that the production and dissemination of knowledge that emerges in a market economy will not, in general, be efficient, there are several other market failures that inevitably arise in an important way in the context of a learning economy.

The first set is related to the fact that those who produce innovation seldom appropriate the full value of their societal contributions. There are large externalities, and these externalities will play a pivotal role in the analysis below. Even when an innovator becomes rich as a result of his innovation, what he appropriates is sometimes but a fraction of what he has added to GDP. But even more, many of those who have made the most important discoveries — those who regularly contribute to the advances of basic science and technology — receive rewards that are substantially below their social contributions: Think of Turing, Watson and Crick, Berners-Lee or even the discoverers of the laser/maser and the transistor.

But externalities are more pervasive. Individuals who learn about better ways of doing business transmit that knowledge when they move from one firm to another. (We discuss these spillovers at greater length below.)

The second set is related to our imperfect attempts to provide incentives for innovation, through intellectual property. The result is that private rewards are typically not commensurate with (marginal) social returns, in some cases exceeding the social returns (me-too innovations, innovations that are designed to lead to “hold-up” patents), in other cases being markedly less. The fact that the distortion which industrial policy may be
attempting to partially “correct” arises from a government policy highlights an aspect of industrial policy upon which we comment further in the concluding section of this paper: it is not just market failures which lead to “distortions” in the economy, but also “government failures.” (One could argue that it would make more sense to eliminate the government failure than to introduce another intervention in the market. But for one reason or another, typically related to political economy, it may not be easy to eliminate some government policies; it may be easier to introduce a new countervailing policy.)

A third source of inefficiency that industrial policies may address arises from capital market imperfections (themselves endogenous, arising from information asymmetries). But capital market imperfections can be particularly adverse to learning: Because R&D investments (or “learning investments”) typically cannot be collateralized, unlike investments in buildings, machines, or inventories, it is more likely that there will be credit and equity rationing, leading to underinvestment in these areas, compared to others.

There are other important interactions between traditional market failures, like imperfect competition, and learning: sectors in which innovation is important are naturally imperfectly competitive—research expenditures are fixed costs, and give rise to increasing returns. Because sectors in which competition is limited, output will be lower, and accordingly returns to cost-reducing innovations are lower (Arrow, 1962b).

Still another market failure arises from imperfections in risk markets. Innovation is highly risky – research is an exploration into the unknown. But firms cannot purchase insurance against these risks (because of well-known problems of moral hazard and adverse selection). However, because of imperfections in capital markets, firms act in a risk-averse manner, particularly in the presence of bankruptcy costs (Greenwald and Stiglitz, 1993), and this discourages investment in riskier innovation.

Problems of the appropriability of returns and imperfections of capital markets (including the absence of good risk markets) result in barriers to the entry of new firms (entrepreneurs) and the exploration of new products or processes that might be particularly appropriate for a developing country. Consider an “experiment” to discover whether conditions in a country are particularly suitable for growing a particular kind of coffee. If the experiment fails, those who conduct the experiment lose money. If it succeeds, there may be quick entry. The country benefits, but the “innovator” can’t capture much of the returns. In short, an experiment that is successful will be imitated, so the firm won’t be able to reap returns; but the firm bears the losses of an unsuccessful experiment. As a result, there will be underinvestment in this kind of experimentation (Hoff, 1997).

A similar argument holds for why private markets will lend too little to new entrepreneurs. The borrower who becomes successful will be poached by other lenders, so the interest rate that he can charge (after the entrepreneur has met the competitive rate. But external effects limit the intersectoral mobility, which implies that there will be “sticky wages” (Stiglitz, 2009).

In the absence of intersectoral mobility, the use of an idea, so that it might be the product of the first best) and/or a patent system (in which short-run costs of the market competition.) When it freely, there is still distortion, but there is no distortion.

In light of the potential for learning, the commitment that government should make to the point: the objectives of learning, externalities and other there can be large gains from excessive risk sharing, with an equally impressive.

While governments might, there is by now a consensus that regulations have been explicit. If government identifies policies that they are “zero,” The best way of doing so is in the concluding section of this report: developed and developing interventions.

A closer look at learning. We emphasized earlier that learning. Such spills will occur in industries than in others. These externalities.

Spillovers occur when benefits of much cannot be patented and the benefits of much appropriated. Indeed, the best way to enhance these s
the entrepreneur has demonstrated his success) will be limited to the competitive rate. But Stiglitz-Weiss adverse selection and adverse incentive effects limit the interest rate that can be charged in the initial period, which implies that there will be limited lending to new entrepreneurs (Emran and Stiglitz, 2009).

In the absence of lump-sum (non-distortionary) taxation, there is a fundamental tension: research is a fixed cost, and there is no marginal cost to the use of an idea, so that knowledge should be freely provided. But that would imply that the producer of information (knowledge) would receive no returns. Thus, it is inevitable that there be an underproduction of knowledge (relative to the first best) and/or an underutilization of the knowledge that is produced. The patent system (in principle) attempts to balance out the dynamic gains with the short-run costs of the underutilization of knowledge and imperfections of market competition. When the government finances research and disseminates it freely, there is still a static distortion (from the distortionary imposition of taxes), but no distortion in the dissemination and use of knowledge.

In light of the pervasive market failures associated with innovation and learning, the commonly heard objection to industrial policies – the mantra that government should not be involved in “picking winners” – is beside the point: the objective of the government is to identify, and “correct” externalities and other market failures. While it is now widely accepted that there can be large negative externalities (for example, from pollution, or from excessive risk taking in the financial sector), we are concerned here with an equally important set of positive externalities.

While government may not be perfect in identifying negative externalities, there is by now consensus (except among polluters) that environmental regulations have been very beneficial; so too for positive externalities: even if government identifies such externalities imperfectly, it is wrong to assume that they are “zero”: government can improve upon the market allocation. The best way of doing so is a matter of controversy, upon which we comment in the concluding section. But it is clear that many governments (both in developed and developing countries) have a credible record of industrial policy interventions.

A closer look at learning spillovers

We emphasized earlier that there are important positive externalities from learning. Such spillovers are pervasive and large, and they are larger in some industries than in others. And obviously, markets will not take into account these externalities.

Spillovers occur even in the presence of a patent system. Many advances cannot be patented (advances in mathematics, for example); and the benefits of much of what is learned in the process of research cannot be appropriated. Indeed, the disclosure requirements of a patent are intended to enhance these societal benefits. We’ll provide further illustration below.
There are many aspects of learning spillovers. There are direct technological spillovers: the production of any good involves many stages, and some of the stages may involve processes that are similar to those used in another seemingly distinct sector. As Atkinson and Stiglitz (1969) noted, learning is localized: it affects production processes that are similar to those for which there has been learning. But the learning is not limited to a single process and related processes for a particular product. Innovations in one sector may benefit other sectors that look markedly different, but use similar processes. Sectors that are in one way or another, more similar may, of course, benefit more. (Indeed, the same argument holds within a sector. An innovation in one technology in a given sector may have limited spillovers for other technologies – the spillovers may be greater to other products using analogous technologies.)

There are especially important spillovers in methods of production. Inventory control and cash management techniques affect virtually every firm in an economy. Just-in-time production or assembly lines are examples of production processes that affect many industries. Improvements in skills (techniques) in one sector have spillover benefits to other sectors in which analogous skills are employed. Hidalgo and colleagues (2007) characterized the product space, attempting to identify the “capabilities” that different sectors have in common. Presumably, if two products entail similar capabilities, learning that enhances a particular capability in one sector will have spillover benefits to related sectors for which that same capability is relevant.

