

PUBLIC POLICY FOR A KNOWLEDGE ECONOMY

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INTRODUCTION

KNOWLEDGE AND DEVELOPMENT

Development Knowledge and the World Bank

The Knowledge Culture

Changing Ways of Thinking

Tacit Knowledge and Local Adaptation

Active Learning and Intrinsic Motivation

BASIC ANALYTICS OF THE KNOWLEDGE ECONOMY

The Scarcity-Defying Characteristics of Ideas

Intellectual Property Rights

Not Ordinary Property Rights

Externalities

Competition

Organizational Dimensions of Knowledge and Information

Knowledge Transactions within Firms

Openness and Knowledge Transfer

Experimentation

The Marketplace of Ideas: Decentralization, competition, and experimentation

Pluralism in Project Selection

Towards Robustness: Some Implications of Imperfect Knowledge

The importance of recognizing human fallibilities and imperfections of information

The failure of central planning: an example

Decentralization and Participation within firms
Openness in the Political Process

PUBLIC POLICY FOR A KNOWLEDGE ECONOMY

Some Recent U.S. Policies

Increasing Capacity

Industrial Policy and the Support of Research

Competition

Financial Markets

Tax Policy

CONCLUSION

REFERENCES

INTRODUCTION

The past several centuries have witnessed several fundamental economic transformations, and each of these economic transformations has had fundamental implications for the nature of society.

The industrial revolution laid the foundation of the transformation of the economy from agriculture to industry; with it, not only did living standards rise, but also the location of life changed, from rural communities to metropolitan megalopolises. The scientific revolution of the past century has resulted in the systematization of change itself: the very process of producing new innovations has been altered, from isolated and independent inventors like Thomas Edison to huge research laboratories. Knowledge and information is being produced today like cars and steel were produced a hundred years ago. Those, like Bill Gates, who know how to produce knowledge and information better than others reap the rewards, just as those who knew how to produce cars and steel a hundred years ago became the magnates of that era.

In what ways are the laws that govern the new Economies differ from that of the old? To be sure, we still face the economics of scarcity. But just as the importance of land in production changed dramatically as the economy moved from agriculture to industry, so too does the movement to a knowledge economy necessitates a rethinking of economic fundamentals. Knowledge is different from other goods: it has many of the central properties of a public good, indeed of a global public good.¹ While government has a key role in protecting all property rights, its role in intellectual property rights is far more complicated: the appropriate definition of these rights is not even obvious. And in the knowledge economy, the dangers of a monopolization are perhaps even greater than in industrial economies. These are but three examples of the ways in which the role of government in the knowledge economy may differ markedly from that in the industrial economy with which we have become familiar over the past century.

¹ See Stiglitz (1995, 1998).

I want, however, to broaden the discussion beyond these technical economic issues in three directions: to the role of knowledge in development, to the *culture* of the knowledge economy and to some of the implications of the new economy for democratic processes.

I approach the problem of the knowledge economy from three perspectives: from that of a theorist, who has spent almost three decades thinking about the economics of information and knowledge; as Chairman of the Council of Economic Advisers, where we struggled with many of the same questions that are the focus of concern of your recent White Paper,² and, most recently, as Chief Economist at the World Bank. In hope to weave these three perspectives into my remarks this morning. I shall begin by looking at the problem from my current vantage point.

KNOWLEDGE AND DEVELOPMENT

Development Knowledge and the World Bank

The World Bank is concerned with promoting growth and reducing poverty in the developing world. Our most recent *World Development Report* (1998/99) was devoted to the theme of Knowledge for Development—and I am of course glad to see it cited in the U.K. White Paper. For many years the received wisdom in economic development focused on building infrastructure and factories. Government officials could proudly show these constructions to visiting economists as the tangible evidence of development. The focus was on the “weighty economy”—if we use the metaphor of knowledge as the basis for the “weightless economy.” We now see this strategy as being seriously incomplete—indeed as only focusing on the “easy part” of development.

Today the World Bank has shifted much of its emphasis to the intangibles of knowledge, institutions, and culture in an attempt to forge a more comprehensive New Development Framework for our work.³ We want, for instance, to be a Knowledge

² Department For Trade and Industry (1998a).

³See Stiglitz (1998b).

Bank⁴, not just a bank for infrastructure finance. We now see economic development as less like the construction business and more like education in the broad and comprehensive sense that covers knowledge, institutions, and culture.

The shift in focus was motivated in part by the experience of the most successful countries—and the failures of many of our efforts around the world. By most accounts, the accumulation of capital could explain only a fraction of the increases in per capita income in the countries in East Asia. Their miraculous growth is largely attributed to closing the knowledge gap, the gap between the more developed and less developed countries in the knowledge about how to transform inputs into outputs. To be sure, some of this closing of the knowledge gap was itself “purchased,” the result of investments in capital which embodied more advanced technologies.

The Knowledge Culture

Changing Ways of Thinking

But more than just knowledge was acquired: there was a change in ways of thinking. It is hard to define this change: an acceptance of change, a recognition that the poverty in which they had been mired for centuries was neither inevitable nor necessary, and, perhaps most important, the appreciation of the centrality of knowledge and education in general and the science and technology in particular. To be sure, even in the most advanced societies, the scientific approach, as much as it has benefited all of us, remains concentrated within relatively small circles—a fact that those of us who moved from academia to government saw all too clearly. The process of development can be seen as extending the reach of these basic ways of thinking, making them more pervasive in every corner of life.

