Finland in a Digital Era:
How Do Wealthy Nations Stay Wealthy?

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Finland’s image shifted in the 1990s from that of Soviet supplier and basic forest products provider to that of telecommunications leader and sophisticated equipment producer. It seized an opportune moment in the global electronics industry and the process of European integration to accomplish a significant structural change of its economy. Finland’s growth was rapid as Nokia, and its associated cluster of firms, became a major player in the world communications industry and the forest products industry modernized, becoming ever more competitive in product and equipment.

The 1990s was a transition as an electro-mechanical era of Walkmen and VCRs gave way to an era of digital products -- computers, networks, and, and of course, mobile telephony. The European decision to establish a single GSM mobile standard, building on the Nordic mobile roaming system, facilitated a remarkable build out of demand for mobile communication. Nokia’s took advantage of the possibilities, creating globally competitive products, marketing, and production systems.

But now is a new era. The two pillars – ICT and Forest products -- may not be sufficient to sustain growth and employment. Finland’s success depends heavily, perhaps too heavily, on Nokia. Nokia faces new challenges in a digital era of mobile broadband data networks and new mechanisms of value creation. It will have a tough fight to maintain its current dominant market, and will require innovative strategy to build position as the markets evolve. Even if Nokia, which has grown well beyond Finland, succeeds in the face of these challenges, this does not automatically imply that Finland will succeed as well. Nokia certainly cannot rest on its laurels. Neither can Finland. Instead both will have to do it again.

To clarify Finland’s choices, the paper first situates the present Digital Era in historical perspective. The second part of the paper will look at the changing problem of Value Creation in a Digital Era. The “global” and the “digital” constantly shift the levers of advantage. The analysis leads to the roles of experimentation is corporate and national adaptation.

Evolving Models of Production and Competition: The Digital Era in Historical Perspective[1]

The influence of the digital revolution is visible in the productive economy, through the evolution in how we make and distribute goods and services. We briefly summarize the evolving model of production and value creation that follows an historical sequence that goes from American dominance with mass manufacture, through challenges to mass manufacture in the form of Japanese lean production and European flexible specialization or diversified quality production.[2] Then we focus on the transition that comes with Wintelism from a mechanical or electro-mechanical age to the digital era[3], before examining in more detail the dynamics of the digital era itself. Each phase involved different business problems, different policy issues, and, importantly, a different emphasis on the State's role in the economy.

American Dominance: Fordism and Mass Manufacture

Mass manufacture, epitomized by Henry Ford and the Model T, was the first twentieth century production revolution, though its roots lie earlier in the 19th century. Mass manufacture is broadly understood to mean the high-volume output of standard products made with interchangeable parts connected using machines dedicated to particular tasks and manned by semi-skilled labor.[4] Traditionally noted features of this basic definition include:

- The separation of conception from execution—managers design systems, operated by workers in rigidly defined roles that match them to machine function;
- The "push" of product through these systems and into the market;
- Large-scale integrated corporations, whose size and market dominance reflect mass manufacture's economies of scale.

In this system large scale manufacture implied rigidity. Fixed costs in the production line and design were high; consequently changes in products or reductions in volume were difficult and expensive. Alongside the technical production issues was a political question. The national economy was rigid as well, in part as a consequence of the production rigidities, since drops in demand would be difficult for companies built on Fordist models to absorb. An initial downturn in demand could cumulate into sharper economic downturns. Booms and busts implied worker dislocations, and the national economic policy counterpart of the corporate business cycle management task became the political debate about how to use a public policy to cushion not only the economic dislocations but also the political dislocations that would come from mass unemployment. Demand management policies, associated with the label of Keynes, were born. *Fordism,* an American innovation, was, and I use the past tense intentionally, mass production with Keynesian demand management. In any case, Fordist mass manufacture was associated with American industrial development, military success, and post-war hegemony. With its emphasis on internal demand and domestic demand management, Keynsianism might have been called a strategy for "capitalism in one country."

Challenges from Lean Production and Flexible Specialization

American mass production as the model of manufacturing leadership gave way in the 1970s and 1980s to innovations from Europe and Japan. Producers abroad, often with the support of their governments, tried to imitate the American mass manufacture model. While most failed against American competition, some of these efforts generated new rounds of production innovation, a second phase in twentieth century manufacturing. These challenges to American manufacturing came from two different directions.

The more important challenge was the interconnected set of Japanese production innovations loosely called *flexible volume production* or *lean production*.[5] Japanese producers created an entirely new approach to volume production that culminated in flexible volume production, more often labeled lean production. The Japanese production machine in mechanical and electro-mechanical goods set American, and secondarily European, industrial establishment on its heels. It attracted intense attention because of the stunning world market success of the Japanese companies in consumer durable industries requiring complex assembly of a large number of component parts. The Japanese lean production system seemed to provide flexibility of output in existing lines as well as rapid introduction of new products, which permits rapid market response. High quality has come hand-in-hand with lower cost.

The Japanese state's developmental strategies were essential to corporate production innovation. The distinctive features of the Japanese lean production system were a logical outcome of the dynamics of Japanese domestic competition during the rapid growth years, and this system was firmly in place by the time of the first oil shock in the early 1970s.[6] Indeed, protected domestic markets and exports were decisive in Japanese success in export markets. Moreover, those closed markets were critical to the emergence of the innovative and distinctive system of lean flexible volume production.[7] While the Fordist story highlights national strategies for demand management, this Japanese story of lean production and developmentalism highlights the interaction among the markets and producers of the advanced countries in international competition. The Japanese developmental system hinged on closed markets at home and open trade into the critical markets in the United States and Europe. The Japanese developmental state actively promoted internal development while free riding on the international system using exports as a domestic balance. It required the combination of an open international system with controlled competition behind managed trade border in Japan. The Lean production was the focus of policy and corporate attention because it represented a direct challenge to both mass manufacturing and assumptions of American global economic policy.

The second challenge to the classical American mass production model had little to do with the volume production strategies emerging in Japan. Different accounts of its development variously labeled this collection of innovations as *diversified quality production* and *flexible specialization*.[8] The "Third Italy" and the Germany of Baden-Wurttemberg were the first prominently displayed examples of an approach in which craft production, or at least the principles of craft production, survived and prospered in the late twentieth century. The particular political economy of the two countries gave rise to distinctive patterns of company and community strategies. [9] Firms in these countries often competed in global markets on the basis of quality not price; they used production methods involving short runs of products that had higher value in the marketplace because of distinctive performance or quality features. Competitive position rested on skills and flexibility, not low wages. These challenges – often in high value-added niche markets – came from small- and middle-sized firms rooted in particular industrial districts. "Craft production or flexible specialization," argue Hirst and Zeitlin, "can be defined as the manufacture of a wide and changing array of customized products using flexible, general purpose machinery and skilled, adaptable workers."[10] Communities or groups of small companies arose, organized in what are perceived as twentieth century versions of industrial districts. These communities are able, in at least some markets and circumstances, to adapt, invest, and prosper in the radical uncertainties and discontinuities of global market competition more effectively than larger, more rigidly organized companies. "These districts escape ruinous price competition with low-wage mass producers," Sabel explains, "by using flexible machinery and skilled workers to make semi-custom goods that command an affordable premium in the market."[11] The emphases in these discussions are the *horizontal connections,* the connections within the community or region of peers, as distinct from the *vertical or hierarchical connections* of the dominant Japanese companies. The flexible specialization model hinges on local institutions that permit the continuous combination and recombination of local activities.

These two challenges to American production dominance each embedded a distinct role for policy and the State: lean production hinging on an arbitrage between closed domestic markets and the open international system; flexible specialization as originally formulated turning on local institutions.

The Transition to a Digital Age and the American Comeback: Wintelism and Cross National Production Networks [12]

Wintelism is a code word points to the shift in competition away from final assembly and vertical control of markets by final assemblers. It was a transition between an electro mechanical and a digital era.[13] It reflects the sudden importance of the constituent elements of the product in the final market competition: the Windows operating system and Intel processors as an example. Hence the name, Wintel. Let us state it formally: This first chapter of the digital era can be best characterized by two elements: Wintelism and Cross National Production Networks (CNPNs).

Wintelism emerged as a response by American producers to the Japanese production challenge. Twenty years ago, the story was that American firms were being dominated in international markets, when a flood of innovative entertainment products like the Sony Walkman and the VCR joined traditional electronic products such as televisions. As the semiconductor industry joined consumer electronics and automobiles as sectors under intense competitive pressure in the late 1980s, it seemed that the fabric of advanced electronics was unraveled. That is, the array of equipment suppliers to the semiconductor industry were eroding, making it more difficult for American semiconductor producers to hold market position. With the weakening position of the semiconductor makers, many feared that final product producers would not have access to the most innovative chip designs needed in their final products.