It is, as we have suggested, impossible to appropriate the benefits of much of this learning. An idea like just-in-time production, replaceable parts, or assembly lines spreads quickly throughout the economy, and can’t be protected by intellectual property. Learning what works well in a particular climate with a particular soil is information that is not patentable. The result, as we noted earlier, is that there will be insufficient investment in exploration. There are equally important economy-wide “technologies,” and improvements in these have society-wide benefits. These include those that arise out of the development of institutions. A financial system developed to serve the manufacturing sector may equally serve the rural sector. Improvements in the education system, necessary for an effective industrial sector, can also have benefits for the service sector or the agricultural sector.

Knowledge is embodied in people. This is especially relevant for what is called tacit knowledge, understandings that are hard to codify, to articulate as simple prescriptions, that could easily be conveyed through textbooks or classroom learning. Workers move from firm to firm, and thus convey some of the learning that has occurred in one firm to those in others. But knowledge is also embodied in firms that supply inputs to multiple firms. What they learn in dealing with one firm in one industry may be relevant for another firm. There can be backward, forward, and horizontal linkages (Hirschman, 1958).

Technological knowledge is constructed for one purpose, but can be an accident that the development of innovations in bicycling, and innovation in the development of the knowledge that goes with it. This illustrates the ex ante what “nearby” sectors in one affects the other.

Knowledge, in this way, is a network of contact. But some knowledge and knowledge that comes into contact with each other is more likely to learn, further. Firms, realizing that the limit the transmission of knowledge can be able to build on its, will go to great lengths to maintain its. It is desirable that knowledge be efficiently as possible, that knowledge limit to the extent possible.

The architecture of intellectual property – affects the ability to create and transfer knowledge (except for ex ante knowledge). There is, however, a problem of knowledge. It is possible for knowledge to be a secret (relative to the creation intention of the open system). Technology spillover movement is a potential economic returns (for example, by the learning/innovation of non-economic returns) (David, 1994).

We can thus think of people interacting directly with others (employers, schools) of which they are created at various networks with whom there is
Technological knowledge is also embodied in machines, and a machine constructed for one purpose can often be adapted for quite another. It is not an accident that the Ohio Valley (stretching up to Michigan) gave rise to innovations in bicycles, airplanes, and cars; while the products were distinct, the development of these products shared some of the same technological know-how. This illustrates the principle that it may be difficult to identity ex ante what "nearby" products are, products such that advances in learning in one affects the other.

Knowledge, in this sense, is like a (beneficial) disease: it can spread upon contact. But some kinds of contact are more likely to lead to the transmission of knowledge than others. Some of the people who might possibly come into contact with the knowledge are "susceptible," that is, they are more likely to learn to use the knowledge, and perhaps even develop it further. Firms, realizing that knowledge is power (or at least money), seek to limit the transmission of knowledge — it might help one's rivals, who might be able to build on it, putting oneself at a disadvantage. Thus, firms go to great lengths to maintain secrecy. While for the advancement of society, it is desirable that knowledge, once created, be transmitted as broadly and efficiently as possible, profit maximizing firms have traditionally sought to limit to the extent possible the transmission of knowledge.

The architecture of the economy — including all the rules concerning intellectual property — affects the speed and extent of transmission of knowledge.

There is, in this, however, a trade-off that is fully analogous to that in the design of patents and that is at the root of the critique of the efficient markets hypothesis: if knowledge were perfectly transmitted, there would be no incentive to expend resources on gathering and producing knowledge. There would be underinvestment in knowledge creation (and in the case of developing countries, gathering knowledge from others). Hence, an optimally designed learning society does not entail the perfect transmission of knowledge (except for knowledge that is publicly provided).¹⁵

There are, however, natural impediments to the perfect transmission of knowledge. It is plausible that a market economy engages in excessive secrecy (relative to the social optimum). This, of course, has been the contention of the open source movement. Collaborative research in the open source movement is still economically viable, both because there are still economic returns (for example, because of the tacit knowledge that is created by the learning/innovation process itself) and because there are important non-economic returns to and incentives for innovation (Dasgupta and David, 1994).

We can thus think of the economy as a complex network of individuals interacting directly with each other and via institutions (like corporations, schools) of which they are a member, ideas (knowledge) being created at various nodes in this network, being transmitted to others with whom there is a connection, being amplified, and re-transmitted,
a complex dynamic process the outcomes of which can be affected by the
topography of the network, which, together with the rules of the game,
afflict the incentives to gather, transmit (or not to transmit), and amplify
knowledge.

A sub-problem within this systemic problem is the design of the
component institutions (for example, corporations). For within the insti-
tution, there may be incentives to develop knowledge and to hoard or to
transmit it. The issue of the architecture of a learning firm is parallel to
that of the architecture of a learning economy. In some ways, the two
cannot be separated: Traditional discussions of the boundary of firms (Coase,
1937) focused on transactions costs; but equally important is the structure
of learning. It may be easier to transmit information (knowledge) within a
firm than across enterprises, partly because the “exchange” of knowledge is
not well-mediated by prices and contracts. If so, and if learning is at the
heart of a successful economy, it would suggest that firms might be larger
than they would be in a world in which learning is less important. (On
the other hand, the difficulties of developing appropriate incentives for
the reward of innovation may militate against large enterprises. There is an
ongoing debate over whether large or small enterprises are most conducive
to innovation. Large firms may have the resources to finance innovation,
typically lacking in smaller enterprises, but there is an impressive record of
large firms not recognizing the value of path-breaking innovations, includ-
ing Microsoft being too wedded to the keyboard, and Xerox not recognizing
the important of a user-friendly interface, like Windows.)

In the discussion below, we mostly abstract from microeconomic struc-
tures, focusing on broader policies, on the principles which should guide
government intervention, and on alternative instruments. Section 1.3.1
summarizes key results on the implications of learning externalities. Section
1.3.2 discusses how, in the presence of capital constraints, access to finance
may be an important instrument of Industrial policy. Section 1.3.3 discusses
other instruments. Section 1.3.4 focuses on the role of government investment
policy. We conclude, in Section 1.3.5, with a general set of remarks
about industrial policy, especially as it relates to the promotion of a learning
economy and society.

1.3.1 Learning externalities

A central thesis of this paper is that government should encourage industries
in which there are large learning externalities. A simple two-period model in
which labor is the only input to production suffices to bring out the major
issues. We show that government should encourage: (i) the production of
goods in which there is more learning; (ii) the production of goods which
generate more learning externalities; and (iii) the production of goods
which enhance learning capabilities.

Assume (for simplicity) production occurs in two periods and between

\[ W_t = x_t^1 + \frac{1}{2} \sum_{t=1}^{\infty} \frac{L_{t+1}}{L_t} \]

where \( x_t^1 \) is the vector supply at time \( t \). The aggregate labor input

\[ L_t = \frac{L_t}{L_{t-1}} \]

where \( L_t \) is the input.

Production is described

\[ P_t = h_t \]

In this simple model, the decision on labor input directly affects production costs in period \( t \).

\[ P_t = h_t \]

where \( h_t \) is the elasticities of output with respect to learning.

The learning function is a central analysis. In the following sections will play a critical role.