I have often found that a study of the development process highlights aspects of the more developed industrial countries' societies and economies. So too here, for it brings home forcefully the change in culture that must accompany success in the new knowledge economy. I have seen this vividly, as I have moved from teaching at

⁴ The concept of the Knowledge Bank was introduced in Wolfensohn's address to the Annual meetings in 1996. See Wolfensohn (1996).

Princeton, on the outskirts of New York, where the culture of Wall Street cast its long shadow, to teaching at Stanford, and then on to Washington. One really felt the entrepreneurial spirit at Stanford. In the corridors and restaurants, there was constant talk of new enterprises, translating the advances in ideas into new products and new businesses. Venture capital firms sought out these new opportunities, providing not just with capital, but with managerial know-how. The focus was on creativity and wealth creation, not on the rearrangements of the use of already existing assets and corporations, the take-overs and mergers, the corporate restructurings that were so much the center of attention on Wall Street. There is no prescription for how a country creates such a culture, just as there is no prescription for how a corporation can create such a culture. But government does have a role—a role in education, in encouraging the kind of creativity and risk taking that the scientific entrepreneurship requires, in creating the institutions that facilitate ideas being brought into fruition, and a regulatory and tax environment that rewards this kind of activity. In the discussion below, I shall focus more narrowly on the technical, economic aspects of government policies, but I cannot emphasize enough my belief that the full benefits of these reforms will only be felt if there is a more fundamental change in culture.

Before moving on to a fuller discussion of these technical issues, let me spend a few more moments dwelling on the central role of institutional and cultural change in the creation of a knowledge economy, focusing on our experiences in transferring knowledge to less developed countries.

Tacit Knowledge and Local Adaptation

The Analytical Background Report⁵ recognizes the importance of non-codified or tacit knowledge and the difficulties in transferring it. Indeed, it is precisely the difficulties in transferring a company's tacit knowledge base embedded in its staff that can be a basis for the company's competitive advantage. But viewed the other way around, this means that transferring tacit knowledge is a substantial obstacle to those of us in the economic

⁵ Department for Trade and Industry (1998b).

development business who view knowledge as Bacon viewed money—as a “muck” to be spread as widely as possible.

Take technology transfer as an example. The technical manuals, blueprints, and instruction books are the codified technical knowledge that could be seen as only the tip of the iceberg. The codified technical information assumes a whole background of contextual knowledge and practices that might be very incomplete in a developing country. Implementing a new technology in a rather different environment is itself a creative act, not just a copied behavior. Getting a complex technical system to function near its norms and repairing it when it malfunctions both draw upon a slowly accumulated reservoir of tacit knowledge that cannot be easily transferred or “downloaded” to a developing country.

If all this is true for relatively cut-and-dry technical knowledge, one can imagine the problems in “transferring” the economic institutions of a private property market economy to developing countries. The word “transferring” must even be enclosed in raised-eyebrow quotes to signify the problematic nature of this venture. Yet we have come to believe that a proper institutional framework *is* key to development.

What part of an institution is only particular to, say, an Anglo-American environment, and what part is more universal? To a boy growing up in the American Midwest with baseball, football, and basketball, it is a rude shock to find out that most other countries do not play these ballgames and that most countries even play a game where the ball cannot be touched with the hands! America has clearly not been successful in teaching the world the *proper* way to play “football.”

But as economists we try to discern more universal principles amidst the “buzzing and booming confusion” of local economic practices, and we try to apply these principles to reform economic institutions. If this is to be more than a quixotic venture to “teach the world the proper way to play football” then we must consider the subtleties of institutional knowledge transfer. Economic agents act in a whole matrix of economic, political, and cultural factors, many of which are tacit factors not apparent to the “visiting economist.” A quick transplant of a “textbook model” will very likely not take root in the local soil. Instead a longer process of transplanting or grafting is required. That process cannot be

engineered from Washington. The local economic agents and agencies—who have the local tacit knowledge—must take charge of the process of recreating the more universal institutional schema within the local matrix of economic, political, and cultural factors. It is this complex interplay of international and local agencies that is key to the Bank’s vision of knowledge-based development, a vision that moves well beyond the idea of universal recipes developed in Washington about “how to play football.”

Active Learning and Intrinsic Motivation

Development is about the transformation of societies which ultimately involves people changing how they think. External agencies cannot force people to change how they think or what they believe.⁶ People can be forced to adopt certain behaviors and to utter certain words, but they cannot be forced to change their hearts or minds. That, they can only do themselves.

In industry, the shift towards a knowledge-based economy involves a shift in organization away from top-down hierarchical structures to flatter structures such as networks of semi-autonomous teams. Tayloristic vertical structures were designed to enforce and coordinate certain physical behaviors while knowledge-based work organization involves greater recognition of the autonomy and self-direction of the mind. Knowledge is best acquired not by passive rote memorization but by the active involvement of the learner. Learning is by doing, not by watching or memorizing. These activist principles were embodied, for example, in John Dewey’s pragmatic philosophy of education.⁷

To foster the active involvement of the learner, the motivation should at best be intrinsic to the activity, not a superadded carrot or stick. While external incentives can

⁶ "As little as another can go to hell or heaven for me, so little can he believe or disbelieve for me; and as little as he can open or shut heaven or hell for me, so little can he drive me to faith or unbelief." See Luther 1942 (1523). This insight was basic to the liberty of conscience and the attitudes of religious tolerance fostered in Europe by the Reformation.