Then suddenly, American producers rebounded. They had not reversed the decline of production in electro-mechanical products, but rather, a new sort of consumer electronics product had emerged, defining a new segment of the industry. What was a “new” consumer electronics product? [14] The then “new” consumer electronics, as Michael Borrus argued at the time, were networked, digital, and chip-based.[15] They involve products from personal computers to mobile devices. The nature of manufacturing and the sources of functionality changed dramatically. The core engineering skills moved to chip-based systems given functionality by software. More or less at that same moment, products that were thought to spin off from technology investment in military good into civilian products seemed less significant. Instead of talking about spin-off technologies, technologies that had their birth in the defense sector and were spin off to commercial applications, talk turned to spin on technologies. Leading edge civilian technologies contained more advanced technologies and components than their military counterparts. Technologies began to spin on from the civilian sector to the military application technologies.[16] The process of creating value and the role of production were beginning to change as well.

Wintelism involved new terms of competition and, linked to that, a new model of production. Consider the PC. What part of the value chain confers the most value added and leverage in the market? It is not the producer of the final product, the metal box we call the PC, even if, like Gateway or Hewlett Packard, the box carries the company logo. Much of the added value is in the components or subsystems: the chip, the screen, and the operating system. This has several implications.

- *First*, each point in the value chain can involve significant competition among independent producers of the constituent elements of the system (e.g., components, subsystems)—not just among assemblers—for control over the evolution of technology and final markets.
- *Second***,** competition in the Wintelist era is a struggle over setting and evolving de facto product market standards with market power lodged anywhere in the value chain, including product architectures, components, and software. Components and subsystems are built to generally agreed standards that emerge in the marketplace, and thus part of their value lies in the standards, in partially open but owned standards that create de facto IP-based monopolies or dominant positions.
- ***Third,*** the constituent elements of the product became modules, as these fundamentals of Wintelism have evolved. Even if distinctive intellectual property remains in the modules, production becomes modularized as the knowledge about the elements and components and how they interconnect becomes codifiable, that is formally stated and expressed in code, and then diffused.
- *Fourth*, as a result, products are increasingly built as modular systems in which many components and subsystems can be easily outsourced because they are clearly defined. Modularization, as it came to be called, facilitated a vertical disintegration of production. Outsourcing, a tactical response usually aimed at cost savings with a decision to procure a particular component or service outside the organization, evolved into cross-national production networks (CNPNs) that could produce the entire system or final product. CNPN is a label we applied to the consequent dis-integration of the industry's value chain into constituent functions that can be contracted out to independent producers wherever those companies are located in the global economy. Then that discussion of CNPNs transformed into a broader business debate of how to manage the supply chain. This strategic and organizational innovation, what we might now call supply chain management, means that even production of complex products can become a commodity service that can be purchased in the market. The nature of those supply chains, now often labeled

global value chains, varies with the complexity of the transactions, the codifiability of the knowledge involved, and the competence of the suppliers.[17] The strategic weapon for companies such as Dell moves from the factory to the management of the supply chain. And the supply chain itself is extended both forwards into the marketplace and backwards into development.

- *Fifth*, the core engineering skills moved to chip-based systems given functionality by software. The range of production skills to produce an optical film camera is much greater than to produce a digital camera, whether in a cell phone or not.

Wintelism was the beginning of the transition from an electro-mechanical era into a digital age, into a digital era in which tools for thought – broadly, communications and computing – are central. The Wintelist era of the 1980s and 1990s, the moment of the American comeback in electronics, turned, politically, on domestic – initially American – deregulations and international deals that created an ever more open international trade system. The two critical elements, Wintelism and Cross National Production Networks, hinged ultimately on domestic deregulation leading to component makers having leverage to influence the course of digital development and the emergence of global market rules that permitted CNPNs. The emerging production structure and trade structure contributed to, if not drove, the expansion of something loosely called Globalism.

Competing in a Global and Digital Era

The distinctive features of the current era, the global and the digital, are changing the mechanisms for creating value. Let us consider each in turn.

Globalization with Borders[18]

The classic version of the globalization story begins with reduced costs for transport and communication that lower "transaction costs." The consequences of these lowered costs of doing business over distance, it is then argued, are incentives for companies to expand trade and drive financial interconnection while often constraining government policy choices.

From an alternate vantage, globalization is a story of national innovations played out on a larger stage. A sequence of new competitors, new and often unexpected loci of innovation and production, bring new processes, new products, and new business models to the larger marketplace. The developments have usually been cooking inside of national systems of innovation and competition, largely unobserved by the outside. Consequently they are startling when they burst on the global marketplace. This gives the global era a feel of a seemingly increasing pace of unexpected competitive challenges.

"Tools for thought" as the foundation of a digital era[19]

This digital era is best characterized by a new set of distinctive tools, Tools for Thought. "Information technology builds the most all-purpose tools ever, tools for thought… These tools for thought amplify brainpower by manipulating, organizing, transmitting, and storing information in the way the technologies of the Industrial Revolution amplified muscle power."[20] The tool set rests on a conception of information as something that can be expressed in binary form, and manipulated by a new tool set, with information defined as a data set from which conclusions can be drawn or control exercised.[21] It consists of the equipment that executes the processing instructions --hardware, the software consisting of written programs including procedures and rules that guides how the hardware equipment processes information; and data networks that interlink the processing nodes, and the network of networks, that together create a digital community and society.

The digital tools constitute a leading sector that has reshaped the economy as a whole. *Demand* for the products and services made possible by the new digital technology have been part of growth and transformation in the advanced economies in the latter part of the 20th century.[22] IT is not unique. Demand for the goods in a leading sector grows faster than the economy, the surge initiated by the leading sector involves not only new technologies embedded in leading sector products but new infrastructures for making and using the technologies. Producing **new** innovative goods creates chains of linked, and inter-linked, activities. The production chains are evident; for example, steel for cars and trains, roads and rails for those cars and trains to move on, petroleum and coal to drive the trains, and coal to make the steel.[23] Many would argue that the significance of information technology for the contemporary economy is greater than that of earlier leading sectors in their era. That argument does not matter here.

What does matter is that the IT tools can affect every economic activity in which information sensing, organizing, processing, or communication is important--in short, virtually every single economic activity.[24] The IT revolution is transformative, changing the character of product, process, marketplace and competition throughout the economy. The capabilities to process and distribute digital data multiply the scale and speed with which thought and information can be applied, are felt in several ways. A first mechanism is that "tools for thought" permit new information products, change the production and distribution of more traditional goods, and alter the markets for both information goods and traditional goods. The widespread expression of information in digital form drives the transformation of the economy in a variety of ways. Some are specific to the digital tools themselves. Because the expression and manipulation of information is now possible in a common digital electronic form, a range of previously separate information and communication sectors become integrated, or at least more intimately influence each other. For example, print, broadcast, and communications suddenly become integrated with the possibilities of search and storage of information thrown in. Some argue that the moveable type contributed to the social revolution of the Renaissance. Is there a parallel here? More important, the knowledge component of much of industrial activity can now be formalized, codified, and embedded in equipment. Industrial processes once defined loosely as know-how can more readily be expressed and implemented in digital code. Examples would include auto braking that could be understood abstractly, but acted on only imprecisely by human intervention or through analog control solutions.[25] Embedding functionality in digital controls rather than in electro mechanical form makes it easier to vary the functionality of many goods, to create a variety of functionally distinct versions from one electro-mechanical foundation that retains scale. Information technology has both moved inside of machines, controlling their functionality, and moved out into the communications networks, altering not only how and at what price we talk, but how we share, store and use information.

The transformative effects of information technologies are also felt through price changes, drops in prices of communication or content replication and changes in relative prices of different kinds of equipment and activities. Most obviously, the decreased communication costs have reduced the costs of conducting transactions, of gathering and applying information; as these costs drop, organization changes. Networks facilitating large scale file transfers, for example x-ray data or the expression of production orders in digital form permit, for example, the geographic separation of semiconductor design from production, indeed easing the separation of these two functions into separate companies. Production management more generally is altered. In industrial sectors, supply chain management consisting of cross national production networks is facilitated by information technologies and prospers in an IT rich environment. Now of course many service activities are themselves being outsourced, moved away from home markets. The gamut of services runs from call centers in Ghana to RandD in Bangalore. Next, the cost of reproducing and transmitting content in digital form drops toward zero, classically noted as a basic feature of the digital era. At the same time the cost of producing digital information remain high. As pirated copies become indistinguishable from originals, indeed are identical to originals, the task of maintaining control of content or intellectual property becomes central, and difficult.

The consequences of often non-existent replication costs are amplified by the very nature of information goods. How do I price and value what you know and want to sell me without seeing it? But if I see it, and thus possess it, how can you still sell it to me? New business models have to be invented, and older models, and the forms of distribution and IP defended through contracts and courts. 3) As important, the application of information within machine makes the trade off between IT and other forms of capital possible. Use more information technology and you need less fuel or simpler machines. These examples of decreased communications, or transaction, costs suggest though that the vocabulary of price, rate on return on investment, trade-offs among different types of capital, has a risk. It can push toward the marginal, obscure the possibilities of radical change. In early days of application of IT and robotics in factories, traditional accounting measures often obscured the benefits. Change had to be forced in basic parameters of how factories operated and the consequences of new technologies evaluated. The basic parameters of the system have to be set, fixed, for such analysis of change on the margins to produce useable estimates. If the changes in price are so great that basic parameters of decision are altered, then the forecasts are speculations about the consequences of altered parameters rather than reasoned projections or estimates.