(a) Learning elasticity of output

We define

\[ h_t = \frac{\partial P_t}{\partial L_t} > 0, \quad j = k \]

while

\[ \frac{\partial P_t}{\partial L_t} = 0, \quad j = k \]

Full learning externalities

Learning externalities
Assume (for simplicity) that utility is separable between goods in the two periods and between goods and labor:

$$W = U(x^t) - v(L^t) + \delta[U(x^{t+1}) - v(L^{t+1})],$$

(1)

where $x^t$ is the vector of consumption $[x^t_k]$ at time $t$ and $L^t$ is aggregate labor supply at time $t$. The disutility of work is the same in all sectors, and $L^t$ is aggregate labor input in period $t$:

$$L^t = \Sigma L^t_k, \text{ and } L^{t+1} = \Sigma L^{t+1}_k,$$

where $L^t_k$ is the input of labor in sector $k$ in period $t$.

Production is described by (in the appropriate choice of units)

$$x^t_k = L^t_k.$$  

(2)

In this simple model, the more output of good $j$ in period $t$, the lower the production costs in period $t+1$. We assume

$$x^{t+1}_j = L^{t+1} H^t[L^t],$$

(3)

where $L^t$ is the vector of labor inputs at time $t$ [$L^t_k$].

The learning functions $H^t$ and their properties are at the center of this analysis. In the following analysis, two properties of these learning functions will play a central role:

(a) Learning elasticity – how much sectoral productivity is increased as a result of an increase in labor input. We define

$$h_k = \frac{d\ln H}{d\ln L_k},$$

(4)

$h_k$ is the elasticity of the learning curve in sector $k$.

(b) Learning spillovers – the extent to which learning in sector $j$ spills over to sector $k$.

$$\frac{\partial H^t}{\partial L^t_j} > 0, \ j \neq k, \text{ if there are learning externalities},$$

while

$$\frac{\partial H^t}{\partial L^t_j} = 0, \ j \neq k, \text{ if there are no learning externalities}.$$

Full learning externalities. One interesting case is that where there are full learning externalities, i.e., knowledge is a public good, so $H^t = H^t = H$. 

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Then we choose \( L' \) to

\[
\max U(L') - \nu(L') + \delta[U(L'^{t+1} H[L']) - \nu(L'^{t+1})]
\]

so

\[
U_i - \nu' + \delta h_i \sum L_k^{t+1} U_k (L_k^{t+1} H[L']) = 0.
\]

If we assume homotheticity, \( U = u(\Phi(x)) \), with \( \Phi_k(x) x_k = \Phi \), then we can rewrite the above as

\[
u' \Phi_i - \nu' + \delta h_i U_0 = 0
\]

where

\[
u = \frac{d \ln U}{d \ln \Phi}
\]

We can generate the optimal allocation by providing a subsidy of \( \tau_i \) on the \( i \)th good, for with such a subsidy an individual

\[
\text{maximizes } U(x) - \nu(\sum x_i (1 - \tau_i))
\]

or

\[
U_i = \nu' - \nu' \tau_i
\]

We can get the optimal allocation by setting

\[
\delta h_i U_0 = \nu' \tau_i
\]

or

\[
\tau_i = \frac{\delta h_i U_0}{\nu'}
\]

Consumption should be subsidized the more the higher the value of future consumption (the larger \( \delta \)), and the higher the learning responsiveness \( h_i \).

Optimal subsidies with no cross-sectoral spillovers, full within-sector spillovers. Similar results hold in the case where there are no spillovers across sectors, but there are full spillovers within the sector. A competitive firm again will take no account of the learning benefits – learning is a sectoral public good. We illustrate with the case with separable utility. With separability of utility across goods (so \( U = \sum u_i \)), the first order condition for welfare maximization becomes

where

Again it is apparent that the higher the value of consumption, the higher the value of learning responsiveness \( h_i \). If the elasticity is 1, the case of full spillovers in production, and in learning, the optimality conditions for a competitive market with no spillovers to other sectors, and the market equilibrium is as follows:

Monopolistic competition: there is a single firm and therefore take into account the actions of competitors in order to find a socially desirable output level.

Differential spillovers: the determinative factor is whether the spillovers are either no cross-sectoral or whether they are sectoral.

There are a variety of reasons. Historically, the reasons for this are: (1) large; (2) long-term, and (3) low, especially as the highly decentralized structures of agriculture or the large organization of large enterprise.
\[ u^{it} - v^{it} + \delta h_i \eta_i u^{it+1} = 0 \]

where

\[ \eta_i = \frac{\text{d} \ln u_i}{\text{d} \ln x_i}. \]

The optimum can be achieved by setting a subsidy on the consumption of good \( i \) at

\[ \tau = \delta h_i \eta_i u^{it+1} / v^{it} \]

Again, it is apparent that, as before, consumption should be subsidized the more the higher the value of future consumption (the larger \( \delta h_i \)), and the higher the learning responsiveness \( h_i \). Now, there is a third factor – the elasticity of marginal utility. If the elasticity is low, then the benefits of learning diminish rapidly.\(^\text{20}\)

The case of full symmetry. In the case of full symmetry (both in consumption and in learning), the only distortion is in the level of output, that is, if there are \( n \) commodities, \( 1/n \)th of income will be spent on each, but in a competitive market with full spillovers within the sector, whether or not there are spillovers to other sectors, no attention is paid to the learning benefits. Hence, the market equilibrium will entail too little production (labor) the first period.

Monopolistic competition. In the case of monopolistic competition, where there is a single firm in each sector, and no learning spillovers, the firm will fully take into account the learning benefits, but now, because of imperfections of competition, output will be restricted. There is again less than the socially desirable level of learning.

Differential spillovers. The formal analysis so far abstracts from the third determinative factor – the extent of spillovers – for we have assumed that there are either no cross-sector spillovers or perfect spillovers from every sector.

There are a variety of reasons that learning may be higher in one sector than another, and why spillovers from one sector may be greater than in another. Historically, the industrial sector has been the source of innovation. The reasons for this are rooted in the nature of industrial activity. Such activity takes place in firms that (relative to firms in other sectors, such as agriculture) are (1) large; (2) long-lived; (3) stable; and (4) densely concentrated geographically. Agricultural/craft production, by contrast, typically takes place on a highly decentralized basis among many small, short-lived, unstable firms.

In the following paragraphs we describe in more detail some of the reasons for the comparative advantage of the industrial sector in learning and why that sector is more likely to give rise to learning externalities.

1. Large enterprises. Since particular innovations are far more valuable to large organizations that can apply them to many units of output than
to smaller ones with lower levels of output (see Arrow, 1962b), there is far greater incentive to engage in R&D in the industrial sector than in the agricultural/craft sector. The result will be higher investments in innovation in the former sector than the latter. This can be looked at another way: Large firms can internalize more of the externalities that are generated by learning. Moreover, innovation is highly uncertain, and firms and individuals are risk averse. Large enterprises are likely to be less risk averse, and thus better able to bear the risks of innovation. Moreover, because of information imperfections, capital markets are imperfect, and especially so for investments in R&D, which typically cannot be collateralized. Capital constraints are less likely to be binding on large enterprises.

(2) Stability and continuity. The accumulation of knowledge on which productivity growth is based is necessarily cumulative. This, in turn, greatly depends on a stable organization for preserving and disseminating the knowledge involved and on continuity in jobs and personnel to support these processes. In large organizations, with the resources to provide redundant capacity where needed, the required degree of stability and continuity is much more likely to be present than in small dispersed organizations where the loss of single individuals may completely compromise the process of knowledge accumulation. As a result, steady productivity improvement will be much more likely to arise from industrial than agricultural/craft production. There is another way of seeing why stability/continuity contributes to learning: As we noted earlier, the benefits of learning extend into the future. Long-lived firms can value these distant benefits—and because industrial firms are typically larger, longer lived, and more stable than, say, firms in other sectors, they can have access to capital at lower interest rates. They are likely to be less capital constrained, act in a less risk-averse manner, and to discount future benefits less.