⁷ Perhaps the foremost example of a school system based on Deweyian principles was the system in my hometown of Gary, Indiana established in the early twentieth century see Bourne (1970). The effects of these reforms were still evident when Paul Samuelson went through the system to be followed by myself years later.

modify short-term behavior, they usually will only temporarily override rather than change the internal system of motivation. When the extrinsic incentives are removed, behavior reverts to the previous motives. In the management literature, the importance of intrinsic motivation has been emphasized by W. Edwards Deming.⁸ An effective quality system is not based on external monitoring buttressed by quality bonuses but on the intrinsic ethos of producing quality for its own sake based on the pride and self-esteem of the workers.

All of these principles are equally fundamental for the knowledge-based transformation of a developing country as they are for a knowledge-based company. “Best practices” that are imposed on a country by conditionalities (“carrots and sticks”) will not produce lasting change. It will undermine people’s incentives to develop their own capacities and weaken their confidence in using their own intelligence. The external development agency, instead of acting as a catalyst or midwife to empower change, will only short-circuit people’s learning activities and reinforce their impotence. The external incentives may temporarily overpower the springs of action that are native to the institutional matrix of the country but that will probably not induce any lasting institutional reforms.

Participation in the vital activities of a developing society, like shopfloor participation in a company, is necessary to foster a lasting transformation. Active involvement brings commitment to the lessons being learned and ownership of the results. Participation and involvement is not just a matter for government officials or managers; it needs to reach deeper to include those who are often excluded and who are key to the strengthening of social and organizational capital.⁹ Outside experts can encourage “ownership” of “best policies” through persuasion, but the degree of ownership is likely to be much greater if those who must carry out the policies are actively involved in the process of shaping and adapting, if not reinventing, these policies in the country (or company) itself.

⁸ See Deming (1982, 1994).

⁹ See Wolfensohn (1997) for a discussion of the importance of inclusion in the development process.

BASIC ANALYTICS OF THE KNOWLEDGE ECONOMY

It should by now be clear that success in the knowledge economy requires a change in culture. But I want to move away from this broader perspective, viewing the knowledge economy within the framework of the economists' more traditional tool-kit. I want to argue that there are some fundamental ways in which knowledge is different from ordinary commodities, differences which have fundamental implications for the way a knowledge economy must be organized, and accordingly, fundamental implications for public policy.

The Scarcity-Defying Characteristics of Ideas

First, and perhaps most fundamentally, is the fact alluded to earlier—knowledge is a public good. Thomas Jefferson described the non-rivalrousness of knowledge and information in the following way: "He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me."¹⁰ The properties of dynamic processes driven by knowledge seem to ultimately derive from the scarcity-defying expansiveness or non-rivalrous aspect of knowledge. Once knowledge is discovered and made public, there is essentially zero marginal cost to adding more users

It is useful to differentiate conceptually the pure non-rivalrousness of knowledge from the low cost of dissemination. The information revolution results in part from the great strides made in modern technology in reducing the costs of processing and disseminating information. But any material embodiment or encoding of information is still strictly speaking rivalrous. As an overdue notice from a library attests, two people in different places cannot use the same book at the same time. And as the waiting time to download from the Internet attests, electronic packets on telephone networks are still rivalrous and can lead to congestion effects. It is only immaterial ("disembodied") knowledge, information, ideas, concepts, functions, and other abstract objects of thought that are purely non-rivalrous. It is the process of embodying knowledge in people (learning) and things (application) that is costly in time and resources.

¹⁰ See Jefferson (1984).

Intellectual Property Rights

Not Ordinary Property Rights

A pure public good is a good that is non-rivalrous and also cannot be excluded from certain users. Knowledge is to some extent excludible so it might be considered an impure public good. But efficiency in use requires that there be no charge; yet with no charge, firms would have no incentive to produce knowledge. For knowledge to be provided privately, there must be some form of ‘protection’ – knowledge cannot simply be made publicly available. In some instances, trade secrets will do. But in other instances, the broader protection of intellectual property rights is required.

Too often, however, the difference between intellectual property and other forms of property rights are glossed over. Clearly, a system of government which protects my physical property from theft is necessary if I am to have any incentive to acquire such property, and there is almost universal agreement that governments should strive to have the most effective protection of physical property as possible. Reasoning by analogy, some have argued for “strong intellectual property right regimes,” failing to note the salient differences. In particular, all ideas build on the work of others, drawing upon the common pool of ideas. Indeed, the basic ideas, such as mathematical theorems (which provided, for instance, the basis for the modern computer) typically are not patentable. Strengthening intellectual property rights often means raising the price of a key ingredient into research—knowledge—and thus it is possible that an excessively “strong” intellectual property regime may actually inhibit the pace of innovation. Issues of the breadth (scope) of a patent, the standards of novelty, and even the duration pose difficult problems and trade-offs: not only between static and dynamic efficiency (a point long emphasized in the literature) but also between initiating and follow on innovations. As we move into the knowledge economy, more thought to these vital issues must be given.

Externalities

Even if knowledge is not a *pure* public good, there are extensive externalities (spillovers) associated with innovations. The full benefits of the transistor or the laser clearly did not accrue to those who contributed to those innovations.