All of this tells us that “tools for thought,” Information Technologies, alter the economy, but not how companies might take advantage of the process or governments might support it to capture gain for their communities. One might list the way the mechanisms through which the digital tools affect business strategy, noting in turn network effects, the changing character of content products when functionally identical copies can be made and copied and distributed at marginal cost, the capacity to identify and create product versions. But this approach, listing the tactical and strategic consequences of the IT tools rather quickly reaches limits without distinctive insight. Information tools and information goods have distinctive logic, “Information rules” to use the clever phrasing and insightful arguments of the Shapiro and Varian book.[26] But when does that logic apply? Certainly an Information Rules logic applies in the competition over browsers, such as Google where Varian is an advisor. But which of the elements of information goods, or digital tools or network economics apply in the case of the automobile industry. And how do we decide which issues matter in a particular setting? We need an alternative strategy to understand value creation in a digital era.

Creating Value: Products, Commodities, and Differentiated Assets

To understand the influence of the global and the digital, let us begin with the basic notion of creating value. Created market value, oversimplified, is price minus cost.[27] (Let us set aside for the moment all the necessary qualifications about externalities and politically set rules.) If we are to locate the influence of digital tools, there are two obvious questions about value creation. *First*, how do digital tools and information product change the task of generating something for which folks will pay a premium? In other words, how do we avoid being a commodity product? How do we create unique or differentiated goods so that the premium price can be charged? There are an array of means: create distinctive products, be early to market, own a standard defining what a product must look like. *Second*, how do these tools affect the cost of providing a product or service to customer; if you can't charge a premium, can one generate distinctive margins by being a low cost producer? The argument here is that the points of competitive leverage, of strategic advantage, are now constantly shifting and moving.

To address these questions we need to define explicitly three notions we are generally familiar with: product, commodity, and differentiated asset.

- A product, whether object or service, is that which can be bought and sold in the market.
- A commodity is a good or service which is exchanged in competitive markets with little advantage to any particular buyer or seller. A product becomes a commodity when it is generally available from a number of suppliers on common terms in the market
- A differentiated asset creates the basis for premium price, distinctive sales advantage, or cost advantage in production or distribution.

There is a constant reshuffling among product, commodities, and differentiated assets. As reshuffling occurs, business models must change as well. The process is accelerated by globalization and often achieved through digital tools. Globalization represents new competitors who may as often transform a premium good into a commodity as generate advantage by adding value to what seemed to be a commodity good. Digital tools change the levers of advantage and value creation, transforming distinctive advantages into commodities, and creating new basis for premium products. Consider versioning. Similarly, what are internal company functions may suddenly be available in the market as products; consider contract manufacturing or Research and development. We consider further on how companies and countries address all this.

Let us consider R & D and production as examples, not only of this constant reshuffling, but of internal company operations that have become first products, and then sometimes commodities. In the case of R & D traditionally an internal differentiator has often been sourced outside. In the case of production there is a constant question of whether the function is a commodity or a strategic asset.

R & D: The presumption has been that product development, and the R & D to support that development, is at its core a strategic asset, the foundation of innovation and antidote to Commodification. But R& D, and thus innovation itself, has taken on aspects of a product, something that can be purchased in the marketplace. Even as innovation and continuous product/production improvement becomes more critical, major corporations are shrinking their core research departments. Simply, they can buy much of what they had to develop internally.

There are a variety of sources from which to buy R & D. *First*, in the United States, universities become a source of technology and joint technology development. Many of the engineering schools are rooted in science based engineering, solving engineering problems by working with fundamental principles. The Bayh-Dole act pushed universities into "marketing" technologies developed with federal funding. An array of mechanisms from licensing through facilitating "spin-offs" to institutions for joint development and array of institutions have been established at the major technology universities to facilitate ties to industry. Other countries seek to achieve the same model of industry-university relations. *Second*, of course there are start-ups that spin out developing particular elements of products or services, drawing from the pool of research and early development to cash it in through final development. Many projects are best developed outside the traditional hierarchy of a major company. Firms from Intel through Nokia through IBM establish mechanisms, including their own investment companies, to support startups as an approach to technology development and an alternative to internal development. *Third*, companies set up joint product development projects with other companies, basically combining technology strengths. *Fourth*, major companies establish technology development outposts both to monitor developments and to tap into distinctive pools of talent and technology around the world. *Fifth*, a wide range of countries are entering the development game investing in R & D, both in public labs and in support of industrial labs. Hence the number of points of purchase of "technology" and development have grown.

Major firms become, at least in part, technology integrators, and not just technology developers. Many of the technologies a company needs are readily available in the market. Not all technologies are available in the market, of course. Some technologies that may seemingly be available as commodities in the market may be undergoing disruptive evolutions, opening radically new lines of product development or provide distinctive advantage in existing products. How to proceed is then not only a dilemma, but a serious strategic problem. Often disruptive technologies, which are capable of supporting newcomer entry into the market, are difficult to develop by established companies in-house.[28] Existing paradigms of research, often reinforced by past corporate bets and ties to existing customers, can create blinders that make radical breakthroughs less likely to emerge in-house. That makes a corporate capacity to assess and respond quickly to outside developments all the more important. Centrally, firms have to decide which technologies or products must be developed in house, which should be procured on an exclusive basis even if developed outside, and which can safely be sought in the market as commodity components. Firms have to decide what elements of development are effectively high-end commodities, which technologies are strategic assets, and how to move to capture those distinctive technological assets. And to make the problems more difficult, the reshuffling proceeds it is certain that the choices made today are not likely to be appropriate tomorrow as.

Production in a Digital Age: Production in a digital era, for companies, and countries, can be either a strategic asset or a vulnerable commodity. The production problem seems the reverse of R & D. Over the past decades production has increasingly become a commodity, a product bought in competitive markets. Manufacturing firms went offshore for cost or access to local markets, but discovered abroad a widely distributed capacity for technical and management innovation. Outsourcing led to cross national production networks and eventually skills of supply chain management, each step making the next phase of outsourcing, commodifying production, easier. It may be easier for services to move offshore today than it was for manufacturers to do twenty years ago. Of course the manufacturing experience of the past years creates the institutional foundation for outsourcing and off-shoring. The required tool set consisting of computers, software, and communications are available in the market and easily transported. These are largely general-purpose tools that can be adapted to particular service tasks. The underlying materials for the products are themselves moved seamlessly. At low marginal cost as digitized information, the tools for management of documents and data sets evolve rapidly, skilled labor is available at diverse locations, and the management skills to integrate geographically and organizationally diverse service activities have grown. These activities can be managed either within the single firm or by outsourcing to suppliers. How far, we may ask, will this go? Is there any geographic stickiness to production?

Not all of production is a commodity. In fact production skills are often a strategic asset creating distinctive advantage. For companies the question is: When is it simpler and easier to just buy production as a commodity service? Conversely, when can production serve to generate and maintain advantage? Under what circumstances would the lack of in-house world class production skills be a strategic vulnerability? For the nation, or the region perhaps, the question becomes, "What can be done to make this country/region an attractive location for world class manufacturing, an attractive place for companies to use production to create strategic advantage?"

In answering question we make no distinction between manufacture of physical goods and production of software or services. The same issues pose themselves in different contexts. While manufacturing implies manipulating things and materials, its definitions in my on-line dictionary more generally talks of "the organized action of making goods and services for sale" and putting a product together from components and parts.[29] Certainly a software product, Quicken, qualifies as manufacturing by this definition, as does the creation of the Yahoo web site, and the assembly of the software tools that allow that web site to function. But the word manufacturing implies smoke and factories. At least in English, we require a new word, stripped of the grime of 19th century manufacturing. It may not be possible to fit the concepts we are developing within the tonality and images of the word, manufacturing, a word already loaded with centuries of accumulated meaning. But why not just talk of production as the general case, and manufacturing as the specific case of physical production? In that case, production – the know-how, skills, and mastery of the tools required -- is absolutely central to the products in the digital sector. We must broaden the meaning of a production worker from someone in a factory to an array of other activities. But when we do, the traditional questions, what should be produced or built in house, which can be outsourced, do not disappear. What skills are required to produce the digital product? Is the quality influenced by outsourcing? The corporate strategy questions remain. They are just posed in a new context.[30] We must revisit the policy notions of nodes of activity, of regional skill bases, of communities of know-how. Note that because of the ability to segment supply chains, the questions would need to be asked not only about control of the whole process of producing a good or service, but asked about each individual element of the process.

There are at least three circumstances when in-house control of production, or elements of production, can be a strategic advantage. *First*, if in-house control of production provides advantage in cost, timing of goods to market, quality, or of distribution that cannot be obtained by outsourced production. *Second*, if knowledge about existing production processes is required to design next generation product entry, whether design of the products themselves or of the processes to produce them. Said differently, is in-house production mastery required for rapid product innovation. *Third*, if critical intellectual property about the products themselves is so tightly woven into the production process that commodity outsourcing is tantamount to transferring product knowledge to competitors.