(3) Human capital accumulation. Opportunities and incentives for accumulating general human capital are likely to be far greater in large complex industrial enterprises with a wide range of interdependent activities than in small, dispersed narrowly-focused agricultural/craft enterprises. (There is, for instance, a greater likelihood of benefits from the cross-fertilization of ideas.) Long-lived stable firms may have a greater incentive to promote increased human capital that leads to greater firm productivity, better stability of these investments, and more willingness to bear the risks. The resulting human capital accumulation is a critical element in both developing the innovations on which productivity growth depends and in disseminating them as workers move between enterprises and across sectors.

(4) Concentration and diffusion of knowledge across firms. Diffusion of knowledge among densely collocated, large-scale industrial enterprises (often

producing complementary goods) can be greater than for small enterprises. The proximity principle is emphasized by the following:

(5) Cross-border diffusion. The presence of several large enterprises within a single country enhances the learning environment. Often, learning is more extensive when it is spread over several countries. The presence of one countrywide firm may be greater if the rest of the enterprises are large. Learning environments are extensive if there is widespread diffusion of knowledge, and often this is common. Large-scale enterprises are typically numerous. Learning by the larger firms is common. Learning by and the smaller firms have cross-selling opportunities.

(6) The ability to tax. Tax revenue is a form of tax collection, and tax revenue is a form of public finance. Tax revenue is a form of public assistance for capital formation, and tax revenue is a form of public assistance for interest payments. Tax revenue is a form of public assistance for education, and tax revenue is a form of public assistance for medical care. Tax revenue is a form of public assistance for infrastructure, and tax revenue is a form of public assistance for transportation. Tax revenue is a form of public assistance for the environment, and tax revenue is a form of public assistance for energy. Tax revenue is a form of public assistance for the arts, and tax revenue is a form of public assistance for science. Tax revenue is a form of public assistance for religion, and tax revenue is a form of public assistance for charity. Tax revenue is a form of public assistance for the military, and tax revenue is a form of public assistance for the police. Tax revenue is a form of public assistance for the judiciary, and tax revenue is a form of public assistance for the bureaucracy. Tax revenue is a form of public assistance for the government, and tax revenue is a form of public assistance for the public.
producing differentiated products is likely to be far more rapid than diffusion of knowledge among dispersed small-scale agricultural/craft enterprises. (Recall that earlier we had emphasized the importance of the diffusion of knowledge, and stressed the key role that geographical proximity plays. More recent discussions of the role of clusters have re-emphasized the importance of geographical proximity. See Porter, 1990.)

5) Cross-border knowledge flows. While learning is facilitated by geographical proximity, especially developing countries (where many firms are operating far below “best practices”) can learn from advances in other countries. While agricultural conditions may differ markedly from one country to another, the potential for cross-border learning may be greater in the industrial sector; and the existence of large, stable enterprises with the incentives and capacities to engage in cross-border learning enhances the role of that sector in societal learning. Indeed, it is widely recognized that success in the industrial sector requires not just knowledge, but also the ability to acquire knowledge, some of which is common across borders. Again, some of this knowledge and these abilities are relevant to the agricultural sector, and disseminate to it.

Learning by one firm or subsector spills over to other firms and subsectors within the industrial sector, through, for instance, the movement of skilled people and advances in technology and capital goods that have cross-sector relevance. But the benefits spill over more broadly, even to the agricultural sector, and in the following paragraphs we describe some of the ways that this occurs, especially as a result of the tax revenues that a growing industrial sector can generate. Large-scale, densely concentrated activities are by this very nature far easier to tax than small-scale dispersed activities.

6) The ability to support public research and development. Thus, economies with large accessible industrial sectors will be far better able to support publicly sponsored R&D than those consisting largely of dispersed, small-scale agricultural/craft production units. This factor may be especially important in the support of agricultural research, like that undertaken by Agricultural Extension Service in the United States. These activities directly contribute to agricultural productivity growth, but could not be supported without a taxable base of industrial activity.

7) Public support for human capital accumulation. Just as in the case of R&D, private capital market failures may mean that public support in the form of free primary and secondary education is a critical component of general human capital accumulation. Moreover, the high returns to education in the industrial sector lead to a greater demand for an educated labor force. Again, the greater susceptibility of concentrated industrial enterprises to taxation is key to funding. And again, as workers migrate across sectors, ultimately higher productivity growth in the agricultural/craft sector will be engendered as well.
(8) The development of a robust financial sector. Greater investment in the industrial sector leads to higher levels of productivity both directly through capital deepening and the embodiment of technical progress (Johansen, 1959, and Solow, 1960), and indirectly through the capital goods industry, which is often a major source of innovation. Some of the innovations here (such as those relating to mechanization) have direct spillovers to the agriculture sector. But so do the institutional developments that are necessary to make an industrial economy function. The heavy investment of a modern industrial economy requires finance. It is not surprising then that an industrial environment should be characterized by a more highly-developed financial sector than an agricultural/craft environment. Once developed, a strong financial sector facilitates capital deployment throughout the economy, even in the rural sector.24

The implication of this analysis is that it pays government to take actions (industrial policies) to expand sectors in which there are more learning spillovers (in the above analysis, the industrial sector; within the industrial sector, there may be subsectors for which the learning elasticity is higher and from which learning spillovers are greater).

1.3.2 Finance and industrial policy

One of the reasons that markets fail to allocate resources efficiently to “learning” are capital market constraints. R&D is hard to collateralize, and optimal learning entails expanding production beyond the point where price equals short run marginal costs.

Imperfections of information often lead, especially in developing countries, to credit and equity rationing. Interestingly, a key instrument of industrial policy in East Asia was access to finance, often not even at subsidized rates (Stiglitz and Uy, 1996).

There are several aspects of “learning” in the design of financial policy. The first, emphasized by Emran and Stiglitz, is learning about who is a good entrepreneur. The problem, as we noted earlier, is that because of "poaching" the benefits of identifying who is a good entrepreneur may not be approprioted by the lender. There will be too little lending to new entrepreneurs.

Secondly, information is local, which means foreign banks may be at a disadvantage in judging which entrepreneurs or products are most likely to be successful in the specific context of the particular less developed country. Foreign banks are accordingly more likely to lend to the government, to other multinationals, or to large domestic firms. Financial market liberalization may, accordingly, have an adverse effect on development (Rashid 2012).25

1.3.3 Other institutions

Previous sections have shifted production towards learning, meaning that a variety of other institutions—organizations, almost everything—shape an economy.

Here, we focus on intellectual property regimes, providing incentives for the returns. But intellectual property systems are not just about transmission of knowledge. Increasingly, there is a concern with property regimes, and especially for developing countries, since their importance in determining the availability of knowledge is limited. The patent system is, production, thereby giving rise to a patent system of important input into the availability of knowledge.

No wonder there is more money is spent. There are two important critical role of closing, appropriate intellectual property regimes.

There are many emerging markets is in the advanced industrially-size fits all policies are important of designing an innovative and open source. Patents are not getting more attention to different better systems of challenge.

1.3.4 Government involvement

In some ways, government regulations that they have to make decisions regarding education and infrastructure, and future directions of the...
1.3.3 Other instruments of industrial policy

Previous sections have argued that the objective of industrial policy is to shift production toward sectors in which there is likely to be more societal learning, meaning more learning and more learning externalities. There are a variety of other instruments – indeed, as we comment in the concluding section, almost every aspect of legal and economic policy has some effect in shaping an economy.