My predecessor as Chairman of the Council of Economic Advisors, and Stanford colleague, Mike Boskin, was often quoted as saying that he did not care whether an economy produced potato chips or computer chips. This was his quip encapsulating his strong opposition to industrial policy. But he was wrong. There may be a difference between someone who makes a better potato chip and someone who makes a better computer chip: the magnitude of the externalities, the spillovers, may be an order of magnitude greater in the latter case than in the former. I shall return to this theme later in my discussion of industrial policy and picking winners.

Competition

The White Paper rightly emphasizes the importance of competition for the success of the knowledge economy. I find it remarkable how some of the debates over capitalism of former days are forgotten as the world confronts new challenges. In the 1930s, there was a great deal of worry about *monopoly capitalism*; the concern was that the new industrial technologies required sufficiently large scales of production for efficiency that there would be relatively few firms in any economy, leading to concentrations in economic (and therefore political) power. Adam Smith's famous invisible hand theorem was predicated on the existence of competition. But was competition consistent with the newly emerging industrial economies?

Fortunately, it turned out that as the scale of markets expanded and technologies evolved, in most (but not all) industries there were many firms, perhaps not enough that the economy was well approximated by the perfect competition ideal that underlay Smith's theorem, but sufficiently great that the worries about monopoly capitalism seemed ill-founded.

But knowledge, almost by definition, gives rise to a form of increasing returns to scale which may undermine competition. These concerns are reinforced by the large

network externalities, such as those associated with the use of computer “languages.” These network externalities have further consequences: They give rise to positive feedback and locked in effects, which have profound consequences both for equilibria and dynamics; there may, for instance, exist multiple equilibria (with one Pareto inferior to the other), and the economy will exhibit hysteresis (history matters).¹¹

But my concern at this point is the adverse effects on effective competition: Worries about monopoly capitalism are being played out once again, this time on an international scale, with Microsoft being at the center of attention. Without prejudging the outcome of the trial underway, it seems clear that Microsoft has engaged in practices designed to exploit its position as the almost monopoly in PC operating systems, and has clear intentions of leveraging its position further. When I was in the White House, both the Council of Economic Advisers and the Office of Science and Technology Policy were worried about the potential adverse consequences for the pace of innovation. If the practices that they seem to have been engaged in are not against the law, then the issue is, perhaps the law should be changed.

Several fundamental issues are raised. First, this example illustrates the dangers of excessively strong intellectual property rights. Another example may further illustrate what is at issue. Suppose a computer program which turns out to have a high level of success uses the symbol q for “quitting” the program. Should that “innovation” be protected by intellectual property? Doing so can impede the development of common languages and the pace of innovation more broadly.

Historically, patents have sometimes been used to suppress competition (and even competitive innovation.) One of most famous instances was George Baldwin Selden’s attempt to use a patent on a horseless, self-propelled vehicle to establish a cartel in the nascent automobile industry. Another example sometimes cited is Xerox’s use of basic patents to deter other entrants into the copying business which changed only with the settlement of the Federal Trade Commission’s antitrust action in 1975.¹²

¹¹ See Shapiro and Varian (1999).

¹² See Kearns and Nadler (1992).

Secondly, in the knowledge economy, competition is better described by Schumpeterian competition than by the price taking behavior of the Arrow-Debreu model. In the latter, price is driven down to marginal cost. In the knowledge economy, firms live off of their rents, with price well in excess of marginal costs.

I became concerned about the large differences between the two forms of competition almost twenty years ago. This motivated a research program into the economics of innovation¹³. One of the key insights was not only that the standard welfare theorems (on the efficiency of market economies) did not apply¹⁴, but that Schumpeter's conjecture, that a succession of entrants would provide competitive discipline, was not in general true. Even small entry costs could result in large monopoly power, with not only prices being maintained high, but with the pace of innovation far slower than under competition.¹⁵

As we move into the "knowledge economy" just as the new technologies provide greater scope for the suppression of competition, the consequences may be more adverse. I argued earlier that the kind of creativity that is essential for the knowledge economy requires the engagement of the mind. Organizationally, small new enterprises often have provided more fertile ground for this kind of creative engagement than do large established bureaucracies. Many of the most important innovations have originated in these small enterprises. These firms typically begin with a number of disadvantages, such as lack of access to inexpensive capital. If, in addition, there are artificially created market (anti-competitive) barriers then the pace of innovation may well be slowed.

¹³ See, for instance, Dasgupta and Stiglitz (1980a, 1980b).

¹⁴ Indeed, the standard theorems on welfare economics, which underlay the presumption of the efficiency of the market economy, *assume* that information and knowledge is unaffected by any action taken by any participant in the economy. Thus standard economy theory has little to say about the efficiency of the knowledge based economy. More generally, Greenwald and Stiglitz (1986) showed that whenever information is imperfect (and can be affected by actions of participants) the economy is not, in general, even constrained Pareto efficient (i.e., even taking into account the limitations imposed by the imperfections of information and the costs of acquiring further information.)

¹⁵ See Stiglitz (1988) and Dasgupta and Stiglitz (1980b, 1988). See also Gilbert and Newbery (1982).

Organizational Dimensions of Knowledge and Information

Knowledge and information differ from other commodities in a number of other ways, which result in markets for information and knowledge differing markedly from markets for other commodities. For instance, by definition, each piece of information is different from every other piece of information: intrinsically, information cannot satisfy the essential property of *homogeneity* that characterizes competitive markets. For forms of knowledge (information) that are not protected by patents, there are real problems in market transactions: How can I sell the knowledge? I have to tell you at least something about what I will disclose to you, something that you presumably did not know before; thus, in the process of trying to engage in a market transaction, I lose some of my property. In practice, markets for knowledge and information depend critically on reputation, on repeated interactions, and on trust.