Evidently, these same questions pose themselves differently, in each market or industrial context, and those contexts evolve. Let us consider "emerging sectors," based on new processes and new materials. An emerging sector such as nanotechnology is all about how you make a thing. Product knowledge and process knowledge are intertwined. Biotechnology, likewise, is about how you make things. In these sectors the question of production, product innovation, value creation, and market control remain entangled. More generally, the strategic place of production in these emerging industries is evident if we ask, who will dominate the new sectors? Will those who generate or even own, in the form of Intellectual Property rights, the original science-based engineering on which the nanotechnology or biotechnology rests be able to create new and innovative firms that become the significant players in the market? Or will established players in pharmaceuticals and materials absorb the science and science-based engineering knowledge and techniques, by purchase of firms that have spun out from a university, or alternately by parallel internal development by employees hired from those same universities?[31] There is an on-going, critical interaction among: 1) the emerging science-based engineering principles; 2) the re-conceived production tasks, and 3) the interplay with lead users that permits product definition and debugging of early production. Arguably, that learning is more critical in the early phases of the technology cycle. Can a firm capture the learning from that interplay if it outsources significant production?

We might consider here the history of the semi-conductor industry in which the underlying production process and materials evolved radically as transistor size shrank. In this sector the question of production, product innovation, value creation, and market control remained entangled for many years.[32] A generation ago the industry was threatened when its ability to develop and source leading edge production equipment was weakening. The capacity to retain an innovative edge in product seemed endangered. Now, the cycle comes full circle after a generation in which semiconductor design has often become separated from production, with foundries producing for pure design houses. Once again the question is posed as to whether product position in microelectronics can be held if the underlying technologies and their implementation in production systems are not held within house, or not within the control of the national government of the parent company.[33] Fundamentally this is no longer an argument about national protection, but about open access on equal terms to production innovation and about balancing the political and logistical risks of distributed production. The answer at the firm level depends on a particular firm's product and the market position.

The question about production posed by the emerging sectors is a general one. For the firm, the question is whether that interaction is more effective, the learning captured within the firm, or possible at all through arms-length marketplaces? As new processes or materials emerge, it is harder to find the requisite manufacturing skills as a commodity. Certainly, with new process and materials, new kinds of production skills become essential. Will outsourcing risk transferring core product/process knowledge, developing in others strategically critical assets? Or differently put, is it possible to create competitors by outsourcing; can rivals enter the market based on their learning from producing as a subcontractor? One answer is to segment production so that critical knowledge of the entire system cannot be generated from subcontracting, but the issue is there. For the nation or region, the question is whether ongoing production activity is needed to sustain the knowledge required to implement the new science and science-based engineering. In other words, a regional or national government may not care if the learning goes on within a specific firm, as long as the learning is captured in technology development within its domain. Those intimate interplays have traditionally required face-to-face, and hence local and regional, groupings. With the new tools of communication, what happens to the geography of the innovation node is an open question. In this second big category, it is evident that if a firm, or a national sector, loses the ability to know how to make things, to use production as a strategic capacity, then it will lose the ability to capture value. Whatever goes on in the labs at Berkeley, if you can't capture it in a product you can make and defend, then the science is not going to translate into a defensible position in terms of jobs and production.

The answers to these questions about production are not automatic. Companies will develop competing answers. Rapid product introduction, continuous innovation, and rapid response to shifts in market demand are now central to competition, and the production problem. Some firms will address the problem by careful outsourcing of modularized products. Others may try to create advantage by distinctive or custom development of components and products. And the appropriate answer may shift over time. Consider mobile telephony. Nokia, as I understand it, successfully over a decade developed "mother" lines in

Finland for new modularized products with commodity-like components. Now, purportedly Nokia is able to establish daughter production lines anywhere in the world within weeks. Ericsson less successfully stuck to proprietary designs during the same period. But now Nokia has stumbled, and the Japanese producers who are depending more on in-house solutions are surging. Is this shift in result an outcome of production choices or of the fact that the European market surged in the 90s, and the Japanese market has begun to do so more recently? Is company strategy, production choices, or the logic of lead markets, the key to understanding the varied and evolving results?

Similar issues appear in the automobile sector. The Japanese created distinctive advantage with the lean production model; production became a strategic weapon. But arguably those production models and know-how spread widely, largely depriving them of distinctive advantage. In the electronics sector, production skills spread in part in the form of contract manufacturing. Certainly, efficient cost effective factories and production are necessary, and the pace of fundamental model introduction has speeded up. All that forces product development to blend into the establishment of next generation production lines.

We come back again to the fundamental questions: how to create distinctive advantage and value; how to provide the array of models required to segment what was once a mass market? Then the appropriate follow-up questions run from how to organize the production system, better in-house mastery or use outsourced modules, and indeed whether to change the technological or business model underpinnings of a firm’s strategy.. The search for leverage in the creation of value is continuously on, the drive for differentiation ever more critical.

As noted before, the rapid entry of diverse new competitors into global markets contributes to the process of commodifying production and the transformation of “ innovation/ R & D” into market products. The new entrants into markets and the ever-evolving competitive position of others, globalization, represents new opportunities, challenges and threats coming from unexpected directions. Initially, the notion of globalization came with the entry of Asian, really Japanese, producers as fierce competitors in the established European and American markets. Third tier Asian producers --- Korea, Taiwan, Hong Kong and Singapore entered global markets as part of supply chains for Western producers before establishing their own positions. Now India, China, and the countries from the former Soviet Bloc all find their position in world markets. The new entrants represent both new markets, new competitors representing not only new sources of production and R & D but often new product, production, and management strategies.

Differentiated Assets and Corporate Experimentation

How, then, are firms to escape from the world of commodities, escape from new competitors from new places nipping at their heels, to create differentiated products for which customers will pay premiums and differentiated processes that can create distinctive advantages? What to do in an era of hyper competition when everything threatens to become a commodity? What to do as the products, commodities and differentiated assets are constantly reshuffled? The answers will not be clear and may not be arrived at in a straightforward way. Elisason[34] argues that new information and communication technology makes the world increasingly complex, heterogeneous, and unpredictable even as it expands our capacity process and analyze information.

A traditional analytic approach to strategy will be only starting point in the process of corporate adaptation. Companies will have to look at their initiatives as "experiments," attempts to find their way through a maze of uncertainty.[35] They will need to learn how to evaluate their own experiments and interpret experiments of others, both their competitors and possible models. That of course creates dilemmas. Effective execution is what distinguishes a good idea from a real success, and effective execution is all the harder if an initiative is seen as tentative, a feeler. So the management of committed "experiments will be a real and required skill.

The Classical Approaches: Branding and design are classical, and increasingly important, strategies for differentiation that need to be acknowledged. They are quite evidently mechanisms for segmenting the market in an era of potential commodities. Branding is the creation of an identity for a product or set of products, and serves as a critical instrument to differentiate those branded products from a pool of commodities. For example, amongst an array of similar products that tend toward commodity, the question of whom you trust matters. Hyundai's efforts to establish the once low-end Korean cars as high quality, or GM Saturn's efforts to establish a no trickery sales identity, are examples of an effort to create trust through branding. On-line the issue of trust is even more important. Here the possible anonymity of the market participants, the difficulty of imagining recourse to a virtual participant, makes trust essential. It is that problem which e-bay so cleverly has addressed. Hence the branding, defining trust, is all the more significant. As important, an ever-greater array of products are culture products, fashion products, identity products – choose your label – that give expression to a customer's sense of self. And, of course, it is not simply the object, but how the object is perceived by others that matters to that projection of an individual's identity. The "brand" identity in part states the "presentation of self" that the client chooses. For example, Gap Inc. owns Banana Republic, Gap, and Old Navy; the differences in the clothing offered by the three stores are in the quality of the material, the price of the clothing, and the brand name identity. Similarly, Design, likewise, takes on ever-greater importance in differentiating a product that might otherwise be fundamentally commodities. The Danes for decades have been selling the Bauhaus, the source of Danish Modern product style. For me, an extreme example of value created by design is the Danish company Bang and Olufson, which sends high-end consumer electronics based on what to me is high-end commodity technology sold at extraordinarily high-price as a lifestyle good. The "brand" identity is based on its exceptional electro-mechanical characteristics and pure design. In a digital era, of course, where many electronic products are constructed from very similar modules achieving very similar functionality, design – and branding – becomes critical. Certainly part of Apple's appeal is its stylish design projecting the image of innovative daring. And the I-pod may be an extreme example since the fundamental product could be packaged in a whole variety of ways. But our focus here is on digital tools and digital experiments. So let us turn to those.

Experiments and digital tools: The tools for thought that underpin the digital revolution provide, we argued, new ways of organizing, storing, analyzing, and transferring information. Analysts from Brynjolfsson to McKinsey have argued that very substantial complementary investment is required to generate productivity by successfully introducing and implementing IT tool.[36] In other words, to generate productivity gains you can't just buy the tools and store them in a closet. Substantial investments in training, in reorganization, and in strategic reorientation are required. The critical question is what to do with those underlying digital capacities and how to use their potential.