Here, we focus on intellectual property. In a sequel (Greenwald and Stiglitz, 2012) we discuss exchange rate policy and foreign direct investment.

Intellectual property regimes are supposed to encourage innovation, by providing incentives to do research, enhancing the ability to appropriate the returns. But intellectual property interferes with the dissemination/transmission of knowledge and encourages secrecy, which impedes learning. Increasingly, there is an awareness of other adverse effects of intellectual property regimes, as developed in the advanced industrial countries, especially for developing countries (see Stiglitz, 2006). Knowledge is the most important input into the production of knowledge, and by restricting the availability of knowledge, the production of knowledge (learning) is inhibited. The patent system gives rise to monopoly power; monopolies restrict production, thereby reducing incentives to innovate. The patent system can give rise to a patent thicket, a complex web of patents, exposing any innovator to the risk of suit and holdup. Because patents “privatize” knowledge while challenging patents moves knowledge into the “commons,” there will be underinvestment in challenging patents and overinvestment in patenting. No wonder then that it has been estimated that in the United States, more money is spent on patent lawyers and litigation than on research.

There are two implications of this analysis. The first is that, given the critical role of closing the knowledge gap for successful development, the appropriate intellectual property regime for developing countries and emerging markets is likely to be markedly different than that appropriate for the advanced industrial countries. In this area, more even than others, one size fits all policies are inappropriate. Secondly, there are alternative ways of designing an innovation system, with greater emphasis on prizes and on open source. Patents will play a role, but a good patent system has to pay more attention to disclosure, to problems of holdup, and to designing better systems of challenging patents (see Stiglitz, 2013).

1.3.4 Government investment

In some ways, governments cannot avoid questions of industrial policy; for they have to make decisions about the direction of public investment, say in education and infrastructure, and this has to be based on beliefs about the future directions of the economy, which are in turn affected by these public
decisions. But the policies with which we are concerned go well beyond this. For government can use public expenditure policies to partially compensate for deficiencies in market allocations.

To see what this implies, let's extend our earlier learning model by introducing Public Goods, denoted by $G$ in the first period. For simplicity, we assume we can impose a lump-sum tax to finance them and that there are full spillovers. We focus on the "direct" control problem, where we choose the level of spending on each private and public good. Focusing on the first period, we have

$$\text{Max } U[L, G] - V(\Sigma L^1 + \Sigma G) + \delta[U(L^t+1, H[L, G]) - V(\Sigma L^{t+1})]$$

where the output of public good $G_1$ is just equal to the labor input in its production. The first-order condition of $G$ is

$$U_G - \frac{V}{G} + \delta U_{L^i} H_{G} = 0$$

In deciding on the optimal level of investment, we look not just at the direct benefits, but also at the learning benefits. But in the absence of subsidies on private goods that take into account the learning benefits and spillovers, the provision of the public good can have another benefit. By expanding the production of public goods which are complements to goods with high learning elasticities and large externalities, the government can help create a more dynamic economy. To see this, we reformulate our optimization as an indirect control problem (still assuming the public good is financed by a lump-sum tax)

$$\text{Max } V(p^t, I - G^t, G^t) + \delta V(p^{t+1}, I)$$

where $V$ is the indirect utility function, giving the level of utility as a function of prices, income net of lump sum taxes, and public goods. In the absence of product subsidies, equilibrium is characterized by price equaling marginal cost, or

$$p^i = 1; p^{t+1} = 1/H(L^t, G^t)$$

The set of equations can be solved simultaneously for $\{x^t = 1\}$ as a function of the vector $(G^t)$. An increase in $G_1$, financed by a lump-sum tax, has complex income and substitution effects on the demand for each commodity. For instance, if some public good is a close substitute for some private good, the lower spendable income as a result of the additional provision of the public good combined with the availability of a public substitute will lead to a reduction in the private demand for that good, but if the public goods were a strong complement, the demand would increase the demand for $G_1$. The term $\partial L^1/\partial G_1$ the change in the demand for $G_1$ of an increase in public goods $G_1$.

Hence, optimizing for learning (by setting $V_0 = 0$) gives rise to the first term.

$$V_0$$

The first term (ignoring the second term $\Sigma H \delta U_{L^i} G_1 H = 0$ for the composition of demands)

We expand the previous section, the learning benefits and spillovers, to see the net effect on learning.

1.3.5 Concluding Remarks

1.3.5.1 Theory of Industrial Policies

Conventional policies (such as subsidizing R&D) emphasized the benefits of externalities, where resources are distorted in one manner or another. The economics of learning give rise to such distortions, where resource distortions in one manner or another.

I use the word "distorted" to emphasize that the returns to R&D are the returns to the learning process. A return to R&D arises from the return to the learning process. It is why simultaneous optimality is important (see, for example, the cost-efficiency of associated with R&D investment in learning).
good were a strong enough complement (a free road to a ski resort), it might increase the demand for the good (trips to the ski resort.) We denote by $\partial L_i^j/\partial G^i_j$ the change in the demand for (consumption of) good $j$ as a result of an increase in public good $i$ at time $t_0$. Standard results give

$$V_i^j / V_i^j = L_i^j.$$ 

Hence, optimizing with respect to $G^i_j$ yields (assuming for simplicity full spillovers)

$$V_i^j - V_i^j = \delta V_i^j \left[ \Sigma L_i^{j+1} \left[ H_{ij} + \Sigma (\partial L_j / \partial G^i_j) H_{ij} / HP \right] \right]$$

The first term ($H_{ij}$) on the left-hand side is the direct learning benefits, the second term ($\Sigma (\partial L_j / \partial G^i_j) H_{ij} / HP$) is the indirect effects on learning as the composition of demand changes.

We expand the production of public goods not only to take into account the learning benefits, but also the indirect effects in inducing more consumption of some goods and less of others, taking into account the total net effect on learning.

1.3.5 Concluding comments

1.3.5.1 Theory of the second best

Industrial policies distort consumption from what it otherwise would have been. Conventional economics (such as the Washington Consensus policies) emphasized the costs of these interventions. We have emphasized that when there are market failures (as is always the case when there are learning externalities), there will be benefits. Optimal policy weighs the benefits and costs as the margin.

The economics of the second best is of particular relevance here: R&D and learning give rise to market imperfections, sometimes referred to as distortions, where resources are not allocated in a "first-best" way. Well-designed distortions in one market can partially offset distortions in others.

I use the word "distortions" with care: Common usage suggests that governments should simply do away with them. But as the term has come to be used, it simply refers to deviations from the way a classical model with, say, perfect information might function. Information is inherently imperfect, and these imperfections cannot be legislated away. Nor can the market power that arises from the returns to scale inherent in research be legislated away. That is why simultaneously endogenizing market structure and innovation is so important (see, for example, Dasgupta and Stiglitz, 1980). Similarly, the costs associated with R&D (or the "losses" associated with expanding production to "invest" in learning) cannot be ignored; they have to be paid for. Monopoly rents are one way of doing so, but – as we argue here – a far from ideal way.
the home or hospital, or effectively move to the places where the conflict develops, that disputes will arise. But it is not easy to predict where there are numerous cases, and the organizations involved in economic performance, and predict the impact (and whether) the outcomes will

The "endowment" concept is, in a sense, society's learning stock. It represents the knowledge that it has and its potential to learn about new technologies. In this context, it is the industrial capability, the capacity for comparative advantage and learning, that is important. The question is, in relation to its competitors. A country may be very adept at producing computer chips, but if there are competitors that are also very adept, it may fall behind. It is important to understand how countries can benefit from learning and innovation.