Knowledge Transactions within Firms

This is seen most markedly in the myriad of knowledge transactions which occur within a firm. Within an organization, the "payment" for knowledge sharing is often recognition and prestige or the possibility of future reciprocity. But if managers or team leaders represent the ideas of the team members as their own or if sharing between certain team members is rather one-sided, then the "supply" of knowledge will be diminished. Workers will not assist in codifying their tacit knowledge about doing their job if they feel it will jeopardize their employment. The knowledge market must be built on trust that there will be reciprocity, some *quid pro quo*, in the transaction.

"Knowledge is power" so, in some cases, knowledge that should be freely available in an organization might be hoarded to create an artificial scarcity or monopoly. In times of difficulty when knowledge sharing might be most important, the threat of downsizing may lead people to hoard their knowledge to increase their indispensability. If knowledge hoarding is rewarded, then there will be a vicious circle of knowledge restriction instead of the virtuous circle of knowledge sharing.

Elsewhere, I have described how managers may deliberately create asymmetries of information, in order to increase their power vis-a-vis outsiders, reducing the chance of a

take-over and increasing rents.¹⁶ While these problems may arise in any firm, they may be particularly acute in knowledge based enterprises.

On the demand side, organizational culture will artificially limit demand for knowledge if it denigrates any requests of knowledge as an admission of ignorance (e.g., like a male driver asking for directions). But a greater limitation on the demand for knowledge is the "not invented here" (NIH) syndrome. Each individual or group will tend to diminish the importance of any knowledge they might obtain from elsewhere, and to greatly embellish the power of the knowledge they already have. This is captured in the barnyard saying that "every rooster likes to crow on top of his own dunghill."

This problem also arises when knowledge is "branded" by an organization. The organization's prestige and image is tied up with that branded knowledge. Any admission that there might be superior knowledge elsewhere from which the organization could benefit would be seen as "criticizing" the organization, "tarnishing" its brand reputation, and "diminishing" its franchise value at the very least, by helping its rivals. If *that* is the corporate culture, then little organizational learning will go on. When Ken Olsen, the founder of Digital Equipment Corporation, forbade any discussion or even mention of "personal computers" within the company that was "identified" with mini-computers, he sentenced the company to its eventual fate of being overtaken by the personal computer market.¹⁷

Openness and Knowledge Transfer

These knowledge principles carry over (making the necessary changes) to countries as a whole. If basic intellectual property rights are routinely violated, then the supply of knowledge will be diminished. Where trust relationships have been flagrantly violated (e.g., as has happened in some cases to companies bringing both financial and knowledge capital to the former Soviet Union), learning opportunities will vanish. The breach of trust will not soon be repaired.

¹⁶ See Edlin and Stiglitz (1995).

¹⁷ See Davenport and Prusak 1998, p. 44.

The openness of a country to foreign trade seems to have a far greater effect on its economic success than would be predicted by the standard trade models of comparative advantage. One explanation is knowledge: trade and foreign direct investment provide important channels for the transmission of knowledge.

Knowledge is also obtained by travel across open borders.¹⁸ Both Slovenia and Albania had borders with west Europe but the borders were not equally open. Slovenia had the most *open* border of the socialist countries and is now also the richest in per capita terms; Albania was the most closed and is now the poorest post-socialist country. (To be sure, there were other differences that accounted for the disparity in per capita GDP, but Albania's insulation certainly contributed.) In East Asia, the key event in Japan's economic development was the dramatic opening to foreign knowledge in the second half of the nineteenth century that marked the beginning of the Meiji period of Japan's determined modernization drive.

Knowledge transfer also follows the trail of foreign direct investment. For instance, a major source of learning about lean production methods and their adaptation to American culture was Japanese direct investment in production facilities in the United States (so the knowledge flows across the Pacific have been two-way).

Experimentation

Another type of openness important to knowledge-based transformation is the willingness to experiment. Societies that do not experiment can be historical deadends like the closed and static feudal manors of medieval Europe. Modern Europe evolved from the towns which grew up in the "cracks" of an otherwise closed medieval society and which functioned as "special zones" where new forms of economic and social organization

¹⁸ "It is hardly possible to overrate the value, in the present low state of human improvement, of placing human beings in contact with persons dissimilar to themselves, and with modes of thought and action unlike those with which they are familiar.... Such communication has always been, and is peculiarly in the present age, one of the primary sources of progress." (J.S. Mill, quoted in Hirschman 1981, p. 17).

could be tested. Experimentation requires an openness to new knowledge and to change, and change can always be unwelcome to the powers that be.¹⁹

The Marketplace of Ideas: Decentralization, competition, and experimentation

Pluralism in Project Selection

Thus, pluralism and competition, often associated with openness, are vital to innovation and the growth of knowledge. The structure of economic and political institutions powerfully affect which ideas, innovations, or projects are selected to be financed and implemented. Decentralization provides the scope for greater experimentation and learning, and the competition among decentralized units may provide an essential spur.