Some of the digital approaches to creating value and to differentiating product have become very well known. *First*, and now widely understood, are digital approaches to segmenting the market and then attacking specific segments with functionally varied, and usually distinctively branded, product. A fundamental feature of the digital era is that analytic tools of database management permit the consumer community to be segmented into sub-components, each with distinct needs and wishes. At an extreme, individuals and their particular needs can be targeted. Early on, the insurance industry moved from using computers exclusively for back office operations to using them to create customized products for particular consumers.[37] Thus collecting detailed information about customers as groups or individuals in a variety of forms, credit cards or grocery store purchases are obvious examples, is a critical matter. The result, of course, is a policy struggle about what information can be gathered, shared and combined. The wishes of companies and governments to assemble information from diverse sources into consumer profiles or threat assessments is set against individual rights for privacy and community needs for the integrity of the individual. Once the market segments are defined, then digital tools help firms by creating functional variety in product. Standard product can be given diverse functionality. The coffee maker that automatically turns on at a particular time in the morning depends on simple digital functionality. The difference between many higher speed, higher price, printers and their slower, lower price, brethren is in the software that tells the printer how to operate.[38] Let us overstate the conclusion. Digital tools permit new answers to the fundamental question of how much people are willing to pay for which products. Firms have new ways to identify who will pay how much for what, and then create products or give functionality to commodity products that people are willing to pay for. But the story goes beyond that.

Secondly, digitally rooted online sales/marketing and supply chain management alter the links between a firm and its customers as well as suppliers. The Dell story tells how innovative uses of the net that tie customers from sales through production can create dramatic advantage.[39] And, as development and production processes are woven together to speed time to market and improve design choices, the lines between production, design, and development blur even more thoroughly. Because the firm is constructing and evolving a complex evolutionary system, not just procuring a set of defined components, should more of the system – a larger portion of the value added – be kept in-house and not outsourced? More generally, if production becomes characterized by rapid turnaround and custom activity, is the decision about where to locate production within the firm changed? Are the lessons of diversified quality production/flexible specialization applicable in a digital era, that custom production and rapid turnaround imply tighter geographical and organizational links between production and development?

The Need for Experimentation: There is a catch. It is not always evident what needs to be done, what strategies and organizations are required to create value or generate productivity. What matters for productivity and growth is the capacity to imagine how the underlying digital technology can be used. Success will require vision and execution; there will be failures of imagination and operation.

The imagination and the applications evolve as an array of experiments; experiments not only in technology or tools but also in the organizations that employ the tools and the business models to establish new ways of creating value. Again, many of those experiments will fail; some will succeed. Analytically, we can't just add up anecdotes of success and failure. So how should we proceed to make sense of the transition to a digital era? We proceed here by considering three categories of experiments: work organization, the use of knowledge, and business strategy.

Reinventing Production? Experiments reorganizing and reinventing production represent a first category of experiments. The introduction and application of networks that permitted easier communication and exchange of data, even in the years before the Internet, followed a clear three-step pattern. Francois Bar and Michael Borrus pointed out that first existing processes were automated; secondly, from the initial but automated base experiments in the use of the new networks were launched; finally, work processes were reorganized.[40]

Seen thus, there are both experiments that reorganize existing work processes implementing digital possibilities and experiments that innovate new processes of production. Some experiments drive production toward commodity status; others push towards creating distinctive advantage. In electronics the emergence of new fangled companies, contract manufacturers, created an outsourcing industry. Modularization, the division of product into modules that can be assembled, making each module a constituent element that itself can be outsourced, has facilitated that move toward production as product and commodity.

A most evident example of reorganizing production is the drive to outsourcing work in the service sector. Evidently the digital capacity to store and transmit information means companies can segment and geographically and organizationally distribute work. And in the current round in the United States of outsourcing service functions offshore, lower wages have been the primary driver. Martin Kenney and Rafiq Dossani have argued in the case of India, although lower costs drove the initial move offshore, which largely meant reproducing existing activity at lower cost as it did in the early days of offshoring manufacturing, many companies found possibilities for higher quality emerged abroad.[41] Management capacity of the contract producer to manage outsourced offshore projects is as critical a variable as cost in explaining the location of tasks. When an Indian company such as Wipro opens outsourced production activities in the United States, it is clear that management skill and experience with outsourcing rather than the cost of labor underlies the move. The conclusion must be that the service sector reorganization afoot is only partly about cost, but more fundamentally about imagining and implementing new approaches to the organization of production. The outsourcing/offshoring debate, whether about services or about manufacturing, inherently considers the reorganization and relocation, and then adjustment, of existing production structures.

Of course, experiments in offshoring and outsourcing have not always proven to be successes. Sometimes outsourcing is an excuse to avoid tough internal choices about product strategy or internal organization. Sometimes, as in finance, outsourcing obscures the possibility of delivering distinctive services. Sometimes, as in software development, outsourcing creates risks of losing intellectual property or propagating competitors.

But of course there are also radically new production systems, such as lean production systems in the 1980s and perhaps open source software, which is really an icon of the digital era. Open source as a principle of organization hinges on distinct approaches to mobilization and coordination of work, not a vague voluntarism but replicable rules of participation and gain. But the principles and rules on which it rests are new. For example, it rests on foundations that turn notions of property from ones of control of the use of an object, or an objectified body of code or knowledge, into control of the processes of distribution. The collaborative work arrangements it points to are both about production of software and made possible by the digital networks.

Managing Knowledge: Knowledge, particularly theoretical knowledge, has been recognized as an essential element of the contemporary economy. Critically though it is the expression of information, data, and knowledge in digital form that is truly distinct, permitting the application of digital tools, the suite of tools for thought. We see myriad experiments with the management of knowledge in a digital era, experiments that force open the very fundamental question of what knowledge is. In a digital form information can be formalized, stored, searched, transmitted, and used to control the operations of physical processes.[42] Or put in the reverse form, digital technology represents a set of tools for thought that formalize, store, organize, search, transmit, and manipulate information in digital form. In so doing they extend the range of what can be constituted as formal data. We can put the Library of Congress onto a single digital memory stick and transmit it in flash. The complex relationships on which engines operate or planes fly can be stated as algorithms, represented in digital form. But how do we know in an avalanche of facts and stated relationships which ones we care about? In one sense the flood of data made possible by these tools can drown the recipient, but oddly the same "tools for thought" make easier the creation of meaningful information and the generation of knowledge from that flood of data. How do we manage the knowledge we have? How to solve the problem? The solution ultimately forces the questions, what is the nature of knowledge, and how will knowledge contribute to the creation of value in companies and the economy? Analytically, there are limits to the value of piling up and searching documented knowledge and limits to formalizing the tacit knowledge embedded in individuals and communities of practice. As Niels Christian Nielsen has argued:

> "Knowledge unfolds in the iterative processes between tacit and codified forms, and optimizing knowledge in organizations is essentially an issue of optimizing these iterative processes. Put in a more grandiose way: Only a recognition that knowledge is embedded in often fundamentally metaphoric frameworks, will allow us to confront the question that knowledge takes on value in the constant interplay of those who cart around both formal and embodied knowledge, in the constant conversation that recreates and recasts the frameworks and metaphors, in the perpetual resorting of knowledge in context that reveals potential relationships and reforms the contexts itself."[43]

There is an organizational implication of this consideration of the nature of knowledge. Internally, the company organizations required for most efficient manufacturing may not be the same as those required for effective exploitation of knowledge. In the 1980s the Japanese innovations of flexible volume production using lean, just-in-time techniques created distinctive production advantage and rocked market competition. Is there a similar revolution afoot now? Lorenz and Vallyre point to the traditional craft organization, taylorist organization, lean production systems, and an emerging distinctive learning organization.[44] That distinctive organizational form is emerging in Northern Europe, principally the Nordic countries. We can only speculate as to why, pointing to experiments in work organization in an era of mass manufacturing that may be paying off in a knowledge era.