It has become conventional wisdom to emphasize that what matters is not the geography of production, but the geography of investment. In particular, the idea of the "enclave" concept, where countries are essentially engaged in producing goods for export, has been questioned in recent years. The focus on the "enclave" concept has been criticized for ignoring the role of domestic demand in determining the location of production. This is particularly true in the case of high-tech industries, where the demand for products is often driven by domestic consumers, and not simply by export markets.

1.3.5.2 Industrial policies and comparative advantage

Justin Lin (2012) has distinguished between industrial policies that defy comparative advantage, which he argues are likely to be unsuccessful, and those that are consistent with comparative advantage, which can be an important component of successful development. While there is considerable insight in this distinction, the key question is, what are the endowments of a country, that determine its comparative advantage? This is equivalent to asking, what are the relevant state variables? And what is the "ecology" against which the country's endowments are to be compared; that is, what are the relevant endowments of different countries?

It has become conventional wisdom to emphasize that what matters is not static comparative advantage but dynamic comparative advantage. Korea did not have a comparative advantage in producing computer chips when it embarked on its transition. Its static comparative advantage was in the production of rice. Had it followed its static comparative advantage (as many neoclassical economists had recommended), then rice might still be its comparative advantage; it might be the best rice grower in the world, but it would still be poor.

Ascertaining a country's static comparative advantage is difficult; ascertaining its dynamic comparative advantage is even harder. Standard comparative advantage (cf. Heckscher-Ohlin) focused on factor endowments (capital-labor ratios). But with capital highly mobile, capital endowments should matter little for determining comparative advantage. Still, capital (or, more accurately, the knowledge of the various factors that affect returns, and what is required to use capital efficiently) doesn't move perfectly across borders; that means that the resident of country i may demand a higher return for investing in country j. There is, in practice, far less than perfect mobility.

Thus the "state" variables that determine comparative advantage relate to those "factors" that are not mobile, which, in varying degrees, include knowledge, labor, and institutions.

Multinationals can, however, convey knowledge across borders. Highly skilled people move too. Migration has resulted in large movements in unskilled labor, but there are other flows too. The notion that the home or hospital, or effectively move to the places where the conflict develops, that disputes will arise. But it is not easy to predict where there are numerous cases, and the organizations involved in economic performance, and predict the impact (and whether) the outcomes will
unskilled labor, but in most cases, not enough to change endowments of the home or host country significantly. Even institutions can sometimes effectively move across borders, as when parties to a contract may agree that disputes will be adjudicated in London and under British law. Still, there are numerous aspects of tacit knowledge, about how individuals and organizations interact with each other, and norms of behavior that affect economic performance, and, most particularly from our perspective, how (and whether) they learn and adapt; and these do not move easily across.

The “endowment” from our perspective which is most important is a society’s learning capacities (which in turn is affected by the knowledge that it has and its knowledge about learning itself) which may be specific to learning about some things rather than others. The spirit of this paper is that industrial policy has to be shaped to take advantage of its comparative learning and learning abilities (including its ability to learn to learn) in relation to its competitors. Even if it has capacity to learn how to make computer chips, if a country’s learning capacity is less than its competitors, it will fall behind in the race. But each country makes, effectively, decisions about what it will learn about. There are natural non-convexities in learning, benefits to specialization. If a country decides to learn about producing chips, it is less likely that it will learn about some other things. There will be some close spillovers, perhaps say to nano-technology. The areas to which there are spillovers may not lie near in conventional product space. There may, for instance, be similarities in production technologies (as in the case of just-in-time production or the assembly line). That is why the evolution of comparative advantage may be so hard to predict.

But while standard economic analysis may provide guidance to a country about its current (static) comparative advantage (given current technology, what are the unskilled-labor-intensive goods), guidance about its comparative advantage defined in this way (dynamic learning capacities) is much more difficult, partially because it depends on judgments made by other countries about their dynamic comparative advantage and their willingness to invest resources to enhance those advantages. Whether ex ante the USA, Japan, or Korea initially had a dynamic comparative advantage in producing chips, once Korea had invested enough in learning about certain kinds of chip production, it would be difficult for another country to displace it.

Looking at what other countries at similar levels of per capita income did in the past or what countries with slightly higher levels of per capita income are doing today may be helpful, but only to a limited extent. For the world today (both global geo-economics and geo-politics, and technology) is different than it was in the past. Competing in textiles today requires different skills and knowledge than in even the recent past; it may (or may not) be able to displace a country that currently has a comparative advantage in some product; the country may (or may not) be in the process of attempting to establish a comparative advantage in some other area.
1.3.5.3 Industrial strategies

A key issue of industrial strategy is not only the direction (should Korea have attempted to reinforce its comparative advantage in rice, or to create a comparative advantage in some other area?), but also the size of the step. Should it try a nearby technology (product), nudging along a gradual, evolutionary process that might eventually have occurred anyway? Or should it take a big leap? The latter is riskier: perhaps greater returns if successful, but a higher probability of failure.

We have not formally modeled this critical decision, so the following remarks are only meant to be suggestive: The ability to learn and the costs of learning increase significantly the bigger the leap; but so may the benefits. There are natural non-convexities in the value of information/knowledge (Rudner and Stiglitz, 1984), implying that it pays to take a moderate step: small incrementalism is not optimal.

By the same token, using another analogy, to corporate strategic policy, it pays to move to a part of the product space where there are rents which can be sustained (for example, as a result of entry barriers, arising, for instance, out of returns to scale and/or specific knowledge). This almost surely entails not doing what others are or have been doing.

1.3.5.4 The inevitability of industrial policy

We have argued that government cannot escape thinking about its industrial structure. It is necessary as it makes decisions about public investments (in education, technology, and infrastructure). But the legal framework of a society also inevitably shapes industrial structure. If, as in the United States, derivatives are given seniority in bankruptcy, while student debts cannot be discharged, and large banks are effectively allowed to undertake high risks, with governments bearing the downside, and speculators are taxed at lower rates than those in manufacturing, the financial sector is encouraged at the expense of other sectors. This is an industrial policy.

Developing countries have to think carefully about every aspect of their economic policy, to make sure that they shape their economy in a way which maximizes learning. But their learning challenge is markedly different from that of the advanced industrial countries, where one of the main objectives is moving out the knowledge frontier. The focus of developing countries should be to close the knowledge gap between them and the more advanced countries (though for some of the more developed among the emerging markets, one of the challenges it to be at the forefront, at least in some particular areas, something at which both China and Brazil have succeeded).

But this in turn has one important implication: legal frameworks and institutional arrangements (such as for intellectual property) that are appropriate for developed countries are not likely to be appropriate for developing countries and emerging markets.

1.3.5.5 Industrial policy

We began the discussion, for example, the effect of general barriers, but the effects of industrial policy seem more pronounced. Many emerging markets are now heavily protected, and the need to liberalize in response to external pressure is thus more acute. But such an approach may also be seen as a solution to the problem of intellectual property. Any country with a high demand for intellectual property will be highly affected by industrial policy. But such an approach also raises the question of whether we can “correct” the distortions that have arisen.

1.3.5.6 The object of industrial policy

Industrial policy is often seen more broadly, as a way to help develop countries compete with foreign investors and large companies. But such an approach also raises the question of whether we can “correct” the distortions that have arisen.

Thus, in those countries where market outcomes are not clear, it is clear that something is needed. Whether or not markets (for example, with unions, or government persistence) or a government to attempt to intervene in intensive sectors of the economy.

In each of these cases, it is evident that the approach is not straightforward. In some cases, there are distortions that do not pay for the public intervention and in some cases, the distortion is high and unresponsive to the distortions that have arisen.