Some years ago, I explored one aspect of this, in contrasting two opposing extremes in project selection: a hierarchical system, where a proposal must pass a series of hurdles to be accepted, or a decentralized system of alternative decision centers, where a proposal can be accepted by any one of them (and can get a second chance if turned down). The hierarchical system would tend to err on the side of rejecting many good projects while the decentralized system would err on the side of accepting many bad projects. The advisability of the two systems (and various mixtures) would depend on the relative cost of accepting a project that turns out to be bad versus the opportunity cost of rejecting a project that turned out to be good.²⁰ The hierarchical system would be best for a decision where accepting a bad project might be fatal—as in the decision to go to war. But where accepted bad projects are not fatal and only expend resources, the clear verdict of history is in favor of a more decentralized system of pluralistic political or economic units.

In a decentralized system, decision-makers compete against one another to find good projects. With centralized or monopoly project selection, there is no fear that a

¹⁹ "And *successful* change requires a large measure of freedom to experiment. A grant of that kind of freedom costs a society's rulers their feeling of control, as if they were conceding to others the power to determine the society's future. The great majority of societies, past and present, have not allowed it. Nor have they escaped from poverty." See Rosenberg and Birdzell, (1986).

rejected innovation will be adopted by a competitor and an accepted innovation might have an uncertain effect on the monopoly. Thus hierarchical centralization has been a recipe for uniform and essentially static societies from ancient Egypt to the Soviet Union. In contrast, Columbus was turned down by the King of Portugal and two Spanish dukes before submitting his proposal to Ferdinand and Isabella. After a four year wait, he was again turned down, but the decision was reversed two years later in 1492. In this manner, the pluralistic and competing channels of selection foster innovation.

Towards Robustness: Some Implications of Imperfect Knowledge

We live in an imperfect world—and that imperfection is mirrored in our own fallibility. We can never know all that we might know, and we are hard put to sift the relevant knowledge from the "knoise" (noise posing as "knowledge") that is always pressing upon us. We may make poor decisions on the basis of what we know, we often fail to communicate our knowledge to others, and we may misrepresent our knowledge or lack of it when dealing with others. All of this affects economic transactions and other social interactions as well as the work of enterprises and other organizations.

The importance of recognizing human fallibilities and imperfections of information

Economists have often assumed away these fallibilities in their models, as physicists might assume away the effects of friction. But we now understand that economics without human fallibility is like the play Othello without Iago. If all the characters in Shakespeare's Othello knew what there was to know and communicated it truthfully to others, it would have been a simple story yielding little insight into the real world—like some economic models. While the consequences of being "all too human" can sometimes be tragic, our goal is not pessimism but realism. Economic policy advice extracted from realistic models is likely to be far more valuable than advice divined from

²⁰ See Sah and Stiglitz (1986).

elegant but Panglossian models of perfect information, unbounded rationality, and truthful behavior.

If an institution was structured to operate on the basis of "perfect knowledge," then experimentation or critical thinking would be seen as a waste of time and resources. The "one best way" would be known; there is no room for "continuous improvement." But under the actual conditions of imperfect knowledge, bounded rationality, and fallible judgment, institutions need to be structured for robustness in the sense of yielding acceptable outcomes with existing or potentially available knowledge (not requiring perfect information in order to function).

The failure of central planning: an example

A major historical example is the recent restructuring of centrally planned economies towards decentralized market economies. Knowledge about beliefs, preferences, technology, and local conditions is dispersed among economic agents. Centralized mechanisms for gathering, processing, and transmitting this information deteriorate as the informational messages grow more complex (as is illustrated by the children's game of transmitting a piece of information or a story around a circle). The problems are compounded by the difficulties of eliciting and transmitting knowledge that is tacit or implicit in behavior (like knowing how to operate a machine skillfully). Centralized attempts to reduce "wasteful" duplication of experimentation ultimately stifle innovation. Centralized structures have worked only for relatively short spans of historical time, e.g., a war effort or a big technology project. Attempts to "command" decentralized behavior in a centralized framework face severe motivational and principal-agent problems, and lack the credible commitment that the "decentralized" decisions will be respected and sustained by the central authorities.

The available but dispersed, local, and tacit knowledge would presumably be used by the agents if they were acting on their own behalf in a decentralized and competitive market process. Instead of postulating some unrealistically ideal information transfer to and from central planners as well as some idealized central information processing capacity, the plan-to-market type of restructuring allows the available knowledge to be

locally utilized by the decentralized agents. The separate agents would also perform many local experiments (which might "wastefully" duplicate one another) to discover new knowledge. Prices would evolve to reflect the relative scarcity of resources and to align subjective expectations with the factual state of affairs.

In a static environment, in which the central output is steel and similar industrial goods, centralization has a chance of at least working. But as the century moved on, and knowledge became increasingly important, the limitations of centralization became increasingly apparent and agency problems became more severe.

Decentralization and Participation within firms

The plan-to-market transformation is but one example of a decentralization to accommodate greater complexity and imperfection of knowledge and information. In the firm, moving from simple repetitive work under central control (Taylorism) to more complex knowledge-based work requires a move towards a more decentralized and participative workplace. Central command structures give way to semi-autonomous teams horizontally coordinating according to centrally given rules. Work organized according to the externally determined "one best way" is replaced by participative experimentation leading to continuous improvement.

Within the firm, the transfer of localized tacit knowledge takes place mainly through horizontal apprentice-like relations, not vertical training from managers to workers. Moreover, the information transmitted upwards in a hierarchy to inform decisions is explicit codified information, so decisions are made in a hierarchical structure without lower level uncoded tacit knowledge. Better decisions might be made lower in the hierarchy closer to the source of the knowledge. Decentralized authority also partly unifies principal and agent to mitigate agency problems. When these local decisions require informational inputs from various different job categories, it is best for the decision-makers to have rotated through those job categories to have acquired their tacit components. These arguments for fuzzy job boundaries and job rotation cut against the traditional arguments for specialization and division of labor.