Experiments in Business Strategy: The tactical experiments – branding, design, versioning, production reorganization, and knowledge management – have to find expression in new business models, the underlying strategies for creating and capturing value. Those new business models must reflect the shifting location of leverage in creating value. But that is not easy. Many of the most spectacular failures of the bubble era were simply business strategy experiments gone awry, sometimes gone awry exploitively and on a grand scale. Many were failures of conception; others failure in execution. Recall that the dotcom investment wave hinged on the notion that the network tools would "disintermediate" traditional distributors, that bricks and mortar relationships would be replaced by electronic links or that wholesale intermediaries would be eliminated by electronic markets. Often the fantasy was that new entrants, new companies, using these digital tools could displace established companies. There are some evident successes; the travel industry from travel agent through airlines is being reformed by online operations. But "Borders" and "Barnes and Noble" in its brick and mortar form are probably more of a threat to the local bookseller than Amazon. Indeed, VCs behind Amazon report that the original investment was an "experiment" in the consequences of net-based retail marketing by new entrants, disintermediation, and the conclusion they drew early on from Amazon was that there were sharp limits to the possibilities the tools provided. Disguising their conclusion, one VC reports allowed history to make a good deal of money from the Amazon investment, but they made no others. But other investors saw this premier VC make this bet, and took that investment as a sign of confidence in the disintermediation bet, in the dot com movement and concluding that online companies and markets would work, then made a whole array of largely unsuccessful bets. Similarly the telecom collapse hinged on faulty, or false, notions of how data networks would be used. A most evident false notion was the asserted belief in the staggering and continuing expansion in the use of bandwidth principally, it was argued or implied, to carry entertainment content. The image was often that the consumer net would become a sophisticated vehicle for centrally distributed content. However, the error is evident in the history of the American post office. The post office in the United States was established to distribute newspapers, but the killer application that supported the system was letters, peer-to-peer communication to use today's vocabulary. Communication, not just voice but messaging and video meetings, and peer-to-peer exchanges are likely to be the killer applications. Use of Napster and peer-to-peer tools took off, but to succeed as businesses would have required a reformulation of Intellectual Property law. The basic instincts about where the networks will go have to be translated into viable business models. Consider another example. Enron, for example, should be in part treated as a failure to understand the collaborative possibilities of the new networks, argues Andrew Schwartz in "Enron's Missed Opportunity."[45] The classic Enron story focuses on the easy answer, fraud, on Enron as a Ponzi scheme designed to enrich scoundrels. But, Schwartz argues that beneath the off-balance sheet transactions and partnerships that have drawn such intense scrutiny, Enron's efforts to reduce complex products into tradable commodities represented one of the most promising ideas of the past twenty-five years. Enron's failure, the argument goes here, was due in part to a business strategy that missed the collaborative opportunities represented by the new network marketplaces. Enron saw competitors as ruthless and uncompromising, a mentality that rejected the very real possibility that rivals could, working together, create new markets that in turn would open up profit opportunities for all. Enron's brilliant vision of the New Economy, contends Schwartz, didn't go far enough; it required a new economy business model that emphasized cooperation among competitors.

By contrast, consider IBM's two fundamental shifts. IBM's first fundamental shift is from a product company wrapping its products in high value service support into a service company selling solutions that embed its products. As IBM migrated from electro-mechanical to digital information processing, it established itself as the dominant player in the market. Consequently its per unit development costs were radically lower than its competitors, making its margins substantial. That allowed “service” to be bundled into costs, offering a sense of certainty and reliability to its customers. Its market share allowed it to keep its core software, operating systems and the like, closed and privileged. That model of competition was no longer viable as the era of the mainframe and even the mini computer passed. Networks emerged supporting business services comprised of multiple networks and varied suppliers. IBM began to offer service solutions.

More generally, the IBM story points to the blurring distinction between service and product in a digital era. The distinction between service and product has never been very clear. Once, national accounts categories obscured the relative importance of services and production in an evolving economy (see *Manufacturing Matters*.)[46] A window washer at Nokia or G.M. is a manufacturing employee; if Ace Window Washers contracts to outsource the washing of Nokia’s and GM windows the same employees are counted in the service sector. Now the blurred line between product and service becomes a matter of strategic importance. Consider accounting: Accounting is a personal service provided by accountants utilizing tools from the original double-entry bookkeeping system to computers. But if you create a digital accounting program and put it on a CD, put it in a box, call it Quicken, and allow its unlimited use by the purchaser, then you have a product. If you put the program on the Web for access with support for use on a fee basis, then you likely offer a service, as an ASP, or Application Service Provider. Next, consider pharmaceuticals. If NextGenPharma sells a drug to be dispensed by a doctor or hospital, or sold in a pharmacy, it is producing a product. With gene mapping and molecular analysis, we are moving toward the possibility of a service model of therapies adapted to particular physiologies. If NextGenPharma really is a database company with a store of detailed molecular-level drug information and genome functionality, it could sell an online service to customize drugs or therapy.

IBM’s second fundamental shift was to support “open source” software, rather than proprietary software and the development of frameworks and tools to implement solutions within that framework. Microsoft and Unix provided common platforms through which competitors could integrate their offerings, limiting IBM’s leverage. Selling solutions in a multi-vendor environment suggested that a move away from closed proprietary systems might as well be to one of hyper-openness in which a capacity to define solutions, provide an integrated offering, and embed some distinctive proprietary modules would be decisive in keeping customers tied to IBM.

If business strategies to capture the evolving advantages of the digital era are experiments or bets with uncertainty about their success, not investments with predictable returns, then it is very difficult to say why some succeed and others don't. Often the failures in the digital era rest on fantasies, images of how the future will work; images that are possibilities taken as solid facts. IBM's success appears to have been the aggressive pursuit of an industry trend to a logical conclusion.

Toward the Experimental Corporation and the Experimental Economy

There are three sets of conclusions to consider. First, companies trying to create value are constantly search for the levers of advantage. The difficulty is that the optimum spots, differentiated assets of various sorts, are ever moving. Company internal functions become products, products become commodities, and the sources differentiation of product and process are constantly evolving. The global, as a set of national stories played out on a larger stage, is a constant source of new competitors, products, and processes. Since often these are innovation being bred privately at home in the diverse national settings before they surge out onto world markets, there is a constant sense of surprise and of accelerating change; certainly the more the players the more often there are radical changes.

So what do companies do? They must undertake experiments in product, business models, the use of knowledge, production strategies and more. Certainly the traditional strategy efforts, devising a strategy after careful logical assessment and then purposefully implementing that strategy, may be inadequate. It isn't just that the company response to the market may be slow, but rather that there will be an endless sequence of dislocating disjunctures, each one difficult to understand. Consequently company responses must be considered experiments in the face of quite fundamental uncertainty, not bets and gambles.[47] Each effort and each effort of a competitor must be culled and systematically assessed for lessons in an ever-evolving competition.

Second, for countries the policy problem is enormously complicated. What does it take to create an Experimental Economy, an environment for firms alone and in networks or clusters to experiment effectively? Certainly the basics are needed; a competitive environment, skilled workforces and investment in underlying technology. However, while it is evident that standard tools of industrial policy may be ever less useful as a means of insulating local producers from changes in global markets, the general lessons for state action from policy experiments around the globe are much less clear. Are there roles for the government in an experimental economy other than creating resources of people and technology on the one hand and assuring the proper rules for experimentation and competition? We must resist the temptation to begin an essay on the State and the Market in the concluding section of this essay. However just consider the buildout of recent networks and we will see the answer defies easy treatment or glib responses. The story of the build-out of the Internet in particular and digital infrastructure in general will provide abundant evidence for whatever ideological predilection you may have. The State's role has been powerful in the unfolding of the digital era, but extremely varied. From the *American* story of the emergence of the Internet itself, just note two examples about the relation of state and economy in the digital era with starkly conflicting messages. First, the creation of the Internet was simultaneously the product of *purposive intervention,* government action by the Defense Department's Advanced Research Projects Agency's, and *aggressive deregulation/re-regulation.* DARPA (the original acronym was ARPA, Advanced Research Projects Agency) seeking to protect defense communications from nuclear interruption funded the creation of the underlying conception and protocols of the Internet.[48] Government managed that network through the National Science Foundation and then prepared it for transfer to commercial use. It was, though, the aggressive introduction of competition into a private utility playing a public role, ATT, under the label of *deregulation* of the telephone system, which unleashed user-led, and consumer based, innovation in data networks. That opened the way to user-generated networks and facilitated the radical and rapid spread of Internet technology.[49] The *European* Story would likewise highlight these twin roles. Simplified, one part of the story is deregulation of the telecommunications system led by the Europe Commission. The Commission created national coalitions for European wide rules that would compel the transformation of State administrations responsible for post and telegraph into regulated companies in at least partly competitive market.[50] The other side of the story is an array of directed state actions intended to develop and diffuse digital technology. Dramatic was the development of the foundations of the World Wide Web at CERN, the Center for Nuclear Research.

Finally, what are the implications of the emerging digital era for Finland? *First*, Finland's traditional strengths may not be enough. Nokia's substantial capacities will be challenged. For example, capturing value from network-based services will be a necessity. European leadership in mobile networks may have been a precondition for Nokia's success. But Europe may not have that network leadership in the next round. Certainly, the 3g-auction debacle has slowed deployment of mobile broadband in Europe, while the emergence of WiFi networks raise questions about the underlying mobile technology trajectory and the appropriate business models for capturing value from mobile broadband internet. As important, a variety of Asian nations are building out innovative infrastructure with the hope that they can create distinctive advantage. *Second*, for Finland to sustain its growth, innovative globally competitive firms must emerge from outside the forest products and telecom sectors. But there are not going to be any silver bullets. As certain as it is that biotechnology and nanotechnology will transform our lives over the next generations, they will not alter our industries in the next decade. The broad array of firms in the fabric of the Finnish economy will have to step forward to innovation and global competition. A diverse pool of entrepreneurial talent and the institutions to support it will be required. The good news is that modularized production in cross national supply chains that emerged with Wintellism creates many opportunities. A firm need not be a giant to compete in global markets; it can be either specialty supplier or implement innovative designs through contract manufacturing. One thing is certain; another structural transformation as significant as that in the 80s lies ahead; and it will require industrial and political imagination to succeed.

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[1] This section draws heavily from John Zysman, "Manufacturing in a Digital Era: Strategic Asset or Vulnerable Commodity?" *New Directions in Manufacturing: Report of a Workshop* (National Academies Press: Washinton, D.C., 2004). John Zysman, "Transforming Production in a Digital Era," in William Dutton, Brian Kahin, Ramon O'Callaghan, and Andrew Wyckoff (Eds.), *Transforming Enterprise* (Cambridge: MIT Press, 2004, in press).