1.3.5.7 Political economy

A persistent criticism of industrial policy is that it is inefficient, even in the best government attempts to intervene in the economy. There is neither the possibility that the losses resulting from distortions before and during the intervention.
1.3.5.5 Industrial policies and government failures

We began the discussion of this paper arguing that industrial policies are, in part, a response to market failures. The sectoral allocations resulting from unfettered markets are not in general optimal. But some of the inefficiencies in markets arise, as well, from government policies. A natural response is to remove the government distortions, rather than to create a new, offsetting distortion. But such an approach ignores the complexity of political economy and the difficulty of fine-tuning public policies. For instance, earlier, we referred to the impact of intellectual property. But a country’s intellectual property regime is greatly affected by TRIPS, the WTO agreement, in ways which may not accord with the country’s own best interests. It may, accordingly, attempt to undo or “correct” the distortions arising from that intellectual property regime.

1.3.5.6 The objectives of industrial policy

Industrial policy is usually conceived of as promoting growth, but it should be seen more broadly, as any policy redirecting an economy’s sectoral allocation where market incentives (as shaped by rules and regulations) are misaligned with public objectives. Governments are concerned about employment, distribution, and the environment in ways in which the market is often not. Thus, in those countries with persistent high levels of employment, it is unclear that something is wrong with market processes: labor markets are not clearing. Whether the explanation has to do with inherent limitations in markets (for example, imperfect information giving rise to efficiency wages), unions, or government (for example, excessively high minimum wages), the persistence implies that “correcting” the underlying failures may not be easy. The social costs of unemployment can be very high, and it is appropriate for government to attempt to induce the economy to move towards more labor intensive sectors or to use more labor intensive processes.

In each of these instances, shadow prices differ from market prices. This is evident in many areas of the environment, where firms typically do not pay for the full consequences of their action. The consequences for investment—including investments in R&D—are obvious. Firms in many countries are searching for labor-saving innovations, even in countries with high unemployment, when from a social perspective, there are high returns to innovations that protect the environment.

1.3.5.7 Political economy

A persistent criticism of industrial policies is that, even if market allocations are inefficient, even if market prices differ from shadow prices, government attempts to correct these failures will simply make matters worse. There is neither theory nor evidence in support of this conclusion. To be sure, there are instances of government failure, but none on the scale of the losses resulting from the failures of America’s financial market collapse before and during the Great Recession. Virtually every successful economy
has employed, successfully, at one time or another, industrial policies. And this is most notable in the case of East Asia (Stiglitz, Wade, Amsden, Chang).

In the sequel to this paper (Greenwald and Stiglitz, 2014b) we explain that limitations in government capacity (“political economy problems”) should play an important role in shaping the design of industrial policies – what kinds of instruments should be employed.

In short, the debate today should not be about whether governments should pursue policies that shape the industrial structure of the economy. Inevitably, they will and do. The debate today should center around the directions in which it should attempt to shape the economy and the best way of doing so, given a country’s current institutions and how they will evolve – recognizing that the evolution of the institutions themselves will be affected by the industrial policies chosen.

Appendix: A simple model of investment in R & D

In the text of this paper, we focused on how learning spillovers affected the optimal production structure—leading to an industrial structure that might be markedly different from that which might emerge in an unfettered market economy. Here, we extend this work by looking at how knowledge spillovers affect the optimal pattern of R & D.

Assume there are two products, produced by a linear technology

\[ Q_i = A_i(R_i, R_j) L_i \]

where \( R_i \) is the amount of research on product \( i \) and \( L_i \) is the labor devoted to production, \( L_j \) to research

\[ E_i = L_i + L_j \]

Total employment in sector \( i \) \( E_i \) is the sum of production and research workers. If \( A_{ij} > 0 \) \( (i \neq j) \) implies there are spillover benefits for product \( i \) from research on product \( j \). For simplicity, we assume \( R_i = L_i^2 \) the amount of labor devoted to research in sector \( i \).

Social welfare maximization entails

\[ \max U(Q_1, Q_2) - (E_1 + E_2) \]

After some manipulation, the first-order conditions can be written

\[ \alpha \frac{1}{L_1} (L_2 / L_1) + \alpha \frac{2}{L_2} (L_1 / L_2) = 1 \]

where \( \alpha \ln A_i / \beta \ln L_j \)

Role of spillovers

With no spillovers or

The ratio of employment directly related to the amount of research intensity can be increased. Consider

With perfect spillovers

so the effect is to increase employment.

Comparison with a market

In a perfectly competitive market, within-industry spillovers allow firms to free ride on others' investments.

At the other extreme, a monopolist firm would engage in research only if the given input, that is, generating
\[ \alpha \frac{L_1}{L_2} + \alpha \frac{L_2}{L_1} = 1, \]

where \( \frac{\partial \ln A_i}{\partial \ln L_i} = \alpha_i \).

**Role of spillovers**

With no spillovers \( \alpha_i = 0 \), so

\[ \frac{L_i}{L_2} = \alpha \frac{L_2}{L_1}. \]

The ratio of employment in research in sector \( i \) to production labor is directly related to the own elasticity of productivity. If the elasticity is high - research increases productivity a lot - then a large fraction of labor should be devoted to research.

It is easy to see that if there are externalities \( \text{I.e. } \alpha_i > 0 \), research is increased. Consider the symmetric case, where \( L_1 = L_2 \) in equilibrium. Then

\[ \frac{L_i}{L_1} = \alpha \frac{L_1}{L_2}. \]

With perfect spillovers,

\[ \alpha = \alpha_i, \]

so the effect is to double the ratio of research workers to production workers.

**Comparison with a market economy**

In a perfectly competitive economy with a large number of firms and perfect within-industry spillovers, there would be no research, as each would try to free ride on others: \( L_i = 0 \) - clearly an underinvestment in research.

At the other extreme, assume that there were no spillovers. Then each firm would engage in some research. It would maximize output for any given input, that is,

\[ \text{Max } A_i (L_i) (E_i - L_i), \]

generating

\[ A_i'(E_i - L_i) = A_i, \]

or

\[ \alpha_i = \frac{L_i}{L_0}. \]
an equation that is identical to that derived earlier for the optimal allocation, in the case of no spillovers – highlighting the crucial role of spillovers in industrial policies. (The overall level of employment may, however, differ in the two situations.)

But there is another critical issue: whether there are spillovers or not is, in part, a matter of industrial policy, for example, concerning compulsory licensing, cooperative research efforts, and disclosure policies.

Thus, assume there are \( n \) firms in the industry, and that \( A_i = A_n + \beta \Sigma A_i \). Government policy can increase \( \beta \) (the spillovers from sector \( j \) to sector \( i \)) and thus the optimal amount of research. Moreover, if sector \( i \) has learning as well as research potential, and the other sector does not, then \( L_i \) will be much greater with \( \beta \gg 0 \), and hence so will \( L_i' \).

More typically, sectors in which research is important are imperfectly competitive. Assume that again there is no knowledge spillover, and that each sector faces an elasticity of demand of \( \epsilon \). Then, as before, we can show that \( L_i / L_n = \alpha \).

But now, with monopoly

\[
p_i = A_i / (1 - 1/ \epsilon),
\]

where \( p_i \) is the price of the \( i \)-th good (taking labor as the numeraire); while in the competitive case

\[
p_i = A_i.
\]

Production (output) is lower, that is, for any given level of productivity (\( A_i \)), \( L_i \) is smaller; and hence \( L_i' \) is correspondingly smaller. The exploitation of market power results in under production, and thus underinvestment in research, since the value of research is related to the cost savings – that is, the level of production.