Openness in the Political Process

These changes in economic institutions have counterparts in the political sphere. Here again, the basic theme is restructuring institutions to deal with an imperfect world in contrast with a hypothetical "ideal world" where power is combined with "perfect knowledge" and "perfect virtue." In the actual world, institutions are best structured with openness and competition to be robust under the assumption that knowledge and virtue are rather less than perfect. That robustness strategy applied to social and political institutions leads to the institutions of an open society such as a free press, transparent government, pluralism, checks and balances, toleration, freedom of thought, and open public debate. The restructuring moves away from the idea of a closed society that "knows the Truth" towards an open society that "knows it does not know the Truth."

This political openness is essential for the success of the transformation towards a knowledge economy. As the economy has gone through successive transformations, there have always been losers as well as winners. The losers, keenly aware of their losses, have often tried to use the political process to thwart the changes that adversely affect them.

We now know a great deal not only about the incentives of these special interest groups, but how they operate and why they are often successful in spite of the fact that society overall loses in the process. Openness, and competition among different political entities, provides one of the most important checks.²¹ But as the pace of change may increase, as we learn how to produce even more efficiently in the knowledge economy, the dangers posed by these special interests may also become all the greater.

²¹ The literature on these topics is voluminous. See, e.g. Olson (1982) and Dixit (1996) On the role of openness, see Stiglitz (1998, 1999).

PUBLIC POLICY FOR A KNOWLEDGE ECONOMY

Some Recent U.S. Policies

The White Paper should be commended for its treatment of the many facets of public policy for a knowledge economy. I do not want to repeat here the messages that are brought out so clearly there; but I do want to share some of the perspectives on these public policy issues as we viewed them in the early days of the Clinton Administration, when there was more attention focused on these issues. And I want to relate these perspectives to the analytic framework of the past two sections.

Increasing Capacity

A key to success in the knowledge economy is a trained labor force. It is not surprising that so many countries have focused on improving their educational systems. All of this is commendable. I would like to make three observations:

First, in the long run, success in the knowledge economy requires creativity, higher order cognitive skills *in addition to* basic skills. Those countries that find ways of fostering this kind of creativity will, in the long run, have more success in the competition of the knowledge economy.

Second, also key to success in the knowledge economy is training in science and technology. There are good grounds for government subsidies to science education: Because those engaged in research so seldom capture the full benefits of their work, there are, as we noted earlier, real externalities. These externalities may be most marked for graduate education.

Thirdly, one of the reasons that the education sector may not be as strong as we would like is that it is one of the sectors in which competition is most limited. Yet there are good reasons why market mechanisms fail to work well and to serve fully national objectives. While I do not want here to enter into the debate on school vouchers and school decentralization, I do think that we need to continue to look closely at how we can most effectively increase competition *and* pursue broader public objectives.

Industrial Policy and the Support of Research

Earlier in this talk, I commended the White Paper for its thoughtful approach to industrial policy, and I referred critically to my predecessor's remarks concerning potato chips and computer chips. Industrial policy has often been criticized as "picking winners"; it is argued that the government is particularly ill-suited to that task.

In fact, the government has had a remarkable history of success, from the support of agricultural research (the core industry in the nineteenth century) which led to huge increases of productivity in that sector, to the first telegraph line (between Baltimore and Washington, in 1842) to the development of the Internet.

But the debate has been framed in the wrong way. The objective of the government is not to pick winners, but to identify externality-generating innovations. While critics of industrial policy recognize the necessity of government support for basic research, they fail to note that there is no bright line between basic and applied research; many applied research projects generate large externalities. The objective of government policy is to identify winning projects with large externalities. In this, they have had a history of notable successes.

In the United States, there have been efforts to improve the selection process, by requiring partnerships between the government and the private sector, i.e., requiring the private sector to risk some of its own equity, and by engaging in competitive selection processes. There is some concern that these reforms have been too successful; as they have eliminated the rents associated with government sponsored research programs, they have also reduced some of the sources of political support.

Before leaving this topic, there are three other important observations. First, much of the innovation which has marked the knowledge economy rests on foundations of basic knowledge, a global public good. There may be a tendency both to under-appreciate the importance of basic research and to attempt to free ride on the basic research provided by others. The result can be disastrous; at the very least a slowing down of the pace of progress.

For at least half a century, in the United States much of the support for basic research was provided through defense budgets. With the end of the Cold War, this support has dwindled. While the backlog of basic research will continue to feed advances in applied technology for years to come, eventually the well will begin to dry up. Now is the time to begin more active measures to replenish the pool.

Second, governments have a proclivity for fancy projects, like space stations, that attract popular imagination but are not necessarily the best way of spending scarce research funds.

Thirdly, one has to take a hard look at other programs supporting new technologies, to assess their incremental effect. There is some evidence, for instance, that the program of research support for small businesses in the U.S., as well intentioned as it may be, has not had any significant effect in increasing research.²²

Competition

The White paper rightly emphasizes the importance of competition. Earlier, I stressed the real dangers to effective competition in the knowledge economy. We need to revisit both the appropriate competition laws and intellectual property regimes. Again, let me raise a few observations.