[2] Japanese lean production is a term associated with the work of Jim Womack, *The Machine that Changed the World* (New York: Harper Perennial, 1991). Flexible specialization is a term widely used by Charles Sabel and Michael Piore, generating a veritable industry of studies. See *The Second Industrial Divide* (New York: Basic Books, October 1990). Diversified Quality Production, Wolfgang Streeck's term for similar phenomena is developed in "On the Institutional Conditions of Diversified Quality Production," in Egon Matzner and Wolfgang Streeck *Beyond Keynesianism* (Aldershot: Elgar, 1991) pp 21-61.

[3] John Zysman and Michael Borrus, "Globalization with Borders: The Rise of Wintelism as the Future of Industrial Competition," *Industry and Innovation*, Vol. 4, Number 2, Winter 1997. John Zysman, "Production in a Digital Era: Commodity or Strategic Weapon?" BRIE Working Paper 147 (Berkeley: BRIE, September 2002).

[4] James P. Womack, Daniel T. Jones and Daniel Roos, *The Machine that Changed the World* (New York: HarperPerennial, 1991) provide a good characterization of the notion. See also Paul Hirst and Jonathan Zeitlin "Flexible Specialization: Theory and Evidence in the Analysis of Industrial Change," in J. Rogers Hollingsworth and Boyer (Eds), *Contemporary Capitalism: The Embeddedness of Institutions* (Cambridge: Cambridge University Press, 1997).

[5] James P. Womack, Daniel T. Jones, and Daniel Roos, *The Machine that Changed the World* (New York: HarperPerennial, 1991). See also: Stephen Cohen and John Zysman, *Manufacturing Matters: The Myth of the Post Industrial Economy* (New York: Basic Books, 1987). Benjamin Coriat, "The Revitalization of Mass Production in the Computer Age," paper presented at the UCLA Lake Arrowhead Conference Center, Los Angeles, CA, March 14-18 1990. Ramchandran Jaikumar, "From Filing and Fitting to Flexible Manufacturing: A Study in the Evolution

of Process Control," Working Paper 88-045 (Boston: Division of Research, Graduate School of Business Administration, Harvard University, c1988).

[6] There are many versions of this story, mine is told in: John Zysman and Laura Tyson, "The Politics of Productivity: Developmental Strategy and Production Innovation in Japan," in Chalmers Johnson, Laura Tyson, and John Zysman (Eds.), *Politics and Productivity: The Real Story of How Japan Works* (New York: Ballinger, 1989). Japan's automobile and electronics firms burst onto world markets in the 1970s and consolidated into powerful conglomerates in the 1980s. The innovators were the core auto and electronics firms who, in a hierarchical manner, dominated tiers of suppliers and sub-system assemblers; the production innovation was the orchestration and re-organization of the assembly and component development process. The core Japanese assembly companies of the lean variety have been less vertically integrated than their American counterparts, but they have been at the center of vertical Keiretsu, loosely speaking, a Japanese conglomerate conventionally understood to be headed by a major bank or one consisting of companies with a common supply chain linking wholesalers and retailers, that have tightly linked the supplier companies to their clients.

[7] John Jay Tate, "Driving Production Innovation Home: Guardian State Capitalism and the Competitiveness of the Japanese Automotive Industry" (Berkeley: BRIE, 1995). The argument is simple. The relationships of production and development in these production systems are, at best, delicate. Just-in-time delivery, subcontractor cost/quality responsibility, and joint component development push on to the subcontractor considerable risk in the case of demand fluctuations. True, there were techniques to continuously reappraise demand levels and indicate to 'client' firms their allocations so that the client firms could in turn plan. This reduced unpredictability throughout the system. But if demand moved up and down abruptly, those techniques would not have mattered. True, government and corporate programs to reduce the capacity break-even point in small firms helped. Nonetheless, imagine that Japan's emerging auto sector had to absorb continuously the stops and starts of the business cycle that typified Britain in the 1950s and 1960s. Would the trust relationships that are said to characterize Japan have held up? Could the fabric of small firms have survived to support just-in-time delivery and contractor innovation? Simply a smooth and steady expansion of demand typified the Japanese market in sectors such as autos and facilitated these arrangements and developments. The high growth rates--combined with the need to re-equip Japan in the post war years--created the basis of the continuous expansion. But domestic growth did fluctuate and the rivalries for market share led consistently to over-investment, or excess capacity, in the Japanese market. The story about Japan told by Yammamura and Murakami, Tsuru, Zysman, and Tyson, and by Tate in the case of the auto industry shows that the excess capacity was "dumped" off onto export markets. Seen differently, these exports permitted a steady and smooth expansion without which the production innovations outlined here would not have emerged. The developmental strategies of Japan were essential to its production innovation.

[8] Wolfgang Streeck, "On the Institutional Conditions of Diversified Quality Production" in Egon Matzner and Wolfgang Streeck *Beyond Keynesianism*, pp.21-61 (Aldershot: Elgar, 1991). Michael Piore and Charles F. Sabel, *The Second Industrial Divide: Possibilities for Prosperity* (New York: Basic Books, 1990). Robert Boyer and J. Rogers Hollingsworth, *Contemporary Capitalism: The Embeddedness of Institutions* (New York: Cambridge University Press, 1997). Robert Boyer and Yves Saillard, *Regulation Theory: The State of the Art* (New York: Routledge Press, 2002).

[9] Charles F. Sabel, Horst Kern, and Gary Herrigel, *Collaborative Manufacturing: New Supplier Relations in the Automobile Industry and the Redefinition of the Industrial Corporation* (Cambridge, MA: International Motor Vehicle Program, Massachusetts Institute of Technology, 1989). Charles Sabel, *Work and Politics* (Cambridge: Cambridge University Press, 1982). Suzanne Berger and Michael J. Piore, *Dualism and Discontinuity in Industrial Societies* (New York: Cambridge University Press, 1980). Paul Hirst and Jonathan Zeitlin, "Flexible Specialization: Theory and Evidence in the Analysis of Industrial Change," in J. Rogers Hollingsworth and Boyer (Eds.) *Contemporary Capitalism: The Embeddedness of Institutions* (Cambridge: Cambridge University Press, 1997).

[10] Op. Cit.: Paul Hirst and Jonathan Zeitlin, "Flexible Specialization: Theory and Evidence in the Analysis of Industrial Change,"

[11] Charles Sabel, "Flexible Specialization and the Re-Emergence of Regional Economiesn" in Ash Amin (Ed.), *Post-Fordism: A Reader* (Oxford: Blackwell Publishers, 1994).

[12] John Zysman and Michael Borrus, "Globalization with Borders: The Rise of Wintelism as the Future of Industrial Competition," *Industry and Innovation*, Vol. 4, Number 2, Winter 1997.

[13] By vertical control we mean both vertical integration from inputs through assembly to distribution, as in the case of American auto producers, and the "virtual" integration of Asian enterprise groups, as when Japanese producers of consumer durables effectively dominate market relations with semi-independent suppliers through the Keiretsu group structure. See Masahiko Aoki, *The Japanese Firm as a System of Attributes: A Survey and Research Agenda* (Stanford, CA: Center for Economic Policy Research, Stanford University, 1993). Mashaiko Aoki and Ronald Dore (Eds.), *The Japanese Firm: The Sources of Competitive Strength* (New York: Oxford University Press, 1994). Masahiko Aoki, *Information, Incentives, and Bargaining in the Japanese Economy* (New York: Cambridge University Press, 1988). Michael L. Gerlach, *Alliance Capitalism: The Social Organization of Japanese Business* (Berkeley: University of California Press, 1992).

[14] Michael Borrus, "Left for Dead: Asian Production Networks and the Revival of US Electronics," BRIE Working Paper 100 (Berkeley: BRIE, April 1997).

[15] Ibid.

[16] Steve Vogel et al. (Eds.), *The Highest Stakes: The Economic Foundations of the Next Security System* (New York: Oxford University Press, 1992). Jay Stowsky, "Secrets to Shield or Share? New Dilemmas for Dual Use Technology Development and the Quest for Military and Commercial Advantage in the Digital Age," BRIE Working Paper 151 (Berkeley: BRIE, April 2003).

[17] Global Value Chain Initiative http://www.globalvaluechains.org/

[18] John Zysman and Michael Borrus, "Globalization with Borders: The Rise of Wintelism as the Future of Industrial Competition," op. cit.

[19] Steve Cohen, Brad Delong, and John Zysman *"Tools for Thought: What is New and Important about the 'E-conomy"* (Berkeley: BRIE, 2001). See also Stephen Cohen, Bradford DeLong, Steven Weber, and John Zysman. „Tools: The Drivers of E-Commerce." *Tracking a Transformation: E-Commerce and the Terms of Competition in Industries* (Washington, D.C.: Brookings Institution Press, 2001).

[20] Ibid.