In the case with identical learning functions but differences in demand elasticities, interestingly, the percentage reduction in output is the same, and hence relative increases in productivity stay the same. The monopoly engages in less than optimal research – but more than the competitive market (with full within-sector spillovers, where there is no research.)

The long-term growth and structure of the economy depends critically on the nature of competition (which itself is endogenous) and spillovers. A Cournot duopoly may, for instance, result in more R&D spending than a monopoly with a similar R&D function. But the pace of innovation may be lower. Over time, the effects can be cumulative, that is, the less monopolized sector has lower productivity growth. Its scale is, as a result, diminished, with resulting diminution in incentives to engage in research.

**Notes**

1. Paper presented at the Policy Round to thank the discussants (Greenwald and others).
2. See Solow (1987) for a discussion of the implications of this.
4. Stiglitz (1987a) for a discussion of the implications of this.
5. One should, however, note that individuals did not have the evidence that the early discussions argued from the most important.
6. The social returns, in contrast, are higher (but still weak).
8. This is an extreme case of the technology lag.
9. Inappropriate technology.
10. In this view, it is perhaps not a case of computer or bureaucrat.
11. The returns on R&D may be higher if the other sector returns correspondingly are.
12. Because caution may be of limited, however, could correspondingly depend on the time horizon.
13. They are also often left out in some cases.
14. We do not consider the set of technologies that are endogenous on other sectors.
15. And indeed, it is expected that they will.
16. That is, it is harder for instance, when
optimal allocation of resources, the magnitude of spillovers depends on whether, or not, there is learning. If there is, then learning will tend to lower the returns to the sector. If there is learning, then the returns to the sector will be lower than if there is no learning. This is because of the positive externality that learning creates. Learning creates the opportunity for other firms to benefit from the innovation of the first firm. This externality reduces the return to the first firm, and thus the incentive to innovate. This is why it is important to have policies that encourage learning. Policies that encourage learning include providing incentives for firms to invest in research and development, and providing education and training programs. These policies will help to reduce the return to the sector, and thus increase the incentive to innovate.

Notes

1. Paper presented to the International Economic Association/World Bank Industrial Policy Roundtable in Washington, DC, May 22–23, 2012. The authors would like to thank the participants in the seminar for their helpful comments. This paper is based on Greenwald and Stiglitz (2006, 2014a) and Stiglitz (forthcoming). Greenwald and Stiglitz (2014a) provides a sequel to this paper, focusing on the implications of learning for industrial policy in the context of Africa.

2. As Solow (1956) pointed out, an increase in the savings rate simply leads to an increase in per capita income, not to a (permanently) higher rate of growth.

3. See Stiglitz (1998), which describes development as a "transformation" into a society which recognizes that change is possible, and that learning how to effect such change.


5. One should, perhaps, not put too much emphasis on the fact that these individuals did not appropriate the full benefits of their innovations: there is little evidence that they would have worked any harder with fuller appropriability. Discussions among economists focus on economic incentives: these may be far from the most important determinants of learning/innovation.

6. The social return is related to the arrival of an innovation earlier than would otherwise be the case. For a more extended discussion of these issues, see Stiglitz (2006, 2008, 2013).


8. This is an explanation of the high observed average returns to investment in technology. See Council of Economic Advisers (1995).

9. Inappropriately designed intellectual property regimes can actually inhibit innovation. (See the references cited earlier in footnote 6.)

10. In this view, it makes no difference whether the economy produces potato chips or computer chips. Let the market make the decision – not some government bureaucrats.

11. The returns on US government investments in technology and science are even higher than those of the private sector (which in turn are far higher than private sector returns elsewhere). See Council of Economic Advisers (1995).

12. Because countries differ, too, some learning that may be relevant in one country may be of limited benefit in other countries. Most changes in technology, however, could confer benefits across borders. The extent to which this is the case may depend on the level of skills (human capital) and the institutional arrangements.

13. They are also examples of ideas that are hard to be protected by patents, though in some cases, America's business process patents may still do to.

14. We do not comment here whether their empirical approach really does fully capture the set of related capabilities. The effects of an improvement in one sector on other sectors depend not just on the similarity of those sectors, but on the institutional arrangements, e.g. providing scope for exploiting linkages. Thus, the fact that natural resource sectors have traditionally not been closely linked to other sectors may be partly a result of the absence of effective industrial policies, and the exploitive relationships often evidenced in that sector.

15. And indeed, this is one of the advantages of public support for the creation of knowledge.

16. That is, it is hard to write good incentive compatible innovation contracts, to know, for instance, when a firm fails to produce a promised innovation whether it was
because of lack of effort or because of the intrinsic difficulty of the task. Cost plus contracts, designed to share the risk of the unknown costs required to make an innovation, have their own problems. See, for example, Naifeh and Stiglitz (1983).

17. An alleged major disadvantage of firms is that transactions within firms are typically not mediated by prices, with all of the benefits that accrue from the use of a price system. But if the benefits of using prices exceeded the costs, firms presumably could use prices to guide internal resource allocations, and some enterprises do so, at least to some extent. There is another perspective on these issues, related to accountability and control. See Stiglitz (1994).

18. Similar results obtain if learning is related to investment, as in Arrow's original 1962 paper. See Greenwald and Stiglitz (2014).

19. The sensitivity of the subsidy to the learning elasticity or to δ depends on the proportionality variable U/v'. Later discussions in the case of separable utility functions will provide some sense of the factors that determine that variable. See also Greenwald and Stiglitz (2014).

20. There is a complicated fourth factor u^{1−1}/v^{1−1} = (u^{1−1} / u^{1−1}) / (v^{1−1} / u^{1−1}) = (u^{1−1} / u^{1−1})(1−γ), so γ(1−γ) = δh, so γ(1−γ) = δh, where γ(1−γ) = δh reflects the diminution of marginal utility as a result of increased consumer goods over time. See Stiglitz (forthcoming).

21. As we noted earlier, it is these learning benefits that help explain an economy's industrial structure — the boundaries of what goes on inside firms. In general, the diseconomies of scale and scope (related, for instance, to oversight) are greater in agriculture than in industry. In the case of modern hi-tech agriculture, there are increased benefits of learning, and that will affect the optimal size of establishments.

22. The importance of these factors has clear implications for the conduct of macroeconomic policy, which we discuss later in this paper.

23. The fact that they are producing different products enhances the likelihood that they will make different discoveries. The fact that they are producing similar products enhances the likelihood that a discovery relevant to one product will be relevant to another.

24. Exploitation by money lenders in the rural sector led to the development of rural cooperatives, for example, in the United States and in Scandinavia.

25. The extent to which this is true may vary, for example, if the foreign bank buys a local bank, it may, at least for a while, provide it with some autonomy.

26. For example, through the use of the “liability system.” The US Supreme Court, in its decision for eBay Inc. v. MercExchange, L.L.C. in 2006, recognized the adverse consequences of the patent system and its enforcement as it had developed in the United States.

27. With stronger assumptions about separability, it is possible to solve for L as a function of G; but we consider here the more general case.

28. Krugman's research made it clear that something besides factor endowments mattered: he observed that most trade today is between countries that have similar factor endowments.

29. We note, however, that we have implicitly assumed the ability to impose lump-sum taxation. With distortionary taxation, the optimal amount of research will obviously be less than with lump-sum taxation. See Stiglitz (1986).

References

Bruce Greenwald and Joseph E. Stiglitz 69


Rashid, H. (2012) "Foreign Banks, Competition for Deposits and Terms and Availability of Credit in Developing Countries," working paper.