First, as we move into a global economy, the issues of competition become raised on a global level. Greater cooperation among competition authorities might be desirable, especially if this led to more effective enforcement of competition standards and a leveling up of those standards—to the highest rather than the lowest common denominator. The world will benefit from a more competitive marketplace, and the countries of the world need to work in concert to achieve that goal.

Second, while there has been much progress in reducing tariffs, non-tariff barriers, including dumping duties and countervailing duties (CVD's) have taken on increasing importance. Both can undermine not only competition, but industrial policies which

²² See Wallsten (1998).

support the new knowledge economy. Restraints against trade in genetically engineered plants and other Luddite measures can similarly impede scientific progress.

Thirdly, the White Paper seeks to encourage collaboration, but does not sound as strong a warning as I would about collaboration slipping into collusion, or providing the basis for tacit coordinated anti- or at least non-competitive policies.

Financial Markets

I believe that one of the important reasons for success of the U.S. in the arena of the knowledge economy are its vibrant capital markets, and especially its venture capital funds. American capital markets have long been far more competitive than those in many other countries. Anti-trust authorities would have looked askance at the kinds of concentrations in banking that are found in many other countries. While it is not apparent what else one can do to encourage this kind of innovative lending, clearly tax policy may be able to play a role.

Tax Policy

In the U.S. there are some features of the tax code that have encouraged innovation, some that have discouraged it. The incremental research and experimentation tax credit has long received official blessing, but has only been renewed on a year-to-year basis. Perhaps this is because there is some evidence questioning its efficacy. There is a recently enacted provision to encourage small new enterprises (by exempting capital gains), but it is too soon to tell its effectiveness, including the extent to which it helps create new knowledge based enterprises.

The limitations on loss deductibility, however, serve as a major deterrent to risk taking.²³ Research, by its very nature, is a risky undertaking. It is like drilling for oil. Success is measured by whether one strikes one successful hole in ten. The corporate income tax is often described as leading to the government as a silent partner; but while a partner who shares risk can encourage risk taking, a partner that shares in the successes but not in the losses is likely to discourage risk taking.

In the United States, preferential treatment of capital gains has been defended on the grounds that it encourages risk taking and entrepreneurship, of the kind associated with the knowledge economy. But most of the tax preferences go not to this kind of entrepreneurship, but, for instance, to speculative real estate lending. I referred earlier to the importance of a change in culture. A tax system that rewards the returns to speculative real estate in the same way that it rewards real innovation is not supporting the culture of innovation.

CONCLUSION

These are exciting times for the economics of information and knowledge. Industry in the developed countries is moving from metal-bashing to knowledge generation. The information or ICT revolution is pushing to eliminate the effects of “weight” and distance. In the days of the pony express, it took many horses, men, and days to send a message from Kansas City to San Francisco whereas today it is done in the blink of an eye by a little quivering in an electromagnetic field. We are slowly shedding the limitations of Matter to unleash the expansiveness of non-rivalrous Ideas.

Economic models that ignore information imperfections and knowledge creation give us poor guidance since so many institutions can only be understood as adaptive responses to informational problems. Only by seeing the central role of informational imperfections can we hope to design and preserve robust institutions. Similarly, understanding the subtleties of tacit and local knowledge as well as the dynamics of knowledge sharing or hoarding will do much to determine the competitiveness of a company or an industry or a country.

It is imperative to understand the ways in which the production and distribution of knowledge and information differs from that of goods like steel and cars. Processes where knowledge plays a driving role will tend to display positive feedback. In social and economic life, we now see the ubiquity of self-reinforcing processes which display multiple equilibria, path dependence (sensitivity to initial conditions), and lock-in effects. While

²³ See Stiglitz (1969) and Auerbach (1983).

impediments to competition may be more important, the advantages to be gleaned from greater decentralization may be all the greater.

The fact that knowledge is, in central ways, a public good and that there are important externalities means that exclusive or excessive reliance on the market may not result in economic efficiency. For those of us who believe in the power of market forces, the challenge is to find the best “partnership” between the private and public sector—an assignment of roles and responsibilities not dictated by the paradigms of the past that are unsuited to the knowledge economy of the future. Unfortunately, in the search for a framework for this new partnership, simple slogans (“picking winners”) will not get us very far. We are all in uncharted territories, and we will have much to learn from the experiments of each other.

Throughout the world, this new perspective is having profound effects on public policy. In development work, the focus has shifted to the intangibles of knowledge, institutions, and culture. The World Bank is now transforming itself into more of a knowledge bank and is forging a more comprehensive development framework to put the new focus into effect. In more advanced, industrial economies, the challenge of creating and nurturing a culture of innovation and change is no less daunting.

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Methodology Knowledge-based economy Institution Institutional economics. This is a preview of subscription content, log in to check access. References.Â Public policy for a knowledge based economy. London: Remarks at the Department for Trade and Industry and Center for Economic Research. <http://www.worldbank.org/htm1/extdr/extme/jsspo12799a.htm>. 21 Jan 2012. Uphoph, D. D. (1999). Building Knowledge Economies: Advanced Strategies for Development is not about the ICT revolution or high technology industries. Rather, it is about economic devel-opment as a process of generating relevant knowledge and putting that knowl-edge to work to generate further growth. As such, it is about the transformation of countries in an open-ended process that is dened more by the initial, necessarily.Â Examples from various parts of the world are provided as possible sources of inspiration for policy-making communities. We sum up the main lessons of our investigation in a conclusion entitled â€œMoving Ahead to a Knowledge Economy.â€ Information and Analytical Bases.