[21] Norbert Weiner, *The Human Use of Human Beings: Cybernetics and Society* (Boston: DaCapo Press, 1954) and Norbert Weiner, *Cybernetics: or Control and Communication in the Animal and the Machine* (Cambridge: MIT Press, 1965). Weiner defines cybernetics, or the theory of messages, as the "entire field of control and communication theory, whether in the machine or in the animal." The development of messages and communication facilities, both man to machine and machine to machine, will play an ever-increasing role in our society. Cybernetics argues the "structure of the machine or of the organism is an index of the performance that may be expected from it." Analogous to humans, communication machines use feedback mechanisms to reduce entropy and maintain effective communication. Claude Elmwood Shannon, "A Mathematical Theory of Communication" in N.J.A. Sloane and Aaron D. Wyner (Eds.), *Claude Elmwood Shannon: collected papers* (New York: IEEE Press, 1993). Shannon argues predictable symbols can be omitted from communication. Information, or "those symbols that are uncertain to the receiver," measures an information source's entropy. Entropy, in turn, "determines the smallest number of bits per symbol that is required to represent the total output." See Lucent Technologies, "The Meaning of Information" at http://www.lucent.com/minds.infotheory/what.html and "An Overview of Information Theory" at http://www.lucent.com/minds/infotheory/docs/history.pdf.

[22] According to the Department of Commerce Bureau of Economic Analysis, in 1998 US trade in IT was $314 billion. The total volume of American trade--imports and exports--in information technology is now doubling in less than seven years. Lawrence H. Summers and J. Bradford Delong in "Is the 'New Economy' a Fad?" Project Syndicate, April 2002 offer the following statistics: in 1950 there were 2,000 computers in the US. By 2002, there were 300 million computers. That is a 4 billion fold increase in raw automated computation power, an average annual rate of growth of 56%.

[23] There are traditional lists of leading sectors, or clusters of technological innovations, over the past two centuries. They include in some format: 1) the industrial revolution and the Arkwright mill, 2) the age of steam and railways, 3) the era of steel/electricity/ heavy engineering, 4) the automobile era of mass production, and now 5) information and telecommunications; See for example: Carlotta Perez, <u>Technological Revolutions and Financial Capital</u> ,Edward Elgar, 2003; According to the Department of Commerce Bureau of Economic Analysis, in 1998 US trade

in IT was $314 billion. The total volume of American trade--imports and exports--in information technology is now doubling in less than seven years. Lawrence H. Summers and J. Bradford Delong in "Is the 'New Economy' a Fad?" Project Syndicate, April 2002 offer the following statistics: in 1950 there were 2,000 computers in the US. By 2002, there were 300 million computers. That is a 4 billion fold increase in raw automated computation power, an average annual rate of growth of 56%.

[24] The use and application of transformative technologies alters the array of activities in the economy as a whole. The diffusion of those transformative technologies is undoubtedly the critical step. It is not just the fortunes made as the leading sector expands, but the industrial development transformative technologies engender. Notably, as Brad de Long points out, in the 19th century the several railroad bubbles brought down the price of transport and in the process, by extending the geographic size of markets, generated such innovations mail order retailing. Thus, ironically, the .com and telecommunications collapse in last years may, in historical perspective, prove to have accelerated use and diffusion. The collapse of major telecom carriers as a result of overbuild of telecom networks has brought a precipitant drop in the price of network use.

[25] Other examples would be hip surgery, or semi conductor ovens that requires temperature controls within one degree C at roughly 2000 degrees.

[26] Carl Shapiro and Hal R. Varian. *Information Rules: A Strategic Guide to the Network Economy* (Boston: Harvard Business School Press, 1999).

[27] Thanks to Stuart Feldman of IBM for his presentation at the Innovation Alliance: Succeeding in an Evolving Global Economy conference, Berkeley Roundtable on the International Economy, Berkeley, August 27, 2004.

[28] Clayton M. Christensen, The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. (Boston: Harvard Business School Press, 1997)

[29] "Manufacture: To make or process (a raw material) into a finished product, especially by means of a large-scale industrial operation. To make or process (a product), especially with the use of industrial machines. To create, produce, or turn out in a mechanical manner. To concoct or invent; fabricate. To make or process goods, especially in large quantities and by means of industrial machines." Source: The American Heritage® Dictionary of the English Language, Fourth Edition (Houghton Mifflin Company, 2000.

[30] The critical question, once we acknowledge that software production is a form of manufacturing, is what are the most effective ways of organizing software production. For this discussion, the list begins with the conventional questions of whether to outsource, of where, geographically, to locate software development. The story becomes interesting when we ask whether to choose conventional hierarchical production structures typified by Microsoft or new alternatives such as the commercialization of Linux products developed in an open source model.

[31] What happened in semi-conductors development was that at a moment of new technology development, the when two major dominant established players – IBM and ATT – were restricted by Anti Trust competition concerns from producing semi-conductor products for sale in the merchant markets. But the Anti Trust ruling was critical to that outcome, and to the emergence of the merchant semiconductor firms. That merchant sector changed the course of the Information Technology evolution worldwide.

[32] Robert C. Leachman and Chien H. Leachman. "E-Commerce and the Changing Terms of Competition in the Semiconductor Industry." *Tracking a Transformation: E-Commerce and the Terms of Competition in Industries* (Washington, D.C.: Brookings Institution Press, 2001). Michael Borrus, Jim Millstein, and John Zysman. "US-Japanese Competition in the Semi-Conductor Industry" (Berkeley, Institute of International Studies: 1982.) *International Production Networks in Asia: Rivalry or Riches?,* edited by Michael Borrus, Dieter Ernst and Stephan Haggard, (London: Routledge: 2000).

[33] National Research Council, Charles W. Wessner, Ed. "Securing the Future: Regional and National Programs to Support the Semiconductor Industry." (Washington, DC, National Academies Press: 2003)

[34] Eliasson, Gunnar "The Nature of Economic Change and Management in the Information Based Knowledge Economy: May 1998 KTH Stockholm"; and "Ignorant Actors in the Resource Rich World of the Knowledge Based Economy: Prepared for ISS International Schumpeter Society, Italy June 9-12 2004."

[35] Ibid.

[36] Stephen J. Dorgan and John J. Dowdy. “When IT Lifts Productivity.” The McKinsey Quarterly, September 2004. Erik Brynjolfsson and Lorin M. Hitt. “The Catalytic Computer: Information Technology, Enterprise Transformation and Business Performance.” in William Dutton, Brian Kahin, Ramon O'Callaghan, and Andrew Wyckoff (Eds.), *Transforming Enterprise* (Cambridge: MIT Press, 2004, in press).

[37] Barbara Baran “The Technological Transformation of White Collar Work: A Case Study of the Insurance Industry.” (Dissertation, University of California, Berkeley: 1986)

[38] Op. Cit. Carl Shapiro and Hal R. Varian. Information Rules: A Strategic Guide to the Network Economy

[39] Gary Fields. *Territories of Profit: Communications, Capitalist Development, And-The Innovative Enterprises of G. F. Swift and Dell-Computer (Innovations and Technology in the World Economy)* (Stanford University Press: Stanford, CA, 2003). Martin Kenney and David Mayer, “Economic Action Does Not Take Place in a Vacuum: Understanding Cisco's Acquisition and Development Strategy.” BRIE Working Paper 148 (Berkeley, CA: BRIE, September 2002).

[40] Michael Borrus and François Bar. *The Future of Networking*. (Berkeley: BRIE 1993).

[41] Martin Kenney and Rafiq Dossani, “Went for Cost, Stayed for Quality? Moving the Back Office to India” BRIE Working Paper 156 (Berkeley: BRIE, 2004).

[42] Stephen S. Cohen, J. Bradford DeLong, John Zysman, “Tools for Thought: What is New and Important about the "E-conomy” BRIE Working Paper 138 (Berkeley: BRIE, 2000).

[43] Niels Christian Nielsen and Maj Cecilie Nielsen. ”Spoken-About Knowledge: Why It Takes Much More than 'Knowledge Management' to Manage Knowledge.” BRIE Working Paper 158 (Berkeley: BRIE, June 2004.)

[44] Edward Lorenz and Antoine Valeyre, ”Organisational Change in Europe: National Models or the Diffusion of a New ‘One Best Way’?” DRUID Working Paper (Elsinore, Denmark: DRUID Summer Conference 2004)

[45] Andrew Schwartz, “Faliure of Vision: Enron’s Missed Opportunity.” *How Revolutionary was the Revolution? National Responses, Market Transitions, and Global Technology in the Digital Era.* A BRIE/ETLA/Helsinki Project. John Zysman and Abraham Newman (Eds.) Forthcoming.

[46] Stephen Cohen and John Zysman, *Manufacturing Matters: The Myth of the Post Industrial Economy* New York: Basic Books, 1987).

[47]Op. cit. Eliasson. Note that this argument is consistent with and now draws on the framing argument of Gunnar Eliasso. It was a considerable relief when Pekka Yla-Antilla pointed out the paper made an argument similar in language and concept to that Eliasson had innovate years earlier.

[48] Katie Hafner and Matthew Lyon, *Where Wizards Stay Up Late: The Origins of the Internet* (New York: Touchstone, 1998).

[49] Ibid.

[50] This comment is based on research interviews conducted with Peter Cowhey